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The Use of an Axiological Lens to Review Globalised Automation and Control Systems Projects

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Abstract: Problems in the design, development and management of large scale systems have be related to the multi-cultural contexts in which these systems are developed and deployed. Culture can be defined in terms of human values (axiology). Using an axiological lens, this paper explores potential value conflicts between systems engineers and the praxis in which they are formally educated. The findings provide evidence to support an axiological perspective of systems engineering and suggest that axiology could be extremely useful in understanding various aspects of systems engineering development, ethics and management.

1. BACKGROUND & MOTIVATION

Cultural meanings are an embodiment of the values held by different cultural groups. These values are formally studied in the discipline entitled *axiology*. Cultural anthropology shows us that organisations will need to adopt an axiological perspective if they are to be successful in a globalised economic system (Barrett (1998), Byrne & Bradley (2007)). Automation and control technologies are now key players in the monitoring, control and management of large-scale organisational activities. These activities occur in a mixed cultural context, across many national boundaries simultaneously and involve human activity systems which comprise people with a wide variety of social and ethnic backgrounds. These technologies are typically constructed by teams of systems engineers distributed across the world, from different socio-ethnic backgrounds and using a variety of engineering techniques.

Some researchers have suggested that the values that inform systems engineering, and the methodologies that are used to develop and deploy automation and control systems, require attention, especially in our attempts to understand the dynamics of system failure (Freeman, Stapleton & Byrne (2007), Goulielmos (2005) & (2003)). In spite of this, a conceptualisation of culture and organisation has yet to be incorporated into theories of technology design, development and management. With a few notable exceptions, neither human-centred systems research nor development methodology research have paid much formal attention to the complexities and ambiguities of cross-cultural exchanges as cultural artefacts.

Anthropologists looking at cultural aspects of information technologies have described culture as “a constellation of meanings” (Greene and Murphy (1997)). This complex web of meanings can be defined in terms of the system of values which inform the culture. Recent work shows how the values espoused by members of national and regional cultural groups explain their distinguishing cultural traits (Schwartz (2006)). These examined cultural effects in terms of values espoused by any particular cultural group. This study explored the relationship between human values (as determinants of cultural similarities and differences) and the development processes of automation technologies.

2. ENGINEERING ETHICS AND VALUES

Researchers have shown that systems engineers experience ethical difficulties in their work. These studies have tended to argue that this requires new approaches to ethics and has tried to set out new trajectories for the ethics of engineering (c.f. Stapleton (2007)). However, any particular ethical stance reflects some set of values which underpin it. Consequently, rather than concentrate just on ethical analyses *per se*, engineering ethics research which attempts to understand the effects of globalisation (for example) should also concern itself with the value systems underlying systems engineering praxis.

Research has shown how certain systems engineering methodologies embody a particular ethical position, and this is reflective of a particular set of values (Rogerson, Weckert & Simpson (2000)). However, few researchers have attempted to frame this as a value-systems issue, rather than an ethics issue. This raises the following question: given that systems engineering methods are underpinned by a set of values, and given that systems engineers come from a wide variety of cultural and ethnic backgrounds, is it possible to explain ethical difficulties that systems engineers experience in terms of value conflicts? This in turn raises a deeper question: is it possible that the praxis of systems engineering has systematically built into it the potential for creating value-conflicts for systems engineers? This paper explores this second question.

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This paper first briefly sets out a theory of human values. It then explores this theory in terms of systems engineering methods. It proceeds to sets out a research question and propositions for the paper and outlines a research study designed to test the propositions. The paper then sets out some findings as regards the personal values of young engineers from distinct cultural groups. Finally, conclusions are drawn from these findings and future research possibilities outlined.

2. ETHICS AND AXIOLOGY: THE STUDY OF HUMAN VALUES

Recently, a series of papers in the automation and control systems literature have called for a revised perspective of engineering ethics (c.f. Stapleton (2007); Hersh (2002); Hersh & Moss (2004); Bitay, Brandt & Savelsberg (2005)). Research has indicated that certain modes of reasoning underpinning systems engineering, which themselves reflect particular value orientations, are becoming outmoded and problematic (Stapleton (2006)). Systems engineering development methods is one particular domain which has received little attention in this regard (Stapleton (2006)). It is clear that the research that underpins the development of the systems engineering methodologies now taught and practiced by systems engineers is itself not morally or ethically neutral. A much richer ethical perspective is urgently needed that takes engineering beyond codes of ethics and explores the deeper processes which inform engineering praxis and the processes by which advanced technologies come to be (Stapleton (2006)).

Ethical analysis alone cannot take into account the human values which underpin ethics itself. The human values which inform engineering research and praxis need careful scrutiny and consideration. Axiology is the study of human values and is a branch of philosophy closely related to ethics. Ethics informed by concerns about morality and the relative importance of human values. Based on the work of Rokeach (1973), Schwartz and Bilsky (1987) devised a theory of universal types of values as criteria by viewing values as cognitive representations of three universal requirements which are, biologically based needs of the organism, social interaction requirements for interpersonal coordination and social institutional demands for group welfare and survival.

In order to measure the values of individuals Schwartz developed the Schwartz's Value Survey (SVS) which measure the relative importance to an individual of 57 sets of different values (Schwartz (1992)). According to Schwartz (1990, 878) "values are concepts or beliefs, that pertain to desirable end states or behaviours, they transcend specific situations, guide selection or evaluation of behaviour and events, and are ordered by relative importance". In the SVS the 57 values are used to represent 10 motivationally distinct value domains that are theoretically derived from universal requirements of human life. Summarising, these are:

1. Power (social power, authority, wealth),
2. Achievement (success, capability, ambition, influence on people and events),
3. Hedonism (gratification of desires, enjoyment in life, self-indulgence),
4. Stimulation (daring, a varied and challenging life, an exciting life),
5. Self-Direction (privacy, creativity, freedom, curiosity, independence, choosing one's own goals),
6. Universalism (broad mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection),
7. Benevolence (helpfulness, honesty, forgiveness, loyalty, responsibility),
8. Tradition (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty),
9. Conformity (obedience, honouring parents and elders, self-discipline, politeness)
10. Security (national security, family security, social order, cleanliness, reciprocation of favours (Lindeman and Versasalo 2005).

Data gathered from individuals along each of these 10 domains have shown to load two bipolar dimensions. These are summarised as:

1. Conservation (whether people resist change and emphasise self-restriction and order) versus Openness to Change (whether people are ready for new experiences and emphasise independent action and thought).
2. Self Transcendence (whether people are willing to transcend selfish concerns and promote the welfare of others) versus Self Enhancement (whether people are more motivated to enhance their own personal interests even at the expense of others).

These two dimensions reflect the different motivational goals of the 10 basic values and the two major conflicts that organise the whole value system (Lindeman (2005)).

3. SYSTEMS ENGINEERING AND HUMAN VALUES

This paper has already shown that systems engineering, as a discipline, is not morally or ethically neutral (Hersh etc…). Control and automation engineering are embodiments of values associated with, for example, the enlightenment, scientific bases for progress and confidence in certain forms of rationality. Not all cultures are framed by these values and, consequently, it is naïve to expect that rationalities based upon these value systems will be universally applicable, accepted or even appropriate.

3.1 Systems Engineering Methods and Values

Stapleton (2007) sets out a series of rationalities which have been highly influential in systems development. These "modes of reasoning" can be summarised as *instrumentalism, functional rationalism, integration rationalism* and *reductionism*. Each rationalism emphasises objectivity and universal truths about how certain activities, such as systems development, should be conceived and enacted. They have resulted in a 'one-best-way' approach which has delivered tremendous advantages by supporting the standardisation and benchmarking of technology development activities. This has, in turn, helped support quality assurance metrics and has created a universal language for tackling the complexity of large-scale systems development work. However, these ways of thinking can also be detrimental, especially in situations where ambiguity and complexity are very high (such as in multicultural technology development and deployment contexts). Furthermore, Stapleton (2006) showed how these rationalities can lead to systems failure as a result of poor ethical reasoning, which by implication is a result of inappropriate value systems.

Modern approaches to systems analysis and design began in the 1950s as a direct response to the growing complexity of computing machinery at the time (Date (1970)). The major methodological approaches to systems development were established and formalised by the early 1990s and largely based on research in the 1970s. Up until relatively recently it was thought that most large-scale systems development projects rigorously adopted a well-defined methodology for organising activities. However, since the late 1990s studies have emerged which suggest that systems engineering methods, especially in information systems development, were being deployed in an ad-hoc fashion in some instances, and in other situations were being tailored fro ma variety of tools and techniques according to the particular requirements of a particular context (FitzGerald (2000)).

Ovaska & Stapleton (2008) More recently, research into multicultural development contexts has indicated that systems engineers working in globalised distributed teams were, in many cases, forming their own structured methodologies by which they organised their work.

This contingent approach to the formalisation of systems engineering praxis suggests that value conflicts were likely to arise. Engineers were not prepared for the complex web of multi-culturalism into which these methods were deployed. Studies of engineering education suggests that neither values nor ethics have received much attention from engineering curricula. Consequently, engineers were rarely trained to understand complex value systems and did not have the expertise to assess the value impacts of a series of methodological techniques. Furthermore, engineers did not have the expertise to scrutinise the appropriateness of the techniques themselves, which were heavily value laden (Stapleton (2007); Rogerson, Weckert & Simpson (2000)).

Figures 1 and 2 provide a simple illustration of the historical development of the complexities and ambiguities that technologists face in their development work, as regards value systems.

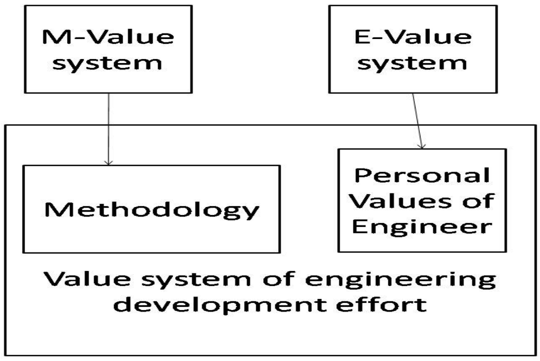

Fig. 1. Early Systems Development

Figure 1 represents the value systems at play in early systems development projects. Here the system analyst often worked alone having minimal contact with other people. Where that contact existed it was typically 'co-located' i.e. with people physically located close-by and with similar value systems. The methodology was employed formally and underpinned by a potentially different value systems (M-Value System) to that held by the engineer (E-Value System).

Figure 2 is a similar representation but better reflects the complexities of modern development activities. Here, techniques derived from a variety of methodologies, with potentially differing underlying values, have been stitched together from various components (C1, C2 etc. in the figure) into a tailored methodology. Evidence has suggested that this tailoring has been quite dynamic as methodologies were negotiated and re-negotiated as contingencies changed (Ovaska & Stapleton (2008); Vakola, Rezgui & Wood-Harper (2000)). Furthermore, Mullally and Stapleton (2007) show how systems development teams could be relatively dynamic, forming and breaking apart as individual projects came and went. This contrasted with the earlier history of systems development where engineering or information systems departments would staff many projects over time and stay working together in the same functional group for many years. The particular context depicted in figure 2 therefore involved numerous systems engineers working in many locations at different times and with a variety of socio-ethnic backgrounds. These engineers then pieced together a negotiated methodology from a selection of components sourced from a variety of methodologies. Axiologically, this suggested an extremely complex set of value systems all in play at any one time and potentially shifting over time as contingent factors shifted in and out of focus as suggested by Avison *et al* (1998)).

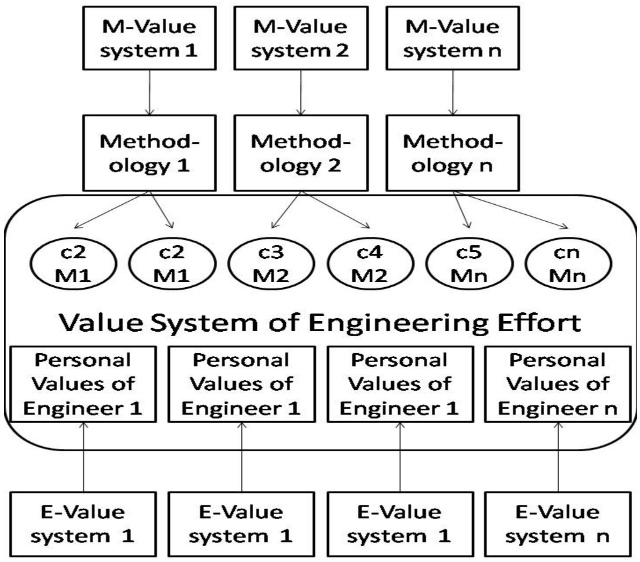

Fig. 2. Contemporary Systems Development

4. RESEARCH PROBLEM, QUESTIONS AND PROPOSITIONS

This paper has suggested that value conflicts can emerge as a direct result of the conflicts between the values that underpin systems engineering methodologies and those values held by engineers. Therefore, the research question for the study was:

RQ: Is the potential for value conflicts amongst systems engineers systematically built into systems engineering approaches?

A study was designed to test two propositions which could be used to explore the research question. The study examined the relationship between the values of young computer engineers and the practices into which they are inculcated during third-level technology education. The study recognised that these practices embodied a series of values (i.e. those represented by M1, M2 etc. in figure 2). It assessed the extent to which these values could be at odds with the personal values of the students themselves. Formally, the propositions were set out as follows:

P1: It is possible to identify personal values of a culturally definable group of technologists which are different to the values embodied in a technology development methodology in which they are formally trained.

P2: Technologists with differing cultural backgrounds display different values as regards key aspects of systems engineering methods in which they are formally trained.

The first proposition enabled the study to test the extent to which systems engineering education, and, by extension, systems development research, was at variance with the values espoused by the engineers. In the event that a variance was measured, it was postulated that this would lead to value conflicts. This was because technologists would use methods which do not reflect their own values and cause them to act in ways at variance with their espoused values. In this way potential value conflicts associated with systems engineering praxis could be assessed. The second proposition tested the effect of different value systems by measuring the values of culturally distinctive groups of technologists. If an effect was measured, it provides evidence for an impact of complex, multi-cultural values systems in engineering work. This in turn strengthened the case for the importance of axiology in technology development and demonstrated further potential for value conflicts systematically associated with systems development approaches which assume that universal approaches are best.

5. RESEARCH DESIGN AND METHODOLOGY

Schwartz's original value survey instrument (the SVS) reviews all 57 universal value types. Subsequently, Lindeman and Verasalo (2005) developed a shorter version of the SVS, which they called the Short Schwartz's Value Survey (SSVS). In this study it was decided that the SVSS was sufficient to indicate whether an effect along the lines of the above propositions could be isolated.

The sample consisted of Irish computer engineering students (78.9%) and (21.1%) of foreign students from the following countries, China, Pakistan, Nigeria, England, Italy, France, Sudan, Poland, Ukraine, Russia, Spain, Malawi, and South Africa . The sample consists of 161 participants representing a convenience sample, which is appropriate for a preliminary study of this nature. The respondents ranged from first year computing students up to computing master's students. The participants were told that the study concerned values and that participation was voluntary and that all information would be treated confidentially. Using the Short Schwartz's Value Survey participants were presented with the name of a value along with its value items. Participants were asked to rate the importance of each value as a guiding principle in their life. The ten values were rated on a 9-point scale ranging from -1 (opposed to my principles), 0 (not important), 3 (important) to 7 (of extreme importance).

5. FINDINGS

0.5 page of findings maximum setting out the data – AMANDA CAN YOU PLEASE SET OUT SOME FINDINGS AS PER THE PROPOSITIONS ETC> USE

THE DATA YOU COLLECTED ALREADY AS BEST AS YOU CAN>

6. DISCUSSION

0.3 page maximum discussing the data in light of the propositions and RQ – LARRY AND GABRIEL CAN SET THIS OUT

6. CONCLUSIONS

Seven lines maximum conclusion section. LARRY TO COMPLETE>

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