A Multiverse of Systems: Global Challenges for Educational Technology.

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Abstract

Systems thinking is emerging as a new methodology for the study of Education from a fresh perspective. It has a long history but has gained wide popularity in recent decades. This novel approach is being utilised to examine issues surrounding the use of Education for Sustainable Development (EfSD), particularly within the special context of Developing Countries, from the perspective of current efforts within an International EfSD environment, namely United Nations University (UNU). Thus socio-cultural, organisational, pedagogical, technological and economic issues will be considered as part of this research program as well as others which may emerge. The intended outcome is a system model of EfSD which may be used to inform future work at UNU.

1. Introduction: The Emergence of a New Paradigm.

There is a certain perspective emerging in Science which advocates a view of phenomena from a conceptual framework based on notions of systems. This new perspective may afford a fresh purchase on many problems facing humanity in the world today. Chief amongst these issues are notions of Sustainable Development which aim to address present social, economic and environmental difficulties. Current efforts in Education for Sustainable Development (EfSD), that is the promotion and dissemination on thinking for sustainable futures, may also benefit from a reorientation with a systems approach. Currently, such initiatives are prone to being facilitated by carefully negotiated diplomatic avenues which may be reliant on important yet inherently biased personal networks. Thus the hypothesis is that a systems approach may offer a more scientifically rigorous method that may provide more potentially successful solutions. This possible systemic conceptualisation has already occurred in other sectors of Education, particularly in the emerging Globalisation facilitator of Information Communications Technology (ICT). Thus this paper explores such possible additional approaches.

The New Pocket Oxford Dictionary [1] defines a system as:

“1 a set of things working together as a mechanism or network. 2 a person’s body. 3 Computing. a group of related hardware units or programs or both. 4 an organized scheme or method. 5 orderliness. 6 the existing political or social order.”

Although space restriction prevents us from further decomposing this definition here a brief tour of the history of Systems Theory follows. Subsequently we will examine previous systems approaches to Education (and ICT), realign this with Education for Sustainable Development then illustrate this with a current research program at UNU.

2. A Potted History of Systems Thinking.

According to The Oxford Companion to the Mind [2] the study of systems has a long history perhaps commencing with self-regulating or cybernetic systems. These self-regulating devices had appeared as early as 2000 years ago such as those used for the control of water reservoirs. However, during the 18th Century it became necessary to apply such feedback techniques in terms of more complex machinery as evidenced by the first patent application for Windmill regulation in 1787. Later developments included their use in the Steam Age then subsequent derivation, during the 19th Century, of the associated mathematical language to describe such mechanisms allowed their more precise formulation and application. Also during the 19th Century notions of biological feedback systems were being developed amongst at least several prominent anatomists and physiologists. Of note is Eduard Pflüger’s 1877 paper...
which employed a term *teleology* as the study of final causes, that is the apparent link between a system’s output and it’s input which allows the output to effectively control the degree of input resulting in a stable system. This work built on the earlier work of Charles Bell which utilised mechanical models of biological systems. Thus similarities were beginning to be made between biological and mechanical control systems leading, inevitably, to Felix Lincke combining the two types of systems in his 1879 lecture “The Mechanical Relay” which described a human arm in terms of mechanical components.

3. Cybernetics.

Subsequently, a term *cybernetics* was coined by the mathematician Norbert Wiener in his book entitled “Cybernetics, or Control and Communication in the Animal and the Machine” [3]. Cybernetics also has applications in the realm of Social Sciences. Kenneth Craik (1914-1945) was perhaps one of the pioneers of control theory in terms of what is now termed Human-Computer Interaction (HCI) or human factors. His work was based on his studies during the Second World War of operators of tank and aircraft gunnery. He recognised a tendency towards *steady-states* or *homeostasis* in systems involving both man and machine. In contrast, if the machine is removed from the equation and replaced by another human the field of control theory is applied to Social systems, that is, feedback is provided as one human controls another’s behaviour and vice versa. These systems, connecting one or more humans, or indeed animals, are usually *open* in that they form parts of larger systems such as a family unit interacting with each other but also within the wider community.


Ludwig Von Bertalanffy [4] became a key proponent of systems thinking in the 1960s. He states that a number of discrete fields had an impact on his conceptualisation of General System Theory (GST), notably:

1. Cybernetics;
2. Information theory;
3. Game theory;
4. Decision theory;
5. Topology;
6. Factor analysis;
7. General systems theory “in the narrower sense”.

To this list we may also add, to date, *complexity* or chaos theory. Early in his career von Bertalanffy realised that the prevailing approaches in Biology did not examine the organisms being studied *holistically* as systems, something which was beginning to be considered by a number of other researchers independently. Encouraged by his work on metabolism and growth in organisms comined with the increasingly apparent need for a GST von Bertalanffy originated a novel theory of open systems based upon observations of organisms. Subsequently von Bertalanffy further generalised his theories into the realm of behavioural and social sciences to discover *isomorphic* mathematical models, stating:

“problems of order, organization, wholeness, teleology, etc., appeared central which were programatically excluded in mechanistic science.” [4]

Although, as stated, Systems Theory can be applied to many domains EfSD is currently of interest. To this end, Systems Theory applied to Education shall first be examined in the light of two recent examples.

5. Liber’s application of Beer’s ‘Viable System Model’.

Liber [5] applies Stafford Beer’s (1926-2002) Viable System Model (VSM) to Educational management problems. The central notion is that “organisations exist to manage complexity (or variety, to use the cybernetic term)” [5]. Thus a controller needs to match the complexity of the controlled by either amplifying it’s own complexity or attenuating the controlled system’s complexity. A further key idea of the VSM is one of fractal recursion in that one system contains any number of others such as the State containing Higher Education itself containing Institutions themselves containing Departments in turn containing courses, etc. Each recursive layer then has a management and operational element. Management consists of the three subsystems of operational management or control, intelligence and policy.
Control handles internal organisational operations whereas intelligence governs how an organisation adapts to changes in the environment. Policy then manages conflict resolution between these two aspects. Importantly, different recursive levels need to refrain from managing others although subsystems must have clear channels of communication to enable self-organisation. Liber uses this model to critique current UK educational systems in terms of a lack of rich inter-system communication channels and minimal autonomy at all levels causing education to fail to adapt to severe changes in its environment. Such manifestations include strict timetabling preventing student autonomy and institutional composition preventing rich inter-disciplinary communication channels. Thus, as well as pedagogical and technological change, new educational systems also require organisational change.

6. Law’s Model for ICT in Education.

Pelgrum and Law [6] propose ‘a systems model of leadership and change for ICT implementation in education’ (see Table 1). Their model operates on the three horizontal levels of ‘education system’, ‘school’ and ‘individual’. Education systems are supported by government, universities and professional organisations, schools are supported by parent associations, private sector and publicly funded organisations and individuals are supported by schools, voluntary agencies, community centres and public libraries. Vertically each level is divided into policies and strategies and implementation factors. Firstly, in terms of education systems policies could include those related to professional development, for instance, and implementation plans whereas implementation activities could include such curriculum and assessment factors as curriculum goals, content and methods and assessment goals and methods. Secondly, in terms of school level policies these could be determined by school governance and management whereas implementation factors could include the influence of physical and technological infrastructure, teaching and learning resources and even the teachers’ vision and expertise. Thirdly, in terms of individual implementation factors the school level implementation factors influence the learning outcomes via classrooms plus are influenced by other implementation factors such as social and economic background and personal characteristics. Finally, monitoring and evaluation allow implementation to influence policy and strategy on all three levels.

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<th>Table 1. Synopsis of ‘a systems model of leadership and change for ICT implementation in education’ (abridged) [6].</th>
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Law and Pelgrum then use this system model to discuss, for instance, the role of curriculum upon the success of ICT such as: ‘Learning about ICT’, ‘Learning with ICT’ and ‘Learning through ICT’ and the effects of these modes upon learning outcomes. Thus pedagogical philosophy, such as student-centred, has an effect upon policy and implementation strategies. Law and Pelgrum also posit ICT infrastructure as a further, perhaps more obvious, factor in the success of ICT in the classroom. Thus hardware, software and communications facilities are explored in the educational context. A further factor in the success of ICT in the classroom, according to Law and Pelgrum, is the issue of staff development and, importantly, the term ‘staff’ is taken quite broadly to mean teachers but also technical support staff, ICT coordinators and interestingly policy makers such as school principals, etc. The penultimate category of factors explored by Law and Pelgrum are those dealing with organisational change and leadership such as a move towards what they call ‘learning organisations’ for instance supporting Lifelong Learning. The final analysis category revolves around what Law and Pelgrum call ‘national educational policies and ICT implementation strategies’ which are, for instance, governmental initiatives to address some of the factors discussed above but which, importantly, vary depending upon national socio-economic conditions.

7. Background to EfSD.

EfSD aims to popularise notions of economic and social equity as well as responsible attitudes to the
environment at a global level. The notion is epitomised by Agenda 21 [7] proposed at the Earth Summit in Rio in 1992 and later reviewed at the Johannesburg World Summit on Sustainable Development in 2002 [8]. This has most recently been concretised in the Millennium Development Goals [9] as well as a number of other initiatives. ICT could increase access to EfSD (as well as lead more directly to development) if barriers, e.g. to access, can be overcome in particular in Developing Countries. In this respect initiatives such as the World Summit on Information Societies (WSIS, www.itu.int/wsis), InfoDev (www.infodev.org), Asia E-Learning Network (www.asia-elearning.org), etc. can play a role to help work towards overcoming the Digital Divide [10] yet these initiatives only address specific aspects of the issues. As mentioned, the hypothesis is that a more systemic, holistic approach is required to address all the issues concurrently.


For instance, in terms of EfSD individual curricula require recontextualisation so that they match the particular local sets of circumstances, e.g. there is little use in teaching coral reef conservation strategies based on a South Pacific context in Sub-Saharan Africa. However, a certain homogeneity is required in the overall EfSD goals so that, for instance, principles of EfSD are adhered to on a global level. Indeed, this apparent dichotomy is analogous to the cultural conflict seemingly arising in many nation states as they grapple with globalisation and can, furthermore be likened to isomorphic concepts such as top-down vs. bottom-up or universalism vs. relativism [11]. In this way systems thinking would teach us that local contexts should be given autonomy in their recontextualisation efforts yet some overall ‘global’ direction could be maintained at a higher fractal level as long as rich communication channels are present between levels and strict protocols are adhered to thus preventing one system inappropriately interfering with another. This also has implications for differing modes of e-learning deployment which can be witnessed today. The differentiation proposed in this research project is that a ‘global’ model is centralised then delivered in multiple countries whereas a ‘local’ model is not centralised, is more context-specific yet lacks the advantages of a carefully managed central ‘vision’.

To this end various institutions have roles to play. E.g., International Organisations such as the United Nations (www.un.org), the World Social Forum (www.forumsocialmundial.org.br), academic collectives such as the Unbuntu Alliance [12], multinationals like Microsoft (www.microsoft.com), charities and Non Governmental Organisations such as Christian Aid (www.christian-aid.org.uk) and Voluntary Services Overseas (www.vso.org) plus regional and municipal governments, individual universities, schools and, of course, students. Again, all these various systems will need to interact to manage the complexity but should not stifle the self-organisation, rather, encourage it.

9. Five Issues for ICT for EfSD.

In this light the following five touchstones have emerged from this and previous research [13] as being key to ensure the success of ICT-based Education, particularly in the special context of Developing Countries. Together they form the mainstay of issues to be examined as part of a current research program within the UNU which seeks to examine barriers to the success of e-learning.

1. Socio-cultural – what particular social, cultural and ‘political’ factors must be considered in the design, implementation and evaluation of e-learning?
2. Organisational – what organisational infrastructure is most appropriate to the success of e-learning and how can a current structure be adapted if necessary?
3. Pedagogical – what existing pedagogies are employed in the educational context and how can existing pedagogical approaches to e-learning be reconciled with other culture’s expectations?
4. Technological – what are the particular limiting (or indeed facilitating) technological factors which need to be considered in the design of e-learning which will allow successful deployment?
5. Economic – what kind of economic factors stand in the way of the implementation of e-learning particularly in Developing Countries?

Thus these five factors are helping to guide the categorisation of data derived from multiple studies of e-learning utilising several methodologies particularly in the context of Sustainable Development and particularly for Developing Countries. The hope then is that results from this research together with a Systems Theory perspective will help guide future policies on EfSD. The current intention then is that this ‘policy’ recommendation will take the form of a system model, in-keeping with those described above, but with a particular emphasis on the issues faced by Developing Countries and particularly in the context of EfSD.

It is too early to speculate on the research outcomes. However, to illustrate the methods Figure 1 shows the geographical distribution of participants in one Case Study who are taking part in a ‘global’ online course in ‘Pedagogy for Online Learning (POL)’, part of the Global Virtual University (GVU), an “online network university for sustainable development” (www.gvu.unu.edu). Data on this course is being gathered for later analysis then later will be triangulated with other Case Studies, Accounts of actors and an Historical Analysis of documents.

Figure 1. GVU POL participant geography. Key: number(s) identify participant(s).

Thus, by combining methodologies, the hope is to begin to address the five issues for ICT for EfSD, propose a system model and, importantly, identify future work.

10. Conclusions: Does Systems Thinking Offer Anything New to EfSD?

Systems thinking may offer a conceptual framework with which to approach EfSD and hence help speed up the process by alleviating the need for lengthy and costly negotiations and pilot studies by providing a rigorous and, importantly, well-studied process by which to proceed. Furthermore, if the Millennium Goals are to be achieved within a reasonable time scale (and there is already some evidence given current progress they may not [14]) a more rigorous approach than diplomacy alone is necessitated. However, no doubt systems approaches are not a panacea and intuitively such complex international systems as are present in the current context of EfSD require very careful analysis and, in turn, complex conceptualisations. However, true dialogue [15] which facilitates understanding of shared identities and cultures [16] cannot be underestimated. In fact, any method should be welcomed in the name of openness and the pressing global need to unite humanity in the face of impending future uncertainties. Surely, success is not the sole preserve of any one system, technological or otherwise.

11. References.