Jun 16th, 12:00 AM

Designers in complex problem solving: the contribution of Systems Thinking

John Darzentas
Department of Product and Systems Design Engineering, University of the Aegean, Ermoupolis, Syros, GR84100, Greece

Jenny Darzentas
Department of Product and Systems Design Engineering, University of the Aegean, Ermoupolis, Syros, GR84100, Greece

Designers in complex problem solving: the contribution of Systems Thinking

John Darzentas, Department of Product and Systems Design Engineering, University of the Aegean, Ermoupolis, Syros, GR84100, Greece

Jenny Darzentas, Department of Product and Systems Design Engineering, University of the Aegean, Ermoupolis, Syros, GR84100, Greece

Abstract

This paper, attempts to provide a useful perspective of Systems Thinking's contribution to Design's theoretical grounding for both research and education. 'Useful' in the sense that it will equip design students and graduate professionals with a supportive and productive way of thinking about Design. This is viewed against the trend of more and more multidisciplinary design problems emerging where designers are asked to deal with the complexity which is inherent in such problems. Thus this discourse is also framed in understandings of interdisciplinarity and further, transdisciplinarity, to attempt to gain some traction on these heterogeneous domains.

Such domains are subject to many attempts to provide them with a theoretical framework. In this paper, it is suggested that Systems Thinking can contribute considerably to such a framework. The world of Systems Thinking is not new to Design, but against the new scenarios of increasing complexity, it is in a stronger position to demonstrate its potential for Design. This paper will posit the enhancements to both the designer's way of thinking as well as the 'design tools' that Systems Thinking could provide.

Hence, the paper's main emphasis is on how and why the designer profile could be positively influenced by Systems Thinking.

Keywords

Design Theory; Design Education; Systems Thinking; Interdisciplinarity; Transdisciplinarity

Introduction

The recent debates centred around Design Thinking (Jonas, 2011; Razzouk & Shute 2012) have been in part provoked as a response to the changing nature of problems that Design is called upon to assist with, such as questions of services, or sustainability. In addition, Design is deploying its existing methodologies and tools in areas that were previously closed to it, such as innovation management and strategy in businesses (Dunne & Martin, 2006; Martin, 2009).

A common feature of these new types of problems is their complexity. To deal with the challenges of complex problem situations, new or revised theories and methods are needed. Thus, as we have seen with Design Thinking, the concern with, and the actual search for, the theoretical identity of various evolving knowledge domains is becoming more and more noticeable. That identity either emerges as a need to ground new practices, or from the need to be able to refer to theoretical frameworks to accommodate evolving groupings of disciplines, such as in Service science. These emerging practices and disciplines are often difficult to identify and define. For instance, Service Science calls

for ways to deal with the “complexity of modelling people, their knowledge, their activities and their intentions” p8 (Maglio, Srinivasan, Kreulen, & Spohrer, 2006)

There are, of course, those disciplines which traditionally existed under the term of ‘multidisciplinary’ (usually engineering departments); those that appeared in the middle of the last century (e.g. Operational Research); and finally the ever increasing numbers of newly emerged disciplines with multifaceted identities and varying characteristics (such as Cognitive Systems Engineering, Human Computer Interaction, User Experience Design, Service Science, etc.) that are variously labelled as ‘multidisciplinary’ or ‘interdisciplinary’, although “transdisciplinary”, in many cases, is also a justifiable characterisation (Klein, 2004).

A common characteristic of these knowledge domains is their human-centric character and, as a consequence, their ill-structured nature which exacerbates the difficulty to provide a robust, commonly accepted, definition. This has been well understood for some time. Design as a discipline has all these characteristics and it is well documented that it is a prime example of a human centric domain which is exceedingly rich and complex, challenging continuously, as it evolves, the research and education world and naturally defying definition as evidenced by many design thinkers and researchers (Findelli, 2001; Love, 2002; Buchanan, 2004; Venable 2006; Jonas, 2007; Eckert et al. 2010; Burnette 2011; Galle, 2011).

When constructing an undergraduate curriculum on design, or attempting to equip practitioners with tools of thinking and praxis, one comes up against a natural mix and perhaps confusion of notions, concepts and general labels. Models are called theory (ies); theoretical frameworks are called models; praxis, methods and methodologies are lumped under design thinking, etc. That as an observation is not necessarily a bad thing, because it is an indication that the Design recognizes and welcomes complexity and multi, inter, or even transdisciplinarity. This makes design properly challenging, and leaves a great deal of latitude and degrees of freedom.

For designers, however, there needs to be continual adaptation of theoretical frameworks for renewed commitment and grounding. A practical question is what is required from the designer profile to be able to accommodate and deal with increasing levels of complexity. It is this question that we seek to examine and understand here. The paper attempts to identify and understand the need for a theoretical commitment for Design given the increasing levels of complexity it is called upon to deal with. It supports the hypothesis that a theoretical view of Design driven by Systems Thinking contributes towards a useful grounding for both Design itself as well as applications of design. More importantly, it puts forward the hypothesis that structuring the profile of designers with the aid of Systems Thinking improves the design praxis in terms of problem understanding as well as the appropriateness and robustness of the outcomes of the design praxis.

This paper is organised as follows: the next section gives some background on the new demands that are being placed upon design and briefly introduces Systems Thinking. Then the following section describes and attempts to justify why the designer profile is positively influenced by Systems Thinking. Further it speculates on using notions and concepts from Systems Thinking, showing how they can go towards shaping theoretical frameworks for contemporary design challenges. The last section presents discussion and conclusions

Background

More than a quarter of a century ago, there was a definite change towards organising and structuring the domain of human-centric design by offering frameworks to designers

through methods and methodologies to approach design problems (Archer, 1979; Jones, 1970; Cross, Dorst & Roozenburg,1992). These were mainly to do with formalising the various stages of the design life cycle, and supporting that endeavour mostly through philosophical argument. This change, started by a number of researchers [see Bayarzit, 2004 for an overview] began a tide which continues to increase, as the need matures for the establishment of theoretical backgrounds and identity of design. It is very timely that such a challenging, and definitely extremely influential domain as design is thus considered more and more as generic domain. In other words, philosophical arguments, methods, methodologies, and techniques, imported from other well established interdisciplinary areas such as structured Systems and Operational Research, etc. pioneered by people like Herbert Simon (1969), seem to have gradually expanded and developed further and become 'of the design world'.

It has to be mentioned here that traditionally, engineering design, stemming as it does from the less complex, not necessarily human centric engineering world, was well founded and continues to be staunchly supported by the engineering research community (Dym, 2005). By contrast, in the domain of human centric design, the needs for grounding are somehow very different. It must be acknowledged that in many cases there is a considerable overlap, and that a useful index of that, is the level of acknowledged problem complexity, and the permitted use of multi/trans-disciplinarity. Norman (2010) recognises that complexity is not to be simplified, and notes "The real problem is that we truly need to have complexity in our lives. We seek rich, satisfying lives, and richness goes along with complexity" (p10).

At the same time, the emergence of the notion of 'transdisciplinarity' is gaining substance. As long ago as the early 1970s, the OECD (1972) noted that specialist and reductionist tendencies in education at Universities were in need of counter balancing. Currently, according to Klein (2004), there are two main traditions of transdiciplinarity. Building on the vision of Piaget, Nicolescu's 1996 "Manifesto of Transdisciplinarity" and his essay ''New Vision of the World'' does not attempt a new discipline or superdiscipline. Rather, Nicolescu calls transdisciplinarity "the science and art of discovering bridges between different areas of knowledge and different beings. The principal task is elaboration of a new language, logic, and concepts to permit genuine dialogue".

The other tradition of Transdisciplinarity thinking is strongly related to research and problem solving and dates from around 2000. It highlights the convergence of transdisciplinarity, complexity, and trans-sectorality in a unique set of problems that do not emanate from within science alone. It recognises that the problems of society are increasingly complex and interdependent. Hence, they are not isolated to particular sectors or disciplines, and they are not predictable. In fact, they are "emergent phenomena with non-linear dynamics, uncertainties, and high political stakes in decision making, centred in complex heterogenous domains" (Bruce, 2004). These domains are those where there is interaction of humans with natural systems, such as the environment and of human involvement with technological developments such as nuclear power. It has also proved effective in fields where social, technical, and economic developments interact with elements of value and culture, including aging, energy, health care, nutrition. The multidimensionality of each of these subjects is now recognised. In the past "they were structured in terms of disciplinary and sectoral boundaries, however transdisciplinary approaches have exposed the limits of segmented thinking and problem solving." (Klein, 2004).

Faced with this state of affairs, we observe changes in design praxis. Design praxis follows, but also influences, changes in Design. For example, in traditional industrial design, it can be said that the designer and the manufacturer did collaborate in as much as they each performed a part of a process, with one carrying out design work and the

other accepting or not the resultant designs. Nowadays, it is clear that in activities like service design the nature of the design work is highly interactive. The designer plays the role of a facilitator in co-designing between stakeholders (Vargo, Maglio, & Akaka 2008; Vosinakis, Koutsabasis, Stavrakis, Viorres, & Darzentas, 2008). The service thus designed and produced is enriched by incorporating results from the involvement of the various stakeholders who are collaborating to co-produce the outcome. In addition, currently, the designing of a product may encompass much more than the artefact. It may include related aspects such as its packaging and the way it will be distributed, which reach back to influence the artefact at the heart of the design effort. It is also not uncommon that these aspects become more important than the artefact in terms of influence. In this way the usability of a product, becomes more important that the product itself. This is because it is touching on the dynamics of the interaction between the user and the product.

Systems as an approach appeared more than half a century ago, in response to the failure of mechanistic thinking and vitalism to explain biological phenomena. A ‘System' is a complex and highly interconnected network of parts, which exhibit synergistic properties, where the whole exceeds the sum of its parts. Systems is a typical paradigm of an interdisciplinary domain, which in its trajectory through time and applications, has amalgamated other domains such as ‘Biology’, ‘Information Theory’, ‘Management’, ‘General Systems Theory’, ‘Cybernetics’ amongst others.

Systems Thinking requires shifts from traditional classical decomposition or reductionist ways of doing things. It looks at relationships (rather than unrelated objects), at connectedness, at process (rather than structure), at the whole (rather than just its parts), the patterns (rather than the contents) of a system, and context. It offers a perspective which provides tools for understanding relationships between things and does not look for a single answer to a problem within the confines of a single discipline (Moore & Kearsly, 1996/2005, Cameron & Mengler, 2009). While understanding the whole involves understanding the parts, it also requires an examination of the inter-relations between the parts. In this way, they present emergent properties, which cannot be deduced from their component parts

A further important part of Systems Thinking is the understanding that living organisms are considered as closed systems in terms of their organisation, while at the same time, in terms of their energy, they are open systems, with incoming and outgoing energy and matter. That is, they are not "idle" or "immobilized" in the immediate surroundings, and are studied as a total entity.

Several groups of Design Researchers have shown interest in bringing Systems Thinking to bear on their research, teaching and practice. (Jonas, 2007; Valtonen, 2010; Sevaldson, 2011). Some of this work is more related to organizational design, including complex problem formulation and systems redesign (Pourdehnad et al, 2011; Nelson & Stolterman, 2002). Others working in the area of sustainable design and the need for ‘whole system design’ have found Systems Thinking approaches correspond to their needs (Charnley and Lemon, 2011). “Systems” has been used in Engineering and Engineering Design for many decades. However the real power of Systems Thinking is in dealing with the high complexity of ill-structured problems. Those are traditionally the human centric ones. This did not go unnoticed by the design community: Buchanan, in his 1992 paper, ‘Wicked Problems in Design Thinking’ was using Design to address intractable human centred concerns.

The Systems Thinking influenced Designer

Systems Thinking has currently evolved into a term which encapsulates the way of thinking about Systems as a ‘holon’ which contains the problem understanding and description of situation of concern. In the position presented here, the knowledge profile of a Designer is assumed to be nurtured by Systems Thinking. As a result, Designers will be thinking about their problem spaces (design problem) holistically.

A product / system designed using Systems Thinking, will have to carry with it from the outset as many aspects, notions and ideas, and the relations amongst them, as can be identified and studied. As an example, in the life cycle of the design of a mobile phone, apart from the knowledge about the materials, ergonomics, hardware, software, human computer interaction etc. the design praxis should include every relevant subsystem of the product’s environment: that includes its packaging, market characteristics, target users (and includes notions of usability, accessibility, respect for cultural paradigms, learnability) etc.

Although this attitude could be expected to be in the thinking tool bag of almost every designer, it has not been the case so far. Decomposing the problem space and reductionism remains the dominant way of thinking, which is understandable since it has been used and has sustained the industrial and technology driven world we live in. However specialists increasingly understand the necessity for the separate disciplines to ‘talk’ to each other, as the complexity of contemporary problems grow. For designers, working with human centric problems, there are benefits to adopting holistic approaches.

Designers do know that the wider their spectrum in examining a design problem the more they will gain in the robustness of their solutions. Time and resources constrain them, however, and direct their efforts to the inevitable reductionism.

What designers should know is that reductionism can lead to serious omissions and mistakes. Reductionism might seem the right thing to do, simply because it feels more natural to design and build parts of an artifact or a system which may have to exist before others, however, with this approach, very important properties of the holon which is being designed, will not present themselves. That is mainly because, as was already mentioned above, parts of a system (the subsystems) cannot identify and reveal properties of the system unless they themselves are considered and recognised as parts of It and have the interrelationships to each other acknowledged.

A Systems Thinking trained designer would consider the design problem as a system knowing that viewing the holon he will ‘see’ a lot more about it than the sum of its parts will ever reveal. This is known as the ‘emerging properties’ which are identified and emerge when subsystems are considered together. The more the subsystems whose associations and interrelationships are looked at together, the more the emerging properties which show themselves as being relevant and important.

Also, Systems Thinking designers welcome and utilize the complexity of their design problem description, being aware that this complexity, if recognizable and describable, offers richness to the description. A design problem that considered as a system is characterized by various levels (or degrees) of complexity, where the interrelationships of the parts it consists of defy analysis. Forcing a de-composition of the problem into sub problems to be tackled separately will inevitably mask properties of whole, since we do not possess or propose a method for piecing it out and keeping all the properties.

Since complexity is now accepted as expected feature that characterises most design praxis, where much design is concerned with human activity systems that involve complex webs of human centric problems that require to be understood and solved. Thus Design

cannot ignore complexity, but should actively seek complexity in its grounding and application. Complexity should be understood as enriching the process of design and leading it to consider larger variety in its definition and its understanding of the problem space.

The designing of a new mobile phone; a self-service terminal; a simplified application form in the context of Information Design; a service design in an accident and emergency department of a regional hospital, and so many others, have been dealt and are being dealt very often almost on a daily basis. What brings them as examples here is that they can be used to demonstrate the importance of the claims made above. For instance a mobile phone is expected to be attractive, useful, accessible, affordable or wanted by the users irrespective of the cost for various reasons, for example its innovative features. If, despite its complexity as a product / system, designers understand, define, and design its components separately without "talking" to each other; i.e. the software developers make sure that whatever is in the phone can be expressed in some way so it can be utilized, but have not worked with the interaction designers to make sure that all required functionality is there. As a result, the emergent properties of those subsystems which should have been considered together will not be recognized and answered to. The same applies to considerations such as the ergonomics and materials used, or the shape and size, marketing, packaging, and image of the user, and so on. The above is also a useful example to demonstrate that the service part of the holon to be designed is the real complex problem and determines the success or failure of the artefact. If that artefact is designed with reductionism adopted as the driving force, then it will probably be foreign to the service it is supposed to offer.

It must be said again, that experienced and talented designers will have methods, methodologies, and experience in their 'toolbox' to deal with most of those issues when doing design. The argument here is that there should be grounding knowledge which provides methodologies with methods and techniques, and way of thinking which give in the 'toolbox' the power to conduct and direct groups of designers in their praxis towards design solutions from the beginning.

Staying with the notion of complexity, it is also interesting here to introduce the concept of variety from Cybernetics. In Cybernetics, variety it has been introduced to measure the potential of a system to defend itself against external threats or interference in a sense that only variety controls or defeats variety. Designers with the profile stated here will accommodate and utilize complexity and variety in their praxis, as an example in a way similar to what follows. Complexity will be welcome because of the richness it offers and there is the understanding that the more complex a system appears to be the 'healthier' it is, because if studied properly, it can be seen that it offers more ways to deal with problems than a less complex one. We could also add that complexity, if appropriately accommodated, promotes simplicity, that is, complexity is not the opposite of simplicity, and to that extent it supports the "simpler" use of a product.

A further example might be in the case of the design of self-services. Systems Thinking designers will possess the knowledge to add in to their methods the determining of the variety of demands, i.e. the types of different service demands. In other words they are aware of the usefulness of knowing the different ways users will demand service. That way, the designers will know the variety of services that should be provided and of course what the self-service terminals such as ATMs should be able to deal with. The notion of requisite variety for dealing with the demand, will lead the designers to those stakeholders involved in the relevant subsystems (e.g. Service Design) for dealing with potential problems, for example of accessibility (Darzentas & Darzentas, 2013).

Designing an office interior will include the design of workstations, which could be seen as a task of designing for a typical member of staff to be operational as possible and accommodating all he needs for performing his assigned duties. Given the type of work, the space available, regulations, the location of working places will also be high in the agenda. However the design of a workstation for one person might not “bring up” some emerging properties which will make the end result successful. That is, since in the office there will be more than one member of staff, the design should be able to accommodate “conversation” and “collaboration”. That need may considerably change the understanding of the workstation requirement. Also knowledge about the “requisite variety” will aid the designer to address accessibility issues in the station itself as well as in the location/ allocation of these stations in the office, so they can be used by people with special needs. Such needs can radically change all of the thinking about the design and layout of the workstations.

The example illustrates the importance of examining the whole problem/system from the beginning. The emerging properties when seen during the understanding of the problem they seem obvious, however it is fairly easy to miss them when the relevant subsystem is not considered.

Summing up, the main aim of the introduction of Systems Thinking as a Design Thinking support is to nurture the profile of designers with it in order to provide them with a very valuable and useful way to deal with the human centric problems they face. These designers can also be taught about and practice Systems Thinking methodologies such Soft Systems Methodologies (SSM) (Checkland, 2000), Critical Systems (Flood & Jackson, 1991) etc. However, this paper is not yet suggesting ways to teach designers, it is presenting and attempting to justify the belief that Systems Thinking can aid the grounding of the domain of design very usefully by providing a theoretical framework which in turn can support designers and their way of thinking towards human centric problems.

In the discussion and theses above about the domain of Systems Thinking and its application to Design, a number of notions and concepts have been mentioned. They are important and they stem out of their multi-inter-trans disciplinary world. They are not though the only ones which can be very relevant and useful to Design Thinking and praxis, but they are representative of the nature of Systems Thinking for the purpose of the paper. These are:

- Complexity (the nature of which has so far led to attempts for reductionism)
- Emergent properties
- Variety (requisite variety)
- Self-reference

As far as the notion of self-reference is concerned, briefly this refers to the fact that designers should be expected to know and feel that their “self-reference” as far the design problem they are facing exists and influences the design and should be managed. This can be achieved partly through co-design which naturally acknowledges also the “self-reference” of the stakeholders, in order to work towards a robust solution.

A final example which can be used to demonstrate the role and usefulness of some of the above notions in a design problem is the design of the packaging of medicine and the corresponding instructions. This can be seen as including an information design problem where the instructions as far as their content, form and positioning have to be designed. If this packaging problem is considered as a system and the designers involved resist reductionism then the design problem will, in its rich Systemic view include all possible subsystems such the type of medicine (including the degree of danger if used wrongly).

This will lead to more appropriate definitions of the user groups (patients, carers, doctors, pharmacists, manufacturers, etc.) and in turn will identify emerging needs of use. For instance in the case of blood pressure pills that will emphasise aspects like the ergonomics of the container, the size of lettering, a “complex” way of describing the use by which is mean a model of information with an appropriate variety of ways to offer the necessary explanations. We must not forget that here complexity is not the opposite of simplicity, but they should work together in making life better by offering a rich adaptable guidance for as many types of users as possible.

Conclusions

Our main thesis is that Complexity is recognised in Design and should be welcomed, and that together with a number of aspects of Systems Thinking enhances the chances of design praxis to succeed in producing a robust design solutions, and characterises and enforces the profile of Designer in a positive way.

One might comment that the above begs the question as to why does one need new theories to proceed, in such an obviously successful and leading domain as design, which has evolved into a prominent leader amongst the newly and powerfully evolving multi / inter / trans disciplinary domains. The answer might be a simple one, that is because of the apparently very important role design is playing in that evolving world, and that it seems to be a naturally mature hyper-domain able to accommodate and direct most of them. Also because that maturity requires new leads and ways of thinking, through which to evolve, understand, and solve a wider range of problems.

A theoretical identity supporting a domain could be a very important aspect of this evolution, it could also be absolutely necessary for its survival. However it could also be very damaging hence one must in most cases, introduce statements such as “lack of owned theory” which could be a conscious decision or evolution. Here, very briefly, it is stated that there is a generic domain, that of Systems Thinking, which can accommodate theoretical needs of design, and complement others such as engineering, in supporting designers to design. A main assumption made here is that design is human centric, assuming that engineering is well founded. It is argued that Systems Thinking helps to understand the problem in hand and to analyse it maintaining a very high level of complexity.

Decorating the living room of a blind person, might sound provocative. One might also get the answer that it is a problem like any other and the designer’s ‘toolbox’ contains tools to deal with it. Of course it does, the thesis here though is that another theoretical framework might be useful in understanding, and ordering / optimising the actions, and of course do what theories help one to do: to provoke, to explain, to define, to ‘predict’. In the case of the decoration problem, it could translate to knowing that, for example, increasing the requisite variety should be a high priority because probably autonomy will be very important to the problem owner.

REFERENCES

Archer, B. (1979) Design as a discipline *Design Studies* 1(1) 7-20

Bayazit, N. (2004) Investigating Design: A Review of Forty Years of Design Research *Design Issues*, Vol. 20, No 1, pp.16-30

Bofylatos, S. Spyrou, T., Georgiadou, A., Darzentas,J S, & Darzentas, J.(2013) Designing an intensive programme based on service design and design for sustainability, submitted to DRS14

Bruce, A., Lyall, C., Tait, J. and Williams, R. (2004) Interdisciplinary integration in Europe: the case of the Fifth Framework programme, Futures, 36: 4, pp. 457-470.

Buchanan, Richard, (1992) Wicked Problems in Design Thinking, *Design Issues*, vol. 8, no. 2, pp. 5-21

Buchanan, R. (2004) Human-centered Design: Changing Perspective on Design Education in the East and West. *Design Issues*, Vol. 20, No 1 pp. 30-39

Burnette, C. (2011, Feb 17) Theoretical Issues for Design Thinking retrieved 12 October 2013
http://independent.academia.edu/CharlesBurnette/Papers/432385/Theoretical_Issues_for_Design_Thinking

Cameron, F. & Mengler, S. (2009) Complexity, Transdisciplinarity and Museum Collections Documentation, *Journal of Material Culture* 14(2) 189-218

Charnley, F. & Lemon, M. (2011) Exploring the process of whole system design, *Design Studies*, vol. 32, pp156-179

Checkland, P. (2000) Soft Systems Methodology: A Thirty Year Retrospective, *Systems Research* 17, 11-58

Cross, N. Dorst, K. & Roozenburg, N. (1992) *Research in Design Thinking*, Delft University Press

Darzentas, J. & Darzentas, J.S. (2013) On the role of systems thinking in design and its application to public self services, *Working Paper in RSD2*, AHO, Norway.

Dunne, D. & Martin, R.(2006) Design Thinking and How It Will Change Management Education: An Interview and Discussion *Academy of Management Learning and Education* 5(4) 512-523

Dym, C.; Agogino, A.; Eris, O.; Frey, D.; & Leifer, L., (2005) Engineering Design Thinking, Teaching, and Learning *Mechanical Engineering* Paper 22 retrieved 12 October 2012 http://digitalcommons.olin.edu/mech_eng_pub/22

Eckert, C.M., Blackwell, A.F., Bucciarelli, L.L. & Earl, C.F. (2010) Shared Conversations Across Design *Design Issues* 26, No 3, pp. 27-39

Findeli, A. (2001) Rethinking Design Education for the 21st Century: Theoretical, Methodological and Ethical Discussion *Design Issues* (Vol. 17, no1, pp. 5-17)

Flood, R.L., Jackson M.C. (1991) *Creative problem solving: Total systems intervention*, Wiley

Friedman, K. (2003) Theory Construction in design research: criteria, approaches, and methods *Design Studies*, 24, pp.507-522

Galle, P. (2011) Foundational and Instrumental Design Theory, *Design Is*sues, Vol. 27, No 4 pp 81-94

Jonas, W. (2007) Research through DESIGN through research: A cybernetic model of designing design foundations, *Kybernetes*, Vol. 36, No 9/10, pp.1362-1380

Jonas, W. (2011) A Sense of Vertigo, Design Thinking as General Problem Solver in Proceedings of Endless End, *Proceedings 9th European Academy of Design International Conference (EAD09) retrieved 13 October 2012* at http://www.transportation-design.org/cms/upload/DOWNLOADS/EAD09.Jonas.pdf

Jones, J.C. *Design Methods, the seeds of human futures*, John Wiley & Sons

Klein, J.T. (2004) Prospects for transdisciplinarity *Futures* 36, pp. 515–526

Love, T. (2002) Constructing a coherent cross-disciplinary body of theory about designing and designs: some philosophical issues *Design Studies* 23 pp.345-361

Maglio, P.P.; Srinivasan,S.; Kreulen, J.T.; Spohrer, J. (2006) Service systems, service scientists, SSME, and innovation *Communications of the ACM*, July 2006 49(7) 81-85

Martin, R. (2009) *The Design of Business: Why Design Thinking is the Next Competitive Advantage*, Harvard Business School Publishing

Moore, M.G., & Kearsley, G. (1996/2005). *Distance education: A systems view*. Thomson/Wadsworth.

Nelson, H.G. & Stolterman, E. (2002). *The Design Way: Intentional Change in an Unpredictable World : Foundations and Fundamentals of Design Competence*. Educational Technology Publications

Nicolescu, B. *Manifesto of Transdisciplinarity*, State University of New York (SUNY) Press, New York, 2002, (transl byVoss, K.-C.)

Nicolescu, B (Ed.) (2008) *Transdisciplinarity – Theory and Practice*, Hampton Press

OECD (1972) *Interdisciplinarity: Problems of Teaching and Research in Universities*. OECD, Paris,

Razzouk, R. Shute, V. (2012) What Is Design Thinking and Why Is It Important? *Review of Educational Research* 82 (3) 330-348

Sevaldson, B. (2010) GIGA-Mapping: Visualisation for complexity and systems thinking in design in Proceeding of Nordic Design Research Conferences Making Design Matter retrieved 13 October 2013 http://ocs.sfu.ca/nordes/index.php/nordes/2011/paper/view/409

Simon, H. (1969) *The Sciences of the Artificial* MIT Press,

Valtonen, A. (2010) Is systemic design the next big thing for the design profession? *Proceedings of Design Research Society Conference 2010* retrieved 13 October http://www.designresearchsociety.org/docs-procs/DRS2010/PDF/121.pdf

Vargo,S.L. Maglio, P.P. & Akaka, M.A (2008) On value and value co-creation: A service systems and service logic perspective. *European Management Journal* 26(3) 145-152

Venable, J.R. (2006) The Role of Theory and Theorising in Design Science Research Chatterjee, S.& Hevner, A (Eds) *Proceedings of Conference on Design Science Research in Information Systems and Technology (DESRIST*) Claremont Graduate University, 2006.

Vosinakis, S. Koutsabasis, P. Stavrakis, M, Viorres, N. & Darzentas, J. (2008) Virtual Environments for Collaborative Design: Requirements and Guidelines from a Social Action Perspective *CoDesign: International Journal of CoCreation in Design and the Arts*, Taylor and Francis, Vol. 4 No. 3, pp. 133-150

John Darzentas:

Professor John Darzentas (BSc Athens, MSc Sussex, UK, PhD, London, UK) is Head of the Department of Product and Systems Design Engineering (www.syros.aegean.gr) of the University of the Aegean (www.aegean.gr).

He has held academic faculty positions in universities in the UK and in Greece, and departmental headships, including Docent at the Abo Akademi, Turku, Finland, visiting Professor in the Department of Economics, University of Athens, and others.

His research interests are wide ranging and include Systems Thinking and Systems Design; Service Design; Information Systems Design; Intelligent Systems and Decision Support Systems; Human Computer Interaction; Design for All; Learning Systems and Technologies, and issues of Multi-Inter-Trans-Disciplinarity.

He is on the editorial board of a number of journals and has authored many papers published in books, journals and conference proceedings. He has served as Scientific Lead in many research programmes, funded both at national and European level. He is invited expert / member of IFIP TC13 (International Federation of Information Processing Technical Committee 13) on HCI.

A fuller Curriculum Vitae is available at http://www.syros.aegean.gr/users/idarz/cv_en.pdf

Jenny S. Darzentas

Dr Jenny S. Darzentas (BA, London, UK, PhD, City University, UK) works in the Department of Product and Systems Design Engineering (www.syros.aegean.gr of the University of the Aegean (www.syros.aegean.gr and lectures on Design for All; Information Design; Interaction Design Communication Theory, Organisational Theory, Behaviour and Service Design.

Her publications cover topics in Design and HCI (Human Computer Interaction), such as user needs for information; accessibility practices and policies; and educational requirements for Design for All. In addition, she has worked on many national and European funded projects, on library and archival programmes; online learning; on issues of accessibility; on personal profiles/device profiles aiming at seamless interactions, and has published on these subjects.

Her current research interests focus on the questions about self service and accessibility, and the contributions of frameworks and methodologies from Systems Thinking to Service Design and its accessibility and to Information Design. A fuller Curriculum Vitae is available at http://www.syros.aegean.gr/users/jennyd/cv_en.pdf