PUBLISHED VERSION

Ockie Bosch, Nam Nguyen, Tuan Minh Ha
Can Advancements in Economic and Managerial Practice be achieved without Systems Thinking Education as the Foundation?
Business Systems Review, 2014; 3(2):33-53

www.business-systems-review.org

Business Systems Review

ISSN: 2280-3866
Volume 3 – Issue 2, 2014
Special Issue - Selected papers of the
2nd B.S.Lab International Symposium

Can Advancements in Economic and Managerial Practice be achieved without Systems Thinking Education as the Foundation?

Ockie Bosch
D.Sc./Professor, Systems Design and Complexity Management,
University of Adelaide Business School, Adelaide, Australia.
e-mail: ockie.bosch@adelaide.edu.au. Corresponding author

Nam Nguyen
Ph.D./Research Fellow, Systems Design and Complexity Management
University of Adelaide Business School, Adelaide, Australia.
e-mail: nam.nguyen@adelaide.edu.au

Tuan Minh Ha
Ph.D. Candidate, Systems Design and Complexity Management
University of Adelaide Business School, Adelaide, Australia.
e-mail: tuan.ha@adelaide.edu.au

Submitted: March 1, 2014- Published: August, 12, 2014
DOI: 10.7350/BSR.D07.2014 – URL: http://dx.medra.org/10.7350/BSR.D07.2014

ABSTRACT

Complex economic and managerial problems cannot be solved anymore with traditional single discipline and linear thinking mindsets. Employers will therefore increasingly require their employees to have the capacity to redesign in systems and sustainability terms. In other words, there is an increasing demand for society to move away from linear thinking that often leads to "quick fixes" that do not last, to a new way of thinking that is systems-based. Understanding the principles of interconnectedness, feedback and leverage points in systems and appreciating the value of cross-sectoral/disciplinary communication and collaboration are the only ways in which society will be able to find long lasting, sustainable solutions to the many problems we are facing. Developing such an understanding in order to address complex economic and managerial challenges, requires a strong level of awareness of the value of knowledge on systems approaches and tools that will increase the demand for systems education.
However, it is evident in many institutions worldwide that the establishment of systems education is a highly complex task. The Evolutionary Learning Laboratory (ELLab) for dealing with complex issues was therefore used to establish an ELLab for systems education in the Adelaide

University Business School. This caused a revolution regarding the integration of systems concepts into discipline specific courses and the development of standalone core systems courses that will help to instill those graduate attributes that industry wants. The ELLab consists of seven steps, starting with the gathering and integration of the mental models of all stakeholders (academics, industry and government departments), followed by capacity building of lecturers, participatory processes to identify graduate attributes and course contents, course offerings (implementation) and a reflection (through questionnaires, analysis and discussion) on the degree to which these graduate attributes are being achieved. The reflection step of the first round in 2013 of the cyclic process of implementation, reflection and adapting the course contents or modes of delivery, has revealed that students have shifted their way of thinking significantly from limited understanding and linear thinking to more coherent and interconnected thinking. During the pre-learning phase one third of the students were inclined to jump to the solution (i.e. treating the symptoms and "quick fixes"). After completing the course nearly 60 percent of the students mentioned the use of their knowledge on systems-based approaches, highlighting the system component interactions, unintended consequences, leverage points and systemic interventions. There was a clear improvement of the knowledge on interconnected thinking and how to deal with complexity and a change in their attitude towards the course. Significant changes also occur in their skill levels (capability to use system tools) and their aspirations (willing- and eagerness to apply their learnings). Based on the survey results and analyses, it could be concluded that systems thinking education can be regarded as the leverage or systemic intervention for being able to take action towards the advancement of economic and managerial practices to improve knowledge, attitude, skills and aspirations. The vision is to link the Adelaide ELLab globally with other institutions that are involved with systems education.

***Keywords**:* Systems Thinking education; Evolutionary Learning Laboratory; Complex problems; New way of thinking; Systems in practice; Systems tools; Co-learning; Graduate attributes; New era MBA; Global Evolutionary Learning Laboratory (GELL); Cross-institutional collaboration; Problem solving; Root causes; Holistic approach; Multi-stakeholder involvement; Capacity for change.

1. INTRODUCTION

The question posed in the title of this paper probably has a quick and clear answer – "no". However, rectifying the situation requires a total change in the way society is thinking. Complex economic and managerial problems cannot be solved anymore with traditional single discipline and linear thinking mindsets. These problems are multi-dimensional and involve different disciplines and stakeholders with varying goals and aspirations. The problems facing our society today also have to be solved in an environment of high levels of uncertainty and risk. Add the lack of capacity of our social, political and economic constructs, it becomes almost an impossible task to rapidly redesign for the new world we are living in.

However, is it that easy to change the mindset of society towards a new way of thinking? This capacity to redesign, in systems and sustainability terms, will increasingly be what society and employers will require from new people entering the workforce – a "requirement" that has become one of the biggest challenges for education in this century. It is not sufficient anymore in today's complex society for graduates to only have a deep understanding of the disciplines they

study. They need to fully understand how their disciplines fit into societal and global systems in a century when humanity will meet ever more limits.

These issues create a significant pedagogical challenge in that current university education tends to be focused on discipline specific teaching which has no room for a wider systems approach. Didactic autonomous discipline based courses fail to foster a social networking culture of interactions between students in different disciplines. This has been proven to enhance the process of deep learning. We need innovative curriculum designs and learning environments that address academic paradigms as well as industry requirements.

One would think that the value of Systems Thinking in dealing with the complexities in this turbulent 21st Century would by now have been recognised; especially the fact that it offers a holistic and integrative way of appreciating all the major dimensions of a complex problem, and enables the formation of effective management strategies (systemic interventions) with long lasting outcomes. Furthermore, systems thinking is not a new concept. It is not easy to identify the precise beginning of the Systems Thinking field, as the beginning is a matter of perspective. For example, M'Pherson (1974) traces elements of Systems Thinking back to the work of Aristotle, while Midgley (2000, 2006) suggests that the field and study of systems began in the early 20th century with either Alexander Bogdanov (1913-1917) or Ludwig von Bertalanffy (1956, 1962). Systems thinking is also being applied for a long time. Several publications (Francois, 2004; Jackson, 2003; Midgley, 2003) offer a 'rich storehouse' of different systems approaches and inclusive sources about the Systems Thinking concepts. It is widely acknowledged in the literature that Checkland (1981, 1999) and Senge (1990, 2006) have proposed influential Systems Thinking approaches.

In spite of its extensive application, Systems Thinking has mostly been used and applied by systems scientists and some academics. The applications of Systems Thinking by policy makers, managers, practitioners, and ordinary people remain limited (Nguyen et al., 2012).

Bosch, Nguyen et al. (2013a) identified three major systems based approaches (leverages) to help current and create future managers and leaders to be equipped with new ways of thinking that are systems design-led to deal with complex problems in a systemic, integrated and collaborative fashion: 1) the establishment of Evolutionary Learning Laboratories (ELLabs) for dealing with complex issues; 2) "Starting with the Young" (systems education at school level) to create a "new way of thinking" in any society or organisation and 3) enhancing Systems Thinking education at tertiary level.

A recent paper provides a comprehensive description of the first systems based approach and its application in four case studies (Bosch et al., 2013a). The generic application of the ELLab approach has also been reported in several other publications (currently under review). A paper on "Starting with the Young" was presented at the 57th conference of the International Society for Systems Sciences (Nguyen & Bosch, 2013a), describing how gamification is being used at school level in various parts of the world to create an awareness of the importance of systems and interconnected thinking from a young age (second leverage). This paper elaborates on the third leverage point mentioned above, namely the enhancement of systems education at tertiary level as a prerequisite for the advancement of economic and managerial practice. The paper also indicates how the first systems-based approach (ELLabs) is being used as a mechanism for achieving the third.

2. CURRENT STATE OF SYSTEMS THINKING EDUCATION

2.1 Difficulties to introduce systems education

Herrscher (1995) has observed that proposals are often made to universities to include systems theory or thinking in the curriculum. In all cases, the university's President was highly in favour of the project, but when it came to implementation, he had to rely on one of his Faculty or Department Deans. However, this is where it became difficult. Deans are 'area oriented', i.e. there is no Dean in charge of 'overall wisdom' or 'general knowledge'. In most cases, the proposal already died at the first step, when deciding which 'specialised area' should handle this 'unspecialised' teaching and research (Herrscher, 1995).

Herrscher's observation was noted almost two decades ago. Unfortunately, things have not changed. Recently, the then President of the International Society for the Systems Sciences stated that: "… there are remarkably few institutions in systems science that have proven to be stable and robust enough to outlive their creators for long. Deans step in and dismantle what they do not understand, taking the money for their discipline-centred favourites" (Allen, 2009, p.3)

The difficulty to establish systems education is evident in many institutions worldwide. Examples in Australia include three very successful systems groups in three large Australian universities that have been 'disestablished' due to the 'silo' and 'discipline' oriented strategy of senior managers at those institutions.

The first group had achieved huge successes in the late 1980s and early 1990s in introducing Systems Thinking and practices in the education of agriculturalists (Bawden et al., 1984), systems programs (Bawden, 1991), and systems approaches to agricultural development (Bawden, 1992). Unfortunately, this innovative "systems agriculture paradigm" is barely alive today (Patterson, 2007). The second group (the Systemic and Action Research group) had also been very active and successful in the late 1990s and early 2000s. This group is now sharing the same fate with the first group.

A third group had done extremely well in the first decade of the 21st century through a school that was dedicated to systems learning, discovery and service (Bosch et al., 2007; e.g. Bosch et al., 2003; Nguyen & Bosch, 2013b; Nguyen et al., 2011; Nguyen et al., 2012; Smith et al., 2007). For example, one of its Systems Thinking courses commenced with 11 enrolments in 2009. The enrolments increased to 109 in 2010 and 151 in 2011. This course has been taken by students from all different Faculties, some of them as a compulsory course, but most (more than 80 percent) as an elective. Unfortunately, the school had been disestablished in 2011 and amalgamated with an agricultural school. As integrative systems are a generic discipline with applications in any area of interest, the agricultural "labelling" significantly jeopardised the vision and scope of activities of the systems scientists – a clear demonstration of (Herrscher, 1995))'s point on the difficulties involved in deciding "which 'specialised area' should handle this 'unspecialised' teaching and research".

2.2 Some examples of successful introduction of systems education

Even though it is not yet well recognised in the same way as other disciplines, there are currently various systems courses and programs being offered world-wide. In the USA, examples include various systems courses which have been offered at the Massachusetts Institute of Technology, the K-12 System Dynamics projects (Forrester, 2007a, 2007b), the ThinkBlocks program

(Cabrera, 2008), and various courses offered in-house or at different Universities. In the UK, various systems courses and program have been or currently being offered by the Open University, London School of Economics, Lancaster University, and by the Centre for Systems Studies at Hull University. There are also various systems courses and programs offered at Universities in countries such as Germany (Blokland & Schumacher, 1990; Klieme & Maichle, 1994), Austria (Brock & Janischewski, 2011), Japan (Kohtake et al., 2010; Takahashi & Takashi, 2011), China (Gu et al., 2002), Switzerland, Slovenia, and Italy.

In Australia, Systems Thinking is a core course in relatively few programs, mainly in business schools. Examples are the MBA program at the University of Adelaide Business School and the Queensland University of Technology Business School. There are also Systems Thinking courses offered at other Universities such as the University of South Australia, The University of Queensland and Monash University, but mostly as an elective.

Of particular importance is also the suggestions that Systems Thinking should be taught to children from an early age (Sweeney, 2001); Evagorou et al. (2009). Results from a study with middle school students (Assaraf & Orion, 2005) indicate that most of them encounter difficulties in all aspects of Systems Thinking, even in the very basic ones. According to Jacobson and Wilensky (2006), even university students tend to solve complex systems problems using simplistic arguments. It is suggested that skills for comprehending the structure and the visible aspects of the behaviour of a system are most easily acquired by young students (Hmelo-Silver & Pfeffer, 2004), and Systems Thinking skills are important in helping younger students understand many complex relationships that exist in the natural and social world (Maani & Maharraj, 2004). Evagorou et al. (2009) reviewed the work of many researchers and educators, highlighting the importance of elaborating Systems Thinking skills in the learning routine of specific scientific fields such as ecology, physics, and social sciences as a prerequisite for conceptual understanding of the topics taught (Hogan & Thomas, 2001; Klopfer & Resnick, 2003; Stieff & Wilensky, 2003; Wilensky & Reisman, 2006). However, Evagorou et al. (2009) claim that there are limited resources for teaching systemic thinking within science, especially for younger students. They also argue that learning about complex systems has proven difficult to improve under current educational settings. This argument is supported by many studies reported in the literature (National Research Council., 2000; Penner, 2000; Richmond, 2001; Sheehy et al., 2000).

2.3 Making progress

The International Federation for Systems Research (IFSR) has dedicated two of its recent biennial Conversations (Fuschl in 2008 and Pernegg in 2010) to the discussion of systems education. The 2008 IFSR Conversation provided valuable insights into the ways in which different systems concepts could be matched with different types of systems education for different types of students (Bosch et al., 2009). An outcome from this Conversation was the development of a Systems Education Matrix - a useful tool for educators charged with designing new university-level curricula that effectively integrate systems concepts and/or teach those concepts explicitly. A full description of this matrix is provided in a recent paper by (Bosch et al., 2013b).

The outcomes of the 2008 IFSR Conversation were followed-up during the 2010 IFSR Conversation with the development of frameworks and modules for introductory and advanced systems courses. The intended learning outcomes of an introductory and an advanced systems course are also summarized in the aforementioned publication (Bosch et al., 2013b).

3. EVOLUTIONARY LEARNING LABORATORY FOR SYSTEMS THINKING EDUCATION.

3.1 Establishing an ELLab for Systems education at the University of Adelaide, Australia

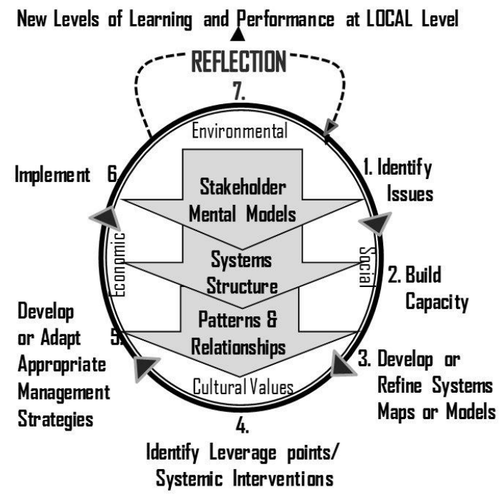
A revolution is taking place at the University of Adelaide's Business School in Australia regarding the integration of systems concepts into discipline specific courses. This revolution has been driven mainly by the need to:

- Educate students who can deal with the complexities of integrating environmental, social, economic and business components associated with the development of sustainable management systems and the creation of new era leadership. This demand for a systems-based focus on sustainability is very rapidly increasing in Australian society as well as globally, and there is thus a great need to provide educational platforms that bring together the concepts of sustainability, social responsibility and systems – in physical terms, social constructs (institutional, community) and using all the tools of our economic and legal worlds (business systems, economic instruments, regulation and pricing constructs). There is thus a clear need for systems scientists to deal with the complexities involved in such integration, as the knowledge and skills required cannot be obtained through some fragmented attempts to include concepts of Systems Thinking and sustainability in individual courses or the programs of a few university schools;
- Instil Systems Thinking attributes in graduates. Industry requires particular attributes from future graduates that will enable them to operate fully and effectively in our turbulent 21st century knowledge society. University Schools should play an active role in enhancing the educational experience of students by focusing on high quality programs and developing a high degree of work-readiness of graduates through incorporating courses that will enhance personal and professional skills. Systems approaches are important mechanisms to help achieve the attributes that industry wants from future graduates - for example, the ability to contextualize (Systems Thinking skills), to identify issues, develop strategies, managing projects (unravelling complexity and problem solving models), convey the message (communication), to build effective networks and work in teams (personal and collaborative skills), the ability to build resilience and being adaptable and socially responsible (dealing with change, complexity and impacts on the human dimensions of systems), and appreciate the need for lifelong learning (self-learning capability). These attributes can be instilled through developing a deeper knowledge of Systems Thinking approaches, without having to become a systems scientist.

The IFSR Conversations led to a major step forward towards introducing systems education worldwide into University systems. This task has been recognised as a highly complex problem and it was decided to use the generic Evolutionary Learning Laboratories (ELLab) process for dealing with complex issues as a mechanism for achieving this goal. The establishment of ELLabs has proven to be an innovative and effective approach (Bosch et al., 2013a; Nguyen & Bosch, 2013b; Nguyen et al., 2011) for unravelling and managing complex multidimensional issues. Bosch et al. (2013a) describes the ELLab as a series of steps that enables diverse groups of participants, all with different mental models, to engage in a cyclical process of thinking, planning, action and reflection of collective learning towards a common vision or goal - learning

together in an 'experimenting laboratory' environment about how best to deal with the complex problem they are facing (Figure 1).

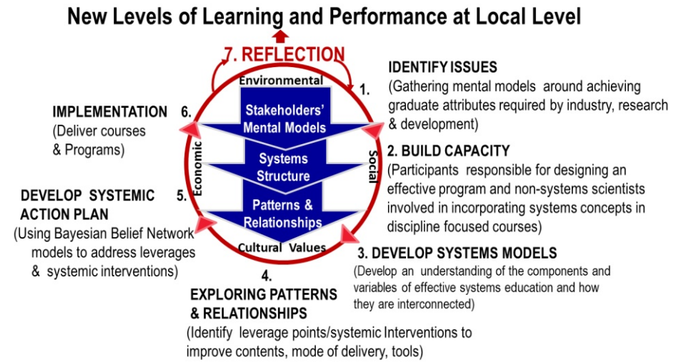
Figure 1. Evolutionary Learning Laboratories for dealing with complex issues.



Source: Bosch et al 2013a.

The seven unique steps were slightly adapted for establishing ELLab for Systems Education. For example, instead of developing appropriate management strategies in Step 5, the ELLab for Systems Education uses this step to develop a plan of what the contents of the courses will be, what order the modules within the courses will be offered, etc. to achieve the graduate attributes that were identified (Figure 2).

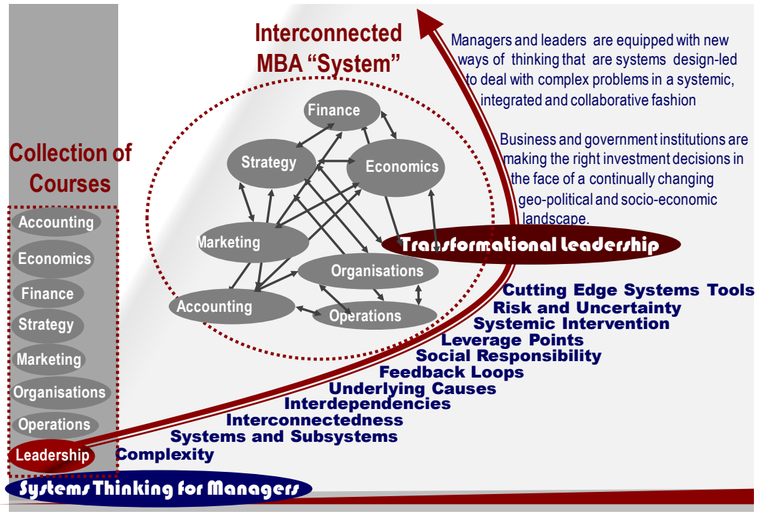
Figure 2. University of Adelaide Evolutionary Learning Laboratory for Effective Systems Education.



3.2 Some preliminary results of the Adelaide ELLab for Systems Thinking Education in operation.

The Adelaide MBA is an excellent example of the incorporation of introductory and advanced courses in redesigning it as a "new era" degree program that is not regarded as merely a collection of courses, but as a "system" in which the various courses are strongly interconnected (Figure 3). This has been explained in detail in a recent paper (Bosch et al., 2013b).

Figure 3. Systems based New Era Adelaide MBA.

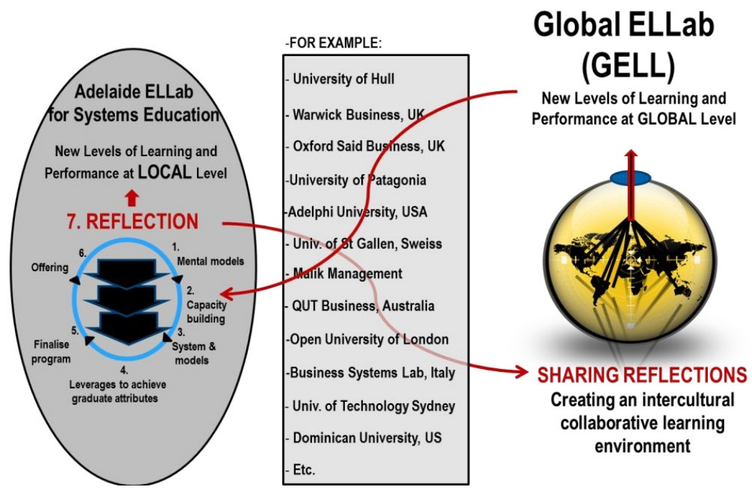


Source: Bosch et al 2013a

The MBA and B. Commerce 'systems' have been established as an ELLab (Figure 2). As mentioned earlier, the ELLab is used as a systems-based methodology and process for integrated cross-sectoral/disciplinary communication, decision making, planning and collaborations in dealing with complex problems. It is used by all involved to develop a deep understanding of the under and post-graduate 'systems' (program contents and delivery), shared vision (learning outcomes) and skills for systemic continuous adaption, innovation and improvement of the new era MBA and systems courses in the B. Com. programs over time, ensuring in this way their contents and modes of delivery remain viable and relevant.
The cyclic process includes different steps as illustrated in Figure 2. In summary, it starts with gathering the mental models of all lecturers and people from industry (job providers) on the nature of the graduate attributes that are required and possible concepts to be included in the course enhancing the capacity of lecturers involved to develop an understanding of the interconnectedness of all components of the MBA and B.Com. systems (programs). The program is then designed and the mental models of all involved on how the contents can be adapted and

especially how learnings can be integrated (contents, mechanisms of delivery, nature of student activities etc.) are determined. After this is the implementation stage (actual offering of the program), which is followed by reflection (co-learning, adaption and the cycle repeats itself) (Bosch et al. 2013b).
The vision is to link the Adelaide ELLab globally with other institutions that are involved with systems education in order to share the lessons learned through frequent reflections on student experience, degree in which graduate attributes are achieved, order of module delivery, value of practical sessions and relevance of the contents with lessons learned in other institutions. Lessons learned in one ELLab enhance the levels of learning and performance locally, while such a worldwide sharing through the Global Evolutionary Learning Laboratory (GELL) (Figure 4) would lead to new levels of learning at the global level. GELL will also provide an opportunity for individual institutions to contribute to the global knowledge pool on systems education. The ELLab concept and creation of a platform for sharing and co-learning are currently being developed as a web-based system (Think2Impact™[1]). This system will make cross-institutional sharing of reflections and co-learning at local and global levels possible without face to face meetings.

Figure 4. Linking the Adelaide Evolutionary Learning Laboratory for Systems Education globally to other institutions.



Source: Adapted from Bosch et al., 2013b

[1] *This project is currently underway under the auspices of the International Centre for Complex Program Management in Canberra, Australia. Launching of the system is expected to be in July 2015. See www.think2impact.org for more information.*

3.3 Preliminary results from the reflection step in the Adelaide ELLab for Systems education.

Two Systems Thinking courses have been developed and offered at the University of Adelaide in 2013. These include an undergraduate course (Systems Thinking for a Complex World II) - a core course for the Bachelor of Commerce program and a postgraduate course (Systems Thinking for Management) - a core course for the Master of Business Administration (MBA) program. The frameworks and modules of these courses have been developed in line with the outcomes and findings of the 2008 and 2010 IFSR (Bosch et al., 2009; 2013b). Step 1 of the ELLab led to a similar set of learning objectives for the two courses:

1. Understand that issues facing the world are complex and multi-dimensional, straddle many different factors and involve diverse multi-stakeholder systems;
2. Understand the context in which the problems arise (culture, political systems, values) and how disciplines or areas of interest fit into the whole;
3. Understand how different disciplines are interconnected and interdependent;
4. Obtain skills to address the underlying root causes rather than the symptoms of a problem;
5. Identify positive and negative feedback across components of a system;
6. Obtain skills to address problems that appear to be intractable;
7. Understand how the changing nature of the world impacts upon the way in which people and organisations make decisions;
8. Identify key leverage points for systemic interventions and to interpret their managerial implications in diverse application areas; and
9. Apply, through a real life project, concepts of systems thinking and some cutting edge tools in understanding and effectively managing complex problems in various areas and contexts.

These learning objectives are expected to provide students with the graduate attributes desired by potential employers. Pre-learning and post-learning surveys were conducted before the commencement and immediately after the completion of the courses for use during the reflection step. The main aim of the surveys was to explore to what extent the learning objectives have been achieved. The survey questions were designed to identify any changes in the students' way of thinking and systems knowledge after completing the systems thinking course. The same 10 questions were used in both surveys with 27 participating students. They include:

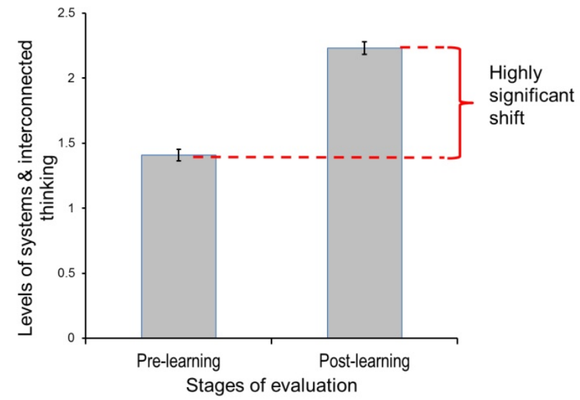
1. What would you regard as the first prerequisite for solving a difficult problem?
2. Why do you agree that it would be better for each country to solve their own problems by themselves?
3. What do you think about the general statement that: "The best solution to a problem in a specific area of interest/discipline will come from experts in that discipline/area of interest"?
4. How would you solve the symptoms of a problem? (E.g. how would you reduce the high crime rate in Shanghai?)

5. What do you understand by the concept of feedback between components of a system?
6. What do you think about the fact that an intractable problem should become part of the management environment rather than to waste time on solving that problem?
7. What do you think about the statement that: "Individual organisations or companies cannot take the changing nature of the world into account when they have to solve a problem that relates only to their own organisation or company"?
8. Why do you agree that the best way of solving a difficult problem is to try out various strategies until you find one that works?
9. Are you aware of any systems tools that can help you to address a difficult problem? If yes, please name them.
10. Why did you decide to enroll in this course and are you happy that you are sitting here today?

The levels of understanding systems concepts and interconnected thinking has been evaluated by using four levels to score the responses (3: advanced, 2: moderate, 1: limited, and 0: no understanding). Half band scores were applied for more accurate results. The encoded data were analysed using the General Linear Model procedure in the Minitab® statistical package (version 15, Minitab Inc., PA, U.S.A.). Additionally, the students' knowledge, attitudes, skills and aspirations as the elements of Bennett's "KASA" change evaluation (Bennett, 1975; Rockwell & Bennett, 2004) were assessed with both "hard" and "soft" indicators throughout the course duration (personal and group learning reflections).

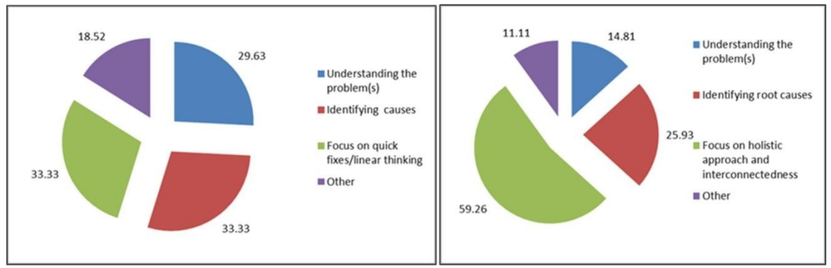
It was evident that overall the students' way of thinking have changed significantly from an average of 1.4 (± 0.05) to 2.2 (± 0.05) ($P < 0.001$) (Figure 5). No significant differences (at $P < 0.05$) were found among gender groups and study program levels.

Figure 5. Average shifts of the students' systems knowledge and perceptions after completing the systems thinking course. (The vertical bars (I) represent the Standard Errors (SE).)



The largest shift was evident from the responses of the students to Question 1, namely from a limited understanding and thinking in a linear way (0.96 ± 0.11) to a more coherent and interconnected way of thinking with an average score of 2.44 ± 0.11 ($P < 0.001$). The comparison is illustrated in the two pie charts below.

Figure 6. Comparison of the students' way of thinking and approaches to problem solving before and after the systems thinking course.



(a) Pre-learning stage (b) Post-learning stage

(Note: the total percentage is greater than 100% because one student responded with several ideas).

Figure 6 clearly indicates that 33.3 percent of the students were inclined to jump to the solution (i.e. treating the symptoms and "quick fixes") at the pre-learning stage. Only 3 students out of the 27 mentioned the importance of identifying the root causes. Interesting, after completing the courses nearly 60 percent of the students mentioned systems-based approaches, highlighting the system component interactions, root causes, unintended consequences, leverage points and systemic interventions.

In terms of the knowledge of system tools prior to the course commencement, only 14.8% of the students were aware of some systems tools. Three students at graduate level, who had prior work experience, mentioned tools such as "Lean and Agile SixSigma (Christopher & Rutherford, 2004; Thomas et al., 2008), "Environmental Scan" (Morrison, 1992), the "Fishbone diagram" (Nair, 2011) and the "Five-Why's" technique (Murugaiah et al., 2010; Serrat, 2009). This pre-knowledge have influenced their motivation for taking the course and their learning attitude. At the beginning of the course, 74.1% students expressed their interest to gain new ways of thinking/approaches (51.9%) and tools/techniques (22.2%) to deal with intricate problems. The rest found the course description interesting and attractive ("new cutting edge material").

The students' learning attitudes were greatly positive during the course and through the class activities and group work. Through the questionnaire survey and personal and group learning reflections, it was found that 100% of the students experienced the course as enjoyable and was greatly satisfied with the new knowledge they obtained. Understanding the systems thinking approach and capability to use the systems tools and techniques have made them more confident. A group of MBA students realised the value of systems thinking as a generic approach that can be applied in any field. Another stated that "we are looking at the world in a very different way now". This would mean that they have developed a strong belief and positive attitude towards the application of systems thinking in their work and lives. Interestingly, four out of the seven Master

students had work experience prior to this course. These students reflected back on their work before they completed the course. They used to struggle with applying a holistic (systems) approach in solving problems. However, after the course they were very confident that they will now be able to improve their productivity and efficiency, since they have been equipped with the framework and new tools to work with. Two of these students also stated that they were frustrated and have been uncomfortable with the, simplistic, reductionist and linear thinking approaches being practiced in their workplaces – especially when it leads to expensive, yet ineffective solutions. They expressed a "great relief" and described the course as the "first wonderful experience of learning how the application of systems approaches can change the current way of operating". Senge (1990, pp139-140) argued that dissatisfaction with the current situation also creates a "source of energy" and/or "creative tension" to change and achieve an individual's vision. In adapting to this situation, the more the students feel uncomfortable with the reductionist tendency and linear thinking in solving complex problems in the workplace at present, the stronger will their motivation, willingness and positive attitudes become to look for a new approach and tools/techniques to prove that traditional approaches are not appropriate any more. The students found it fortunate that they have been provided with what they were expecting before the course. All of these evidences are proof of the positive attitude of the students towards systems thinking approaches and tools.

It is also important to distinguish between the term "education" (what universities are offering to students) and "training". The latter focuses on skill development, while the former is different in the ways it shapes the "attitude" in addition to knowledge and skills for learners (Fabri, 2008). Moreover, education helps learners to be more analytic, that is, students are being equipped with "know why" rather than only "know how" (Essenhigh, 2000). The students were therefore constantly encouraged during the systems thinking course to develop a more open attitude. That is, a more tolerant to divergent viewpoints and perspectives that is typical of complex problems that involve multiple stakeholders.

Although no student had used "Vensim®" (for causal loop modeling - (Ventana®, 2011)) and NeticaTM (for developing Bayesian Belief Network models -(Norsys, 2013)) before the course, all the students became competent users of these easy-to-use software packages through practical sessions and group learning projects. One of the Master students, an independent consultant with 20 years of experience, started to apply systems thinking and the new tools in consultancies immediately after completion of the course. This student described the course content and its applicability as a "fantastic experience". This reaction also implies that the systems tools and approaches presented in the course would be regarded as superior to those that have been used before.

Through the evaluation of students' satisfaction, personal and group learning reflections, it showed that 100 percent of the students developed positive aspirations and a high readiness to apply systems thinking approaches and new tools obtained in their future and/or current professional work in different areas such as business, consultancy, medical science, policy making in government and engineering. One graduate student, an experienced professional engineer, found the "true value" of systems thinking to be in the process itself, in which relevant stakeholders are engaged to share and integrate their different mental models and identifying the causal relationships.

The changes in knowledge, attitude, skills and aspiration (KASA change) as expressed by the students (words and phrases used in the second questionnaire) are summarized in Table 1:

Table 1. KASA change of the students after completion of the systems thinking course.

KASA elements	KASA change evidences
Knowledge	**Holistic approach** and **interconnected thinking**; enhanced **understanding of complexity**, changing nature of the world and the need for **multi-disciplinary** and **multi-stakeholder** involvement; guided (step-based) **frameworks for solving complex problems.**
Attitude	**Positive belief** that the systems thinking course has provided a **novel way of thinking** and approaches to **unravel complexity** and to **solve difficult problems**, while maintaining an understanding of how all the components are **interconnected**. Increased awareness of the **value of teamwork**, i.e. two brains work better than one", where the personal **mental models are shared**, improved and used to develop **shared visions**.
Skills	Capability to use **system tools for integrating diverse mental models**, identifying **systems archetypes**; **Causal Loop Modeling** (**feedback** cycles); **BBN modeling** for the development of **systemic management** and operational plans; improved **team work skills**.
Aspiration	Strong **willingness to apply systems tools** and approaches to real life situations.

We would argue that the students did not only achieve the knowledge and skills as outlined in the requirements within the course description, but also developed a higher level of learning for their future careers. Based on the actual survey results and the above analyses, it could be concluded that systems thinking education is certainly a major leverage for a change from traditional linear thinking and very often "mindless learning", which usually lead to the so called "quick fixes" or "treating the symptoms", to a more comprehensive and integrated systems thinking that eventually bring about long lasting sustainable outcomes/solutions. Mindlessness refers to the learning that relies on the previous experiences without reflections and lack of the openness to new perspectives (Mezirow, 2000).The shifts of all KASA elements from the above analyses are illustrated in Figure 7.

In mathematics, in fact in the real world, there are "necessary" and "sufficient" conditions (i.e. pre-requisites and/or requirements for something to happen) to fulfil a certain goal (Vapnik, 1999). We would therefore argue that systems thinking knowledge and skills would be the "necessary conditions" for the advancement in economic and managerial practices, while attitudes and aspiration (personal attributes) are the "sufficient ones". It is dependent on each individual's motivation and determination to gain a shift in the way he or she thinks, that is, whether they would practice a systems approach in their workplace and lives. Figure 8 illustrates how systems thinking education could contribute to the advancements in economic and managerial practices.

Figure 7. A descriptive (transformative) learning curve for future leaders and practitioners as a result of systems thinking education.

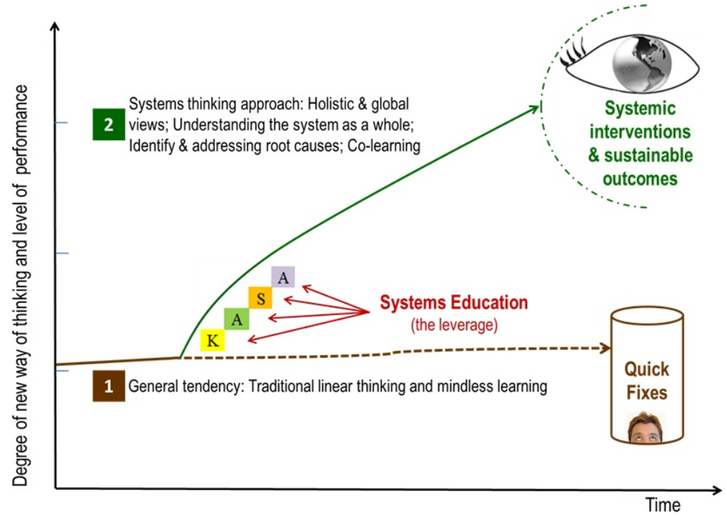
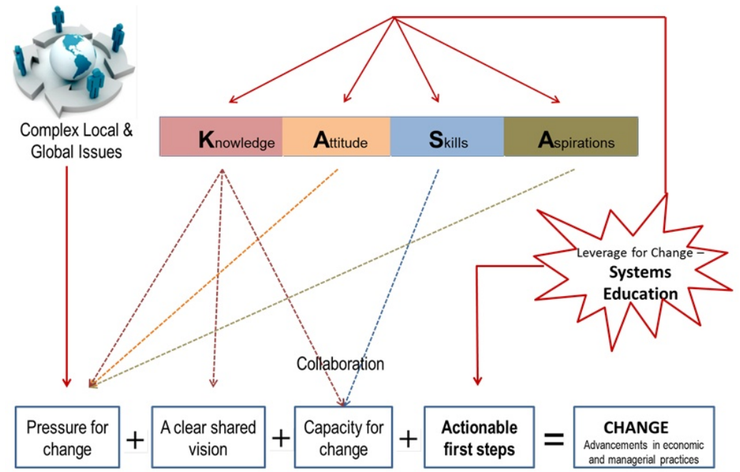


Figure 8. Systems thinking education as the leverage for advancements in economic and managerial practices.



Source: Modified from Beckhard, 1987 and Smith, 1997

Systems education could be regarded as the leverage or systemic intervention for being able to take action towards the advancement of economic and managerial practices to improve knowledge, attitude, skills and aspirations. The complex world we live in and the many complex problems we are facing in this turbulent and ever-changing 21st Century will increasingly become the driving force for acknowledging the importance of systems education.

4. CONCLUSIONS

The introduction started with a statement that advancements in economic and managerial practice cannot be achieved without systems thinking education as a foundation, but to rectify the situation will require the difficult task of a societal change in the way we think about problems or achieving positive outcomes. That is a change away from traditional single discipline and linear thinking mind sets to systems thinking and an appreciation of the interconnectedness between all components of the systems we are dealing with. Although difficult, this capacity to redesign, in systems and sustainability terms, has become increasingly what society and employers require.

Is this requirement such a big educational challenge? Not if there is a demand and awareness of how a holistic and integrative way of thinking could help economic and managerial challenges. Such a demand will further increase if the importance of taking all the major dimensions of a complex problem into account in the formulation of effective management strategies (systemic interventions) with long lasting outcomes can be demonstrated. This only becomes possible when systems scientists take their concepts and theories out into practice were it can make a difference.

There is still much needed to be done by systems scientists and systems educators in order to make Systems Thinking become popular and an integral part of the educational system. Apart from creating a demand, there are limited resources for teaching systemic thinking and it is difficult to improve these under current educational settings. However, it is expected that the slow “infiltration” of systems modules in discipline specific courses and full systems courses in various faculties will lead to a greater awareness of the value of systems education.

The worldwide introduction of systems education into University systems has been recognised as a complex problem, which justifies the use of the ELLab approach as a systems tool to deal with such a complex problem. The outcomes of the ELLab (capacity building, identification of leverages to achieve the learning objectives and the pre- and post-teaching reflections through student surveys, analyses and discussions) provided valuable insights for the Adelaide Business School’s systems courses. After only one year a big shift for all students could not be expected. However, the relatively large change in their thinking with sufficient knowledge and skills at this stage and the high levels of personal motivation and aspiration, would certainly contribute to significant changes in their future work. Having the opportunities to apply systems approaches and tools in “real-life situations” will further improve their knowledge and skills, increase the number of demonstrations of the value of systems and interconnected thinking and contribute widely through creating a better awareness and appreciation to systems thinking becoming an integral part of the way society thinks. When this is starting to happen we will be able to say that economic and managerial advancements have a systemic foundation. In other words decision and policy making will be based on solving the root causes of problems, identifying those components of the systems under consideration where investment decisions will have the biggest impact (improving cost-effectiveness of actions) and developing long lasting systemic and sustainable solutions to the many problems facing our society.

Involvement of more universities and other educational institutions in the Global ELLab for systems education will significantly contribute to co-learning from the global knowledge pool in order to enrich the contents of systems courses, optimise their impact through innovative modes of delivery and remain relevant and at the cutting edge. Such a worldwide collaboration will lead to a society with a new way of thinking, which is a prerequisite for meeting the economic and managerial challenges, now and in the future.

ACKNOWLEDGEMENTS

The authors wish to thank our many research collaborators in various countries and organisations in which they are practicing systems science. A special word of thanks to Dr Nguyen Van Thanh, Professor Dan Duc Hiep and the researchers and managers of the Cat Ba and Haiphong ELLabs in Vietnam; MBA Director Damian Scanlon and Dr Sam Wells for their continual support in encouraging the incorporation of systems approaches in the Adelaide MBA and management programs in general at the University of Adelaide; Professor Gandolfo Dominici for his continuing encouragement and acknowledgement of the importance of our work and the request and signing of an official agreement for collaboration between the Business Systems Lab and the Systems Design and Complexity Management Alliance. A special word of thanks also to various members of the ISSS and IFSR who respectively continue to support the enhancement of systems education globally through administering the Special Integration Groups and providing and funding opportunities for in depth Conversations on the topic of systems education.

REFERENCES

Allen T.F.H. (2009). Welcome Message from the ISSS President. Paper presented at the *Proceedings of the International Society for the Systems Sciences* (ISSS) 2009 Conference, The University of Queensland, Brisbane, Australia.

Assaraf O., Orion N. (2005). Development of system thinking skills in the context of earth science system education. *Journal of Research in Science Teaching,* 42(5): 518–560.

Bawden RJ. 1991. Systems Thinking and Practice in Agriculture. *Journal of Dairy Science* 74(7): 2362-2373.

Bawden R. J. (1992). Systems approaches to agricultural development: The Hawkesbury experience. *Agricultural Systems,* 40(1-3): 153-176.

Bawden R. J., Macadam R. D., Packham R. J., Valentine I. (1984). Systems thinking and practices in the education of agriculturalists. *Agricultural Systems*, 13(4): 205-225.

Beckhard R. (1987). *Organizational transitions : managing complex change*. in Beckhard R., Reuben T. Harris (Eds.). Reading, Mass. (USA) : Addison-Wesley.

Bennett C. (1975). Up the hierarchy. *Journal of extension*, 13(2): 7-12.

Blokland P. V., Schumacher F. (1990). *Handbuch zur Programmierumgebung VUDynamo, Behörde für Schule*. Hamburg (Germany):Jugend und Berufsbildung.

Bogdanov A. A. (1913). *The Universal Science of Organization (Tektologia*). 1996 edition published as Bogdanov's Tektology, Book 1. Dudley, P. (ed.). Hull, UK: Centre for Systems Studies Press.

Bosch O.J.H. , Drack M., Horiuchi Y., Jones J., Ramage M. (2009). Informing the Development of Systems-Oriented Curricula at the University Level: The Systems Education Matrix. In *Proceedings of the International Federation for Systems Research*: Fourteenth Fuschl Conversation, Fuschl, Austria

Bosch O.J.H., King C.A., Herbohn J.L., Russell I.W., Smith C.S. (2007). Getting the big picture in natural resource management - systems thinking as 'method' for scientists, policy makers and other stakeholders. *Systems Research and Behavioral Science,* 24(2): 217-232.

Bosch O.J.H, Nguyen N.C., Maeno T., Yasui T. (2013a). Managing Complex Issues through Evolutionary Learning Laboratories. *Systems Research and Behavioral Science,* 30(2): 116-135.

Bosch O.J.H, Nguyen N.C., Sun D. (2013b). Addressing the critical need for a "new way of thinking" in dealing with complex issues facing our societies. *Business Systems Review* 2(2): 48-70.

Bosch O.J.H, Ross A.H., Beeton R.J.S. (2003). Integrating science and management through collaborative learning and better information management. *Systems Research and Behavioral Science*, 20(1): 107-118.

Brock B., Janischewski A. (2011). How can the educational system enhance the capacity of systems thinking? *Proceedings of the 55th Annual Conference of the International Society for the Systems Sciences*, University of Hull, UK.

Cabrera D. (2008). US Patent 60/888,492. Filed February 6, 2007.

Checkland P. (1981). *Systems Thinking, Systems Practice*. Chichester, UK: John Wiley & Sons.

Checkland P. (1999). *Systems Thinking, Systems Practice: Includes a 30 year retrospective*. Chichester, UK: John Wiley & Sons.

Christopher M., Rutherford C. (2004). Creating supply chain resilience through agile six sigma. *Critical Eye*, June August: 24-28. Retrieved, February 2014 from: *http://valuenetworkmanagementforum.org/vnmf/images/past_events/competitive/publications/Creating_Supply_Chain_Resilience_Through_Agile_Six_Sigma.pdf*

Essenhigh R.H. (2000). A Few Thoughts On The Difference Between Education And Training. Retrieved, February 2014 from: *www.facs.org/education/rap/fabri0408.html/gulledge/Articles/Education versus Training .pdf.*

Evagorou M., Korfiatis K., Nicolaou C., Constantinou C. (2009). An Investigation of the Potential of Interactive Simulations for Developing System Thinking Skills in Elementary School: A case study with fifth-graders and sixth-graders. *International Journal of Science Education,* 31(5): 655 - 674.

Fabri P.J. (2008). Is there a difference between education and training? Retrieved, February 2014 from: *http://www.facs.org/education/rap/fabri0408.html*.

Forrester J.W. (2007a). Systems dynamics - a personal view of the first fifty years. *System Dynamics Review*, 23(2/3): 345-358.

Forrester J.W. (2007b). Systems dynamics - the next fifty years. *System Dynamics Review*, 23(2/3): 359-370.

Francois C. (2004). *International encyclopedia of systems and cybernetics, (2nd ed.)*. Munchen (Germany): Saur.

Gu J., Nakamori Y., Zhu Z. (2002). A report on the China-Japan-UK systems project: cross-cultural learning and integration. *Systems Research and Behavioral Science*, 19(1): 87-93.

Herrscher E.G. (1995). Why is systemic thinking 'difficult to sell'? In *Critical Issues in Systems Theory and Practice*, Ellis K., Gregory A., Mears-Young B., Ragsdell G. (eds), pp. 45-49. New York, (USA): Plenum Press.

Hmelo-Silver C.E., Pfeffer M.G. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviours, and functions. *Cognitive Science*, 28(1): 127–138.

Hogan K., Thomas D. (2001). Cognitive comparison of students' systems modelling in ecology. *Journal of Science Education and Technology*, 10(4): 319–345.

Jackson M.C. (2003). *Systems thinking: creative holism for managers*. Chichester, UK: John Wiley & Sons.

Jacobson M., Wilensky U. (2006). Complex systems in education: Scientific and education importance and implications for the learning sciences. *The Journal of the Learning Sciences*, 15(1): 11–34.

Klieme E., Maichle U. (1994). *Modellbildung und Simulation im Unterricht der Sekundarstufe I. Auswertungen von Unterrichtsversuchen mit dem Modellbildungssystem* MODUS, Institut für Bildungsforschung: Bonn.

Klopfer E., Resnick M. (2003). Technologies to support the creation of complex systems models: Using Starlogo software with students. *Biosystems,* 71(1-2): 111–123.

Kohtake N., Maeno T., Nishimura H., Shirasaka S., Ohkami Y. (2010). Educational curriculum for multi-disciplinary system design and management. *Proceedings of the 54th Annual Conference of the International Society for the Systems Sciences*, Waterloo, Canada.

M'Pherson P.K. (1974). A perspective on systems science and systems philosophy. *Futures,* 6(3): 219-239.

Maani K, Maharraj V. 2004. Links between systems thinking and complex decision-making. System Dynamics Review 20(1): 21-48.

Mezirow J. (2000). *Learning as Transformation: Critical Perspectives on a Theory in Progress*. The Jossey-Bass Higher and Adult Education Series. ERIC.

Midgley G. 2000. *Systemic intervention: Philosophy, methodology, and practice*. New York, (USA): Kluwer Academic Publishers.

Midgley G. (ed). (2003). *Systems Thinking (Volumes 1-4)*. London (UK): Sage.

Midgley G. (2006). Systems thinking for evaluation. In *Systems concepts in evaluation: An expert anthology*, Midgley G., Imam I. (eds), pp. 11-34. Point Reyes, CA (USA): Edge Press.

Morrison J.L. (1992). Environmental Scanning. In *A primer for new institutional researchers*, M. A. Whitely J.D.P, Fenske R.H. (eds.), pp. 86-99. Tallahassee, Florida (USA): The Association for Institutional Research.

Murugaiah U., Benjamin S.J., Marathamuthu M.S., Muthaiyah S. (2010). Scrap loss reduction using the 5-whys analysis. *International Journal of Quality & Reliability Management,* 27(5): 527-540.

Nair A.C. (2011). Assuring quality using 6 sixma tool - DMAIC technique. *International journal of research in commerce, IT and management,* 1(4): 34-38.

National Research Council. 2000. How people learn: Brain, mind, experience and school. In Committee on developments in the science of learning and committee on learning research and educational practice, J.D. Bransford ALB, R.R. Cocking, & S. Donovan (ed). National Academy Press: Washington, DC, USA.

Nguyen N.C., Bosch O.J.H. (2013a). The Art of Interconnected Thinking – Starting with the Young (Special Issue "Systems Education for a Sustainable Planet"). Forthcoming accepted paper *Systems* 1(2).

Nguyen N.C., Bosch O.J.H. (2013b). A Systems Thinking Approach to identify Leverage Points for Sustainability: A Case Study in the Cat Ba Biosphere Reserve, Vietnam. *Systems Research and Behavioral Science*, 30(2): 104-115.

Nguyen N.C., Bosch O.J.H., Maani K.E. (2011). Creating 'learning laboratories' for sustainable development in biospheres: A systems thinking approach. *Systems Research and Behavioral Science*, 28(1): 51-62.

Nguyen N.C., Graham D., Ross H., Maani K., Bosch O.J.H. (2012). Educating Systems Thinking for Sustainability: Experience with a Developing Country. *Systems Research and Behavioral Science*, 39(1): 14-29.

Norsys. (2013). Netica™ Application. Retrieved on February 2014 from: http://www.norsys.com/netica.html.

Patterson T.F. (2007). The Rise and Fall of Innovative Education: An Australian University Case Study. *Innovative Higher Education*, 32(2): 71-84.

Penner D. (2000). Explaining systems: Investigating middle school students' understanding of emergent phenomena. *Journal of Research in Science Teaching* 37(8): 784–806.

Richmond B. (2001). *An introduction to systems thinking*. Lebanon: High Performance Systems, Inc..

Rockwell K., Bennett C. (2004). Targeting outcomes of programs: A hierarchy for targeting outcomes and evaluating their achievement. Retrieved on February 2014 from: ftp://bsesrv214.bse.vt.edu/grisso/Program_Logic/Targeting_Outcome_Programming.pdf

Senge P.M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York, (USA): Doubleday/Currency.

Senge P.M. (2006). *The fifth discipline: The art and practice of the learning organization* (revised and updated). New York, (USA): Random House.

Serrat O. (2009). *The five whys technique*. Washington, DC (USA): Asian Development Bank.

Sheehy N.P., Wylie J.W., C. M, Orchard G. (2000). How children solve environmental problems: Using computer simulations to investigate systems thinking. *Environmental Education Research,* 6(2): 109-126.

Smith C., Felderhof L., Bosch O.J.H. (2007). Adaptive Management: Making it Happen Through Participatory Systems Analysis. *Systems Research and Behavioral Science,* 24(1): 567-587.

Smith S. (1997). Create That Change: Readymade Tools for Change Management. London (UK): Quest Worldwide Education Ltd.

Stieff M., Wilensky U. (2003). Connected chemistry: Incorporating interactive simulations into the chemistry classroom. *Journal of the Science Education and Technology* 12(3): 285–302.

Sweeney L.B. (2001). When a Butterfly Sneezes: A Guide for Helping Kids Explore Interconnections in Our World Through Favorite Stories. USA: Pegasus Communications.

Takahashi K., Takashi M. (2011). The causal SWOT analysis using systems thinking as a tool for situational analysis workshop. *Proceedings of the 55th Annual Conference of the International Society for the Systems Sciences*, University of Hull, UK.

Thomas A., Barton R., Chuke-Okafor C. (2008). Applying lean Six Sigma in a small engineering company–a model for change. *Journal of Manufacturing Technology Management*, 20(1): 113-129.

Vapnik V.N. (1999). An overview of statistical learning theory. *IEEE Transactions on Neural Networks*, 10(5): 988-999.

Ventana®. 2011. Vensim program. Retrieved from: http://www.ventanasystems.co.uk/.

von Bertalanffy L. (1956). General systems theory. *General Systems,* 1: 1-10.

von Bertalanffy L. (1962). General systems theory - A critical review. *General Systems,* 7: 1-20.

Wilensky U,, Reisman K. (2006). Thinking like a wolf, a sheep, or a firefly: Learning biology through constructing and testing computational theories—an embodied modelling approach. *Cognition and Instruction*, 24(2): 171–209.