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Sustainable ICT Education Ecosystem

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Abstract **- ICT education at Tertiary level in Australia is currently faced with the crisis of low student enrolments despite strong demand from the industry. This has resulted in financial sustainability issues for many university schools/ departments offering ICT education. We have seen a large number of Schools or Departments known as e-Commerce, Software Engineering, Information Systems, and Computer Science in Australian Universities have shut down or merged with other Engineering or Business faculties in the last 6 years. This paper examines some findings of this crisis and propose a framework of a sustainable ICT education ecosystem at tertiary level that may be the model to address the current crisis. The framework is inspired by the foundation of the sustainable ecological ecosystems in nature and we provide conceptual mapping of the ICT education ecosystems to the sustainable ecological ecosystem.**

1.0 Introduction

The number of students studying in universities' ICT courses has been steadily declined ever since the burst of the dot com bubble in year 2001, and that had led to the down-sizing or even complete shut down of some university departments that teach ICT courses. However, at the same time, the shortage if ICT skilled workers has also increased sharply with many economists concern that if the situation not rectify soon it will severely affect the economy due to lost in productivity given ICT plays such an important role in almost every industry nowadays.

There are many research done on the causes of this problem, some said young people, being born with the existence of ICT, no longer fascinate with it to want a career in this area; others blame most ICT courses, particularly those offered in universities are too outdated and boring, some outsiders complained that the ICT courses offers no attraction to young people, some graduates think that the courses cannot provide the skills and knowledge to the students and was the causes cannot help them in obtain employment upon graduation.

In this paper, we propose taking a different approach towards ICT education, one that of an ecosystem where all parties involved play their parts to ensure the survival and sustainability of the system so that it can grow, evolve and prosper.

The paper will begin with some close examination of the current problem situation and its related issues before outlining a proposed framework of ICT education ecosystem. The paper will conclude with recommendation on future research that is needed to move forward to realize the proposed solution.

2.0 The evolution of ICT education

In the 1980-90s, we largely see the field of ICT studies split into disciplines such as Computer Science (CS), Information Systems (IS), Software Engineering (SE), Computer Engineering (CE) and a few others as represented on the left-hand-side of Figure 1. As ICT technologies advances and being apply to wider and less conventional areas, courses in ICT application areas such as health and geology as well as Web applications became popular and jobs in these areas were springing up worldwide (see right-hand-side of Figure 1) [1].

Over the past few years we have witnessed the merging of CS and IS schools/departments took place in a number of Australian universities; followed by an approximate 30% disappearance of those named Software Engineering (SE) in the earlier 2000s. In recent years, we see that IS schools and Electronic Commerce (EC) schools slipped into business and CS, and CS being absorbed into mathematics and electrical engineering. The range of courses have been reduced and restricted, in other words, ICT education is shrinking. All these changes were largely brought about by the declining financial sustainability and resource savings in response to the declining student enrolments in these disciplines.

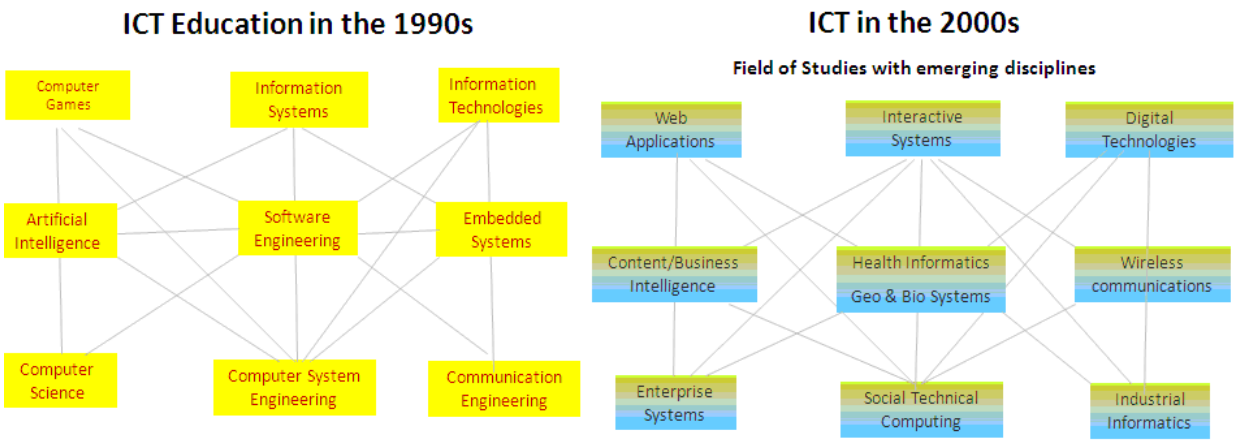

Figure 1 ICT disciplines in the 1990s and 2000s [1]

3.0 Steady Decline in ICT students over the past six years

ICT education is in crisis due to its declining enrolments over the past few years [2]. A recent study conducted in the US reveals that current enrolment in undergraduate degree programs in computer sciences is roughly 50 percent lower than its peak in 2001 [3]. The statistics given by [2] illustrate a marked average decline in enrolments of over 18 % in the period 2002 to 2005 with recent DEEWR (2008) [4] figures indicating that the rate of decline of eligible applicants was 11.4% between 2006 and 2008 [5].

This was despite strong increasing demand of skilled ICT workers from the industry [6] [7] [8]. The Australian Computer Society (ACS) [9] note that the ICT skills shortage will grow 29% by the year 2010 to just over 14,000 jobs unless immediate action is taken.

One of the factors contributing to the crisis is concerned with the perception of ICT and an ICT career amongst school students [10]. A recent study found that most teenagers perceive computing as boring, antisocial and irrelevant to their lives [11]. In another study, 93% of the 126 respondents of university freshmen who had not chosen a major area of study declared that they will choose an area other than computing as their major area of study [12].

4.0 Analysis of the trend of ICT education

Great hope from Gartner's hype curve (Figure 2) represented a reality in of all ICT industry's economic recovery; however, the hype did not happen to ICT related education sector.

As indicated in Figure 2, the growth of the ICT industry has been stabilized as from July 2003 and it will continue to grow. However, this trend does not apply to ICT education. Following the hype of Gartner's trend, a probability prediction of ICT Education are shown in Figure 3 where we can see the decline from 2000 is continuing for the years to come.

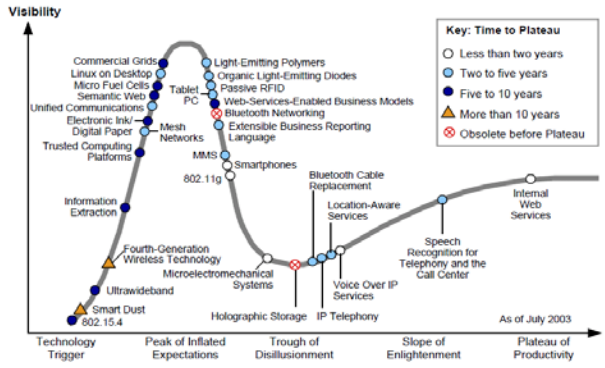

Figure 2 Gartner Hype-Cycle for Emerging Technologies 2003 [13]

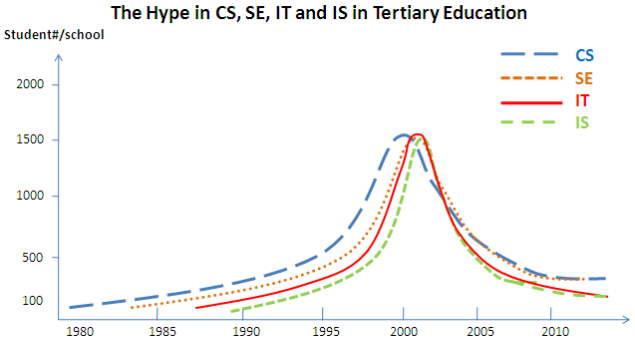

Figure 3 Hype predictions through Probability Analysis of ICT Education [1]

Through the special focus group at ASWEC 2008 [14], a general agreement is that our ICT education is out of sync with rest the world, the changes in ICT happen every 6 months, and in the University, the curriculums is changed every 5 years which is 600% out of date. If it is out dated now, what would happen when students graduate in 3 years time? [15]. It is also perceived that some subject taught are too shallow, hence lead to some students' decision in taking certificates course with industry instead where they believe the knowledge gain is greater that from an IT related course in a university. Research in ICT should feed into teaching; however, that can be hard to achieve when research is in state of art, but teaching is still old fashioned. In addition, from the student and industry point of view, it is difficult to distinguish SE, CS, IT and IS curriculum. Even some academics are confused themselves, worst, some of them could not tell the difference. This resulted in overlapping topics, subjects and units taught through the years. In view of the standard provided by ACM, ACS, AIS and IEEE, their curriculums also have strong overlapping. A probability studies showed that the trend of IT/IS education [figure 3] are taking it time with slow improvement over the next few years. Recent questions asked that if academic has no industry experience or *recent* cutting-age technology experience, how they can design industry relevant courses. This is one of key influence on the slow recovering of the education improvement process. The key solutions is to think how we can provide ICT graduate the industry require, taking into account that ICT is a multi-disciplinary study today with engineering on one side and business/commerce disciplines on the other.

5.0 Why do we need sustainability for ICT education?

To answer this question, we need to review the "Hype for Industry/Business Development" – the economic development followed the hype that Gartner produced in 2003. In figure 4, the growth slowly continued over the 20 years, and last 5-6 years, the growth has tripled in the whole Brake and Motor Industry sector [1]. We are living in the information age and ICT has become ubiquitous. ICT is needed to support almost every industry. Industries demand highly trained human resources, demand for new courses and training programs. It is therefore crucial that there are enough ICT graduates to meet the demand by industries. At the same time, educators must keep ICT curriculum relevant and up to date [15].

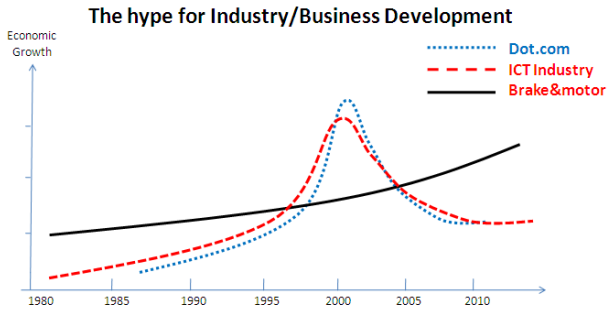

Figure 4. The growth has tripled in the whole Brake and Motor Industry sector [1]

6.0 The key challenges in Sustainable ICT Education

We are living in a society where knowledge plays an important role in daily life. With the world changing in an increasingly fast pace, new knowledge needs to be acquired continuously – be it for doing our work better, understanding what is happening around us, helping others, or even just to be able to communicate with others and fit in with our surrounding. Thus, learning, continuing in acquiring new knowledge and new skills becomes an essential part of our lives. However, today we also lead complex lifestyles with many of us playing multiple roles at the same time. Most of us cannot afford to be just student, just worker, or just parents, career – we are usually everything at the same time. With time being scare commodity, learning needs to be effective and knowledge and skills need to be acquired in the most efficient manner. For many gone were the days when one can afford the time and money to be full time students studying in university for three to four years before stepping into the workforce. Most youngsters now start paid work while they are still in high school. Having a single degree in a particular discipline no longer earns us the ticket to good employment, employers expect their workers to continue in acquiring new knowledge, learning new skills and obtaining new qualifications. Given the scarcity of time, most learners want learning program comes in smaller package with specific and up-to-date content.

Computer technologies have been around for the last four decades so nowadays many young people pretty much grow up with technologies. While they are very accustomed to the idea of using computers to do many things such as school work, play games, make contact with their friends, etc, it may need something a whole lot more exciting to entice them to decide on a career in ICT. It is therefore crucial that ICT

courses be perceived as interesting and exciting to potential students. As mentioned above, ICT are now being applied in just about every industry hence students may wish to pursuit an ICT career in a specific area. We need to cater for diversities by allowing flexibility in the curricula where students can study ICT with other disciplines of their choice. Learning programs will also need to be more flexible to catering for the vast and vary interest of today learners, allowing them to pick and choose what they want without imposing rigid constraints.

Unlike education in other fields, ICT courses need to be constantly updated to stay in tune with emerging technologies. ICT curricula must also take into consideration of the skills and knowledge as demand by the industries to ensure graduates able to ease into the work force upon graduation. However, it is also equally important to teach fundamental ICT concepts to ensure students understand the basics. ICT courses therefore need to be carefully design to have a balance curriculum – meeting students' interest and learning needs, satisfying industries' demand as well as staying up-to-date with latest technologies.

As we can see, today learning environment is very complex with many influencing factors. Learning institutes such as universities which are established with adult learning in mind need to adapt to the changing world. However, the burden should not just lie on universities; other key players need to play their part to ensure the sustainability of ICT education.

7.0 A Framework of a Sustainable ICT Education Ecosystem

"An *ecosystem* is a loosely coupled, domain clustered environment inhabited by species, each proactive and responsive regarding its own benefit while conserving the environment." [16]

Applying the analogy of a biological ecosystem; we are proposing a framework of sustainable ICT education ecosystem. The concepts of ecosystem is not new to teaching and learning, Guetl and Chang [17] had explored the notion of ecosystems for e-learning and examined a number of e-learning ecosystem models such as that by Brodo [18], Ismail [19], and Frielick [20].

Our proposed framework of sustainable ICT education ecosystem concerns about ICT education at tertiary level hence will not include training courses offered outside universities environment. Below we will first define this framework with its key players (species of the ecosystems), we then formally define all the key elements that form the sustaibable ICT education Ecosystems.

7.1 The Key Players

The biological ecosystem is inhabited by species, for ICT education ecosystem we identify its key players, namely: student, academic, ICT industry (employer) and university management. There may be other players in the system; however, we are focusing on these four for the time being.

Students come to the system to receive education; however, students will only come if the courses on offer satisfy their requirements. Traditionally, we saw students as consumer; however, to better understand their learning needs we must engage them as course design partner and rely on their feedback to continuously improving the quality of education.

Academics in ICT education must equip themselves with up-to-date knowledge on current technology as well as sound pedagogical understanding. They should align their research in the areas of cutting-edge technologies and prepare themselves for constant changes.

In the past, input from ICT industries in curriculum development have been kept to minimum if at all and there was barely any communication between academics and industries. In order to ensure ICT courses are equipping graduates with the right skills and knowledge, ICT industries need to be more actively involved in the design and delivery of ICT education. ICT industries also need to be more welling to invest in ICT education and should not see that as the sole responsibilities of the universities.

University management plays an important role in managing resources and also has the authority to create the suitable environment to facilitate the other key players in the ecosystem. University management, in response to government policies, allocate resources such as funding and create opportunities for ICT education system. University management also plays the role in regulating and monitoring performances and outcomes of the system.

7.2 Definition of the Key Elements of a Sustainable ICT Education Ecosystem

We shall define the ICT education ecosystem by describing its key elements:

(1) Self Organization

In the concepts of ecosystem, "self organization" refers to agents being capable of acting autonomously, making decisions and fulfilling responsibilities [16]. To apply this to ICT education will be seen as a paradigm shift as traditionally, education has always been regarded as a service where providers such as universities providing to consumers (students). As in any other service industry, which works on the basis of supply and demand, universities often compete in student recruitment. Students, on the other hand, while able to choose their course and university, usually have little or no input towards the curriculum development or the administration of the course. To achieve 'self organization' in ICT education means having all species or agents, in this case: students, academics, universities management, ICT industry, and other involved parties, to act autonomously, making decisions and fulfilling responsibilities; as well as voluntarily working together in a collaborative manner to achieve the benefits perceived by individual party.

Evolution is the key to survival and growth of an ecosystem. As the environment changes, the system needs to evolve in order to adapt. To stay put will lead to lost of competitiveness and consequently, self-destruction. In the case of ICT education, the rapid changing technology lead to demand of different skills and knowledge from the industry and education providers must respond to such change with more suitable products. The changing learning needs of students should also be taken as a major input to the design of courses and so as their diverse background and various interest. Stakeholders of the education system: i.e. student, academic, employer, university management and other players, must prepare to embrace changes and allow the system to evolve to adapt to change.

(2) Continuing Generations

The survival of species within an ecosystem relies on its ability to continuing generations. In the case of an ICT education ecosystem – more students, better courses, more and better skilled graduates to take up positions in the industry; more sponsorship from the industry and more academic staff being hired. This continuing generation ensures the replenishment of the species or agents within the ecosystem and their continuing contribution keeps the ecosystem alive and prospers. The continuing generation leads to growth in size and complexity in which the original ecosystem may split hence lead to the generation of multiple new ecosystems. The growth and generation of the ecosystem is also necessary in attracting new species or agents.

Currently the problem of low student enrolment poses the biggest threat to the survival of the entire ICT education system. Without the students there will not be enough graduates to take up positions in the industry, without enough skilled workers the ICT industry as well as other industries will lose productivity

(3) Maintaining Balance

To maintain the healthy state of an ecosystem, there must be a balance of power from all species or agents within the ecosystem; there should be no dominant members although some members may act as leaders at a time. In the case of ICT education, education providers can no longer see themselves as the dominant of the system and attitudes such as "students must accept what is being offered to them" will deem to fail. The design of curricula should incorporate contribution from multiple stakeholders: students, academics, and ICT industry; it is important to balance students' interest, academic pedagogy as well as industry demand. The design of course delivery, on the other hand, must consider learners' various learning needs and their complex learning environment, as well as the availability and affordability of technology.

(4) Interact with Environment and Community

The ICT education ecosystem needs to interact with its surrounding environment and the community it resides in. Adapting to the environment contributes to the survival and success of an ecosystem hence it is very important to study the impact of environmental factors such as politics, government policies, national & international economies. Of course, without doubt the advancement of ICT also has an important impact on the ICT education ecosystem. At the same time, there are expectations from the surrounding communities that the system has to fulfill in order to gain support from them.

(5) Benefit and Profits

There needs to be benefits or profits or both to each of the species of an ecosystem otherwise they will not stay in the system. As discussed above, it is very important that all stakeholders, i.e. students, academics, university management, ICT industry and other significant parties to be involved and contribute to the ICT education ecosystem for it to works. However, that means each of these stakeholders must benefit from the system otherwise they will leave. Therefore, it is important that all parties must work together in a collaborative and proactive manner to

ensure the needs of all parties are met hence the survival of the system is secured.

(6) Sustainability and Growth

Sustainability, in the context of ICT education, refers to the following areas:

- Economic sustainability where there is sufficient funding to support the core functionalities of the system: teaching and research. In Australia, education funding can come in a number of sources: government, students' fees, and industry sponsorships. Current problem with low student enrolment has quite a significant impact on funding, not only the decline in students' tuition fees government funding is also affected as they are based on student enrolments. In addition, because the ICT industry is not getting enough graduates to fill vacancies, this is also threatening industry sponsorship.
- Courses in ICT education need to be sustainable where the contents should be relevant and up-to-date with the current technology. The quality of courses plays an important role in attracting the right students. Apart from content, the design of courses should offer flexibility in delivery with a broader focus that encourage multidisciplinary.
- Research is the other core function in ICT education. To be sustainable in ICT research, projects should target cutting-edge technology and establish oneself the forefront leader of the field

Figure 5 depict a graphical representation of a sustainable ICT education ecosystem. At the core of the system are the six key elements discussed above. The inner layer of the diagram shows that the key players of the system: students, academics, employers (ICT industry) and the university management. These are the key players whom should work and contribute to the system in order to achieve sustainability and growth. The outer layer of the diagram shows the environment factors such as the advancement of ICT technology, the economy – national and international, as well as government policies that will impact the system. The diagram also depict that the system is not static with arrows around the system showing that it is continuing evolving.

Figure 6 depict the continuing generation of ecosystems. Ecosystem evolves and updates itself, but at the same time an ecosystem grows in size and complexity, it may split into multiple systems where each is an ecosystem.

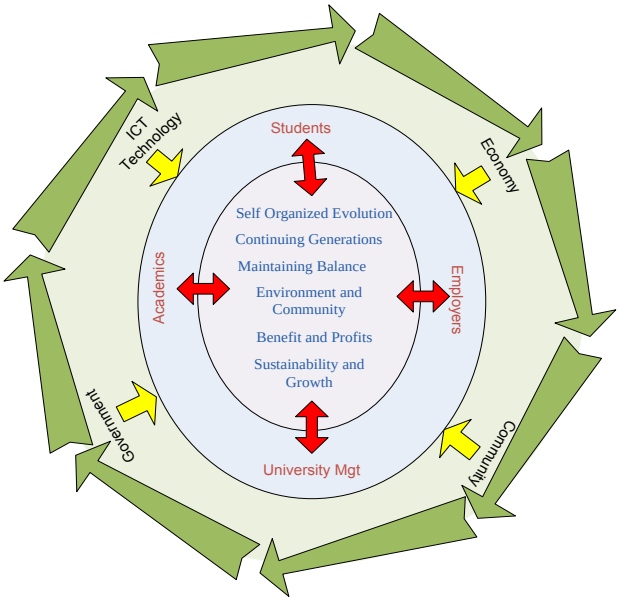

Figure 5. A Framework of a Sustainable ICT Education Ecosystem

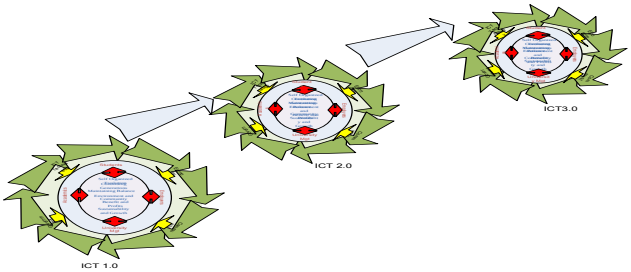

Figure 6. The continuing generation of ecosystems: ICT1.0, ICT 2.0, ICT3.0…

8.0 Practical utilisation of the Conceptual ICT Education Ecosystems

Below we provide high level mapping between the conceptual framework of the Sustainable ICT Education Ecosystem and the practical application in the education sector.

Conceptual Elements	**Practical Applications**
Self Organized Evolution	Empower the University Education with self-organized e-learning, social networks and web 2.0, etc
Continuing Generations	Accept the fact that over 5 years of teaching materials may no longer useful and correct.
Maintaining Balance	The ICT education curriculums have to maintain the same pace as ICT development in the real world.
Interact with Environment and Community	Collaboration with Industry, government and local communities is the key to ensure the employability of the graduates

Benefit and Profits	Education today are expensive, therefore, educators must re-think what benefit they bring the learners.
Sustainability and Growth	Facing the challenges of the rapid changing field, University must have the strategy that can sustain the quality T&L and quality of student learning experience

It is important to note that current ICT education system will not sustain if there if no consideration of the key sustainable elements, namely: (1) Self organize nature of agents are empowered by self-learning through e-learning, social networks and web 2.0. It strengthen the education systems rather than as a drawback; (2) Continuing generation, which indicated that the ICT is not like any other disciplines, that there is no stabilized content in ICT discipline, it has to be continuing keep pace with the fast growing field; (3) Maintain the balance between the rapid development of the ICT and education content; (4) Community or environment Interaction provide feedback on what employable skills are required for the graduate and appreciate what happening around the education sector, rather than ignorance; (5) Benefit and Profit signifies that there is a "give and gain" balance between learners and educators, education is getting more and more expensive if there is no gain from the graduate's point of view of what they are paying for. Educators should seriously consider what they offer is worthy of any value in an ecological system; (6) Sustainability and growth; this provide vision to ICT educators, who must develop strategies that can sustain the ICT education in the fast growing, dynamic changing environment.

9.0 Conclusions

In this paper, we examined some of the issues surrounding the current crisis in ICT education – namely declining student environment despite increasing demand from the industry. We then proposed a framework of sustainable ICT education ecosystem and we give a detailed definition of the key element that formed such ecosystem. Work is currently being undertaken to develop a methodology for the implementation of such sustainable ecosystems.

10.0 Acknowledgement

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