An Entrepreneurship Model for Future Intelligent Enducational Environments

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Abstract. In this paper we introduce a novel entrepreneurial model for funding and managing future intelligent educational environments and other academic business enterprise; the *Faculty-Cooperative*. The goal of this model is to create a business mechanism where academics are both the owners and customers of the IPR they generate, thereby providing synergy to optimize the educational product for the market, provide an embedded sales team and offer a source of investment for the enterprise. Our model is inspired by the cooperative ethos that has historically existed in universities. In addition we draw on parallels with the Western Cooperative movements and Chinese collectives but in a more virtualised form within the university system. To illustrate the *Faculty-Cooperative* approach we examine how it might be applied to the formation of an academic enterprise, FortiTo (a manufacturer of the technology that underpins intelligent educational environments and a producer of learning tools for students engaged in learning these new technologies). Whilst this paper describes the early stages of the development of an entrepreneurial model for academic enterprise, our hope it that this paper will promote discussion and participation in what we hope will be a successful model for funding and managing entrepreneurial academic enterprise.

Keywords. Entrepreneurship, Faculty-Cooperative, Academic Enterprise, Educational Technology, Intelligent Environments, Embedded-Computing.

Introduction

1.1. The Academic Market

Perhaps a good way to start a discussion about entrepreneurial business opportunities in academia is to consider the size of the education market we are addressing. The education sector comprises three main areas, school education (K-12), further education (FE), higher education (HE) and in-work training (eg hospitals). Its difficult to get reliable figures but some estimates place the global academic workforce as approaching 100 million with the global education market value being around $2.5 trillion comprising around 97 million students which may triple by 2025 [1]. Some observers have noted this market is larger than the music and car industries. By way of more reliable figures, the UK's British Council has produced a number of reports that quantify the size UK education market as comprising (in 2008/9) approximately

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500,000 teachers in almost 28,000 schools, over 220,000 teaching staff in FE colleges and 175,000 lecturing staff in 169 HE institutions. The same report suggests that, in 2007, when indirect jobs were taken into account, the total rises to over 668,500 jobs, or 2.6% of the UK total workforce. The higher education market is reported to be worth some $95bn to the UK economy with about $30bn being associated with educational goods and services produced in the UK [2] [3]. By any measure education is a substantial market, with significant funding and a vast pool of actors that our proposed *Faculty Cooperative*" educational enterprise model seeks to work with.

1.2. Academic Collaborative Culture

Universities are, by their nature, scholarly places where teaching staff are motivated by the pursuit and communication of knowledge, above the commercial bounds of the commercial environments they find themselves in. As such there is a tradition of openness and sharing of resources amongst teachers that lives on, despite the advent of commercial market forces that seek to place universities and academics in competition with each other. Thus, university have a natural inclination towards publishing information freely in papers, and sharing technology such as software tools to the benefit of the wider community; the so-called open systems and freeware movement. One example is the GNU project, which seeks to enlist the software community, around open standards, to produce "freeware" software tools such as operating systems and compilers. GNU is especially popular with academics. Open systems can generally be understood as being products based on non-proprietary standards, which are "owned" by the community, thereby promoting interoperability and portability (albeit sometimes managed by a company). Other examples of open systems include Oracle's Java and Open Office. The GNU project points out on their website (http://www.gnu.org/), free (or open) does not mean that the software's users do not have to pay for the software, rather it means they are given a few essential freedoms such as being able to run the program, to study/change the program source code and to redistribute exact/modified copies. Thus, whilst the words "open" or "freeware" may suggest not making a profit, this is not the case but rather it's a freedom of usage, plus harnessing the wider community in defining, building, supporting and funding the product which are also principles that underpin the proposed "*Faculty Cooperative*" educational enterprise model.

1.3. The Cooperative Movement

The vision for people to form cooperative groupings to benefit their wider community can be traced back to the UK in the 18th century when groups, such as the Scottish "Fenwick Weavers Society" (formed in 1769) or the "English Lockhurst Lane Industrial Co-operative Society" (formed in 1832) and now known as the "Heart of England Co-operative Society' became the forerunners of a worldwide movement that saw cooperative groups move from community stores to schools through to business cooperatives. One notable cooperative was the English "Rochdale Society of Equitable Pioneers" (founded in 1844), which established a set of principles that co-operatives still use. These principles include the need to have an open and voluntary membership, the need to avoid unfair discrimination between people, that members should have a sense of Altruism (note that this does not prevent members enjoying financial rewards) and that the enterprise should be funded by the members. [4] There are numerous

variations of these principles such as the "Emelianoff's three cooperative business principles" which seek to embody a principle whereby members may receive outputs at-cost" (but to non-members at good profit levels), a "proportionality principle" which seeks to allocate benefits according to stakeholding and a "self-financing principle". Cooperatives remain popular options for organising work with the United Nations estimating that, globally, around 800 million people are members of cooperatives with almost 100 million people being employed by them [5]. Of course, there are numerous potential hybridisations, one of which we describe in this paper which we call the Faculty-Cooperative.

1.4. New Chinese Collectives

As with the western cooperative, another notable movement occurred in China, where land ownership is spilt into two categories: state-owned land and collectively owned land. "A collective" is a basket of land (resources) that is assigned to a community (e.g. a village or town) and distributed to its members for cultivation (benefit) [6]. Collectives were an instrument used in China during the Mao Zedong era as a means to boost agricultural productivity and provide a much-needed measure of food security [7] [8]. As far as production is concerned, the advantages lay in the nature of ownership and control [9]. Under capitalism, the means of production and economic surplus are privately owned, while in the socialist societies, the ownership and economic surplus are legitimately transferred to government, legally – in the name of the people. The distribution of this 'publicly-owned' surplus is subject to claims by all sectors of socialist society and is a deliberate political process [10]. The collectively owned cooperatives are literally owned by the employees, in which the distribution of profit is subject to claims by the collective shareholders [11] [12]. Whilst the reputation of collectives became tarnished in the west, by association with communism and their perceived poor performance, a more dispassionate analysis might reveal that the collective model had some interesting ideas that could be relevant to a modern global and high-tech business. In this paper we examine we argue that the value of collective stakeholding provides a powerful means to motivate and empower faculty to have a hand in investing, directing and benefiting from the fruits of their intellect. While there are various schemes for achieving this, in this paper we are proposing a loosely inspired variation (cherry picking the bits we like and adding aspects we require) to, create a type of academic collective, or as we prefer to phrase it, a "*Faculty-Cooperative*".

In the following sections we will seek to explain the *Faculty-Cooperative* model which is inspired by the about discussion on the academic market, the historic academic culture and the notion of cooperatives and collectives.

2. The Faculty-Cooperative Model

2.1. From Collectives to Cooperatives

Universities might be seen as a form of educational eco-system. Within this eco-system, they might be regarded as a form of government assigned academic collective

comprising a group of academics (labelled with a university name, eg Oxford, Cambridge, Essex etc) a resource (buildings, degree conferment rights etc) with the responsibility to use them to the good of the country. However, we ask, is such a collective bounded by the physical limits of a particular university, or is it bounded by a different label related to interest groups or specialities (business studies, computer science). In our "*Faculty Collaborative*" model, we are proposing to introduce one such virtual-collective, based on entrepreneurial academic activities, where academic in differing institutions can collaborate together to advance their entrepreneurial visions.

2.2. From Open Systems, to Open-Innovation, to Open Financing

As was described in section 1.2, academics are, by and large, strong advocates for an open approach to innovation based on well-established principles of openly publishing knowledge and actively seeking to collaborate with fellow researchers. In a recent example, "Living Labs", Universities have extended such open research cooperation to local government and communities engendering cooperation to mutually improve the technology that impacts all our environments [9] [13]. The concept of 'open innovation' gives a strategic emphasis on developing and intensifying collaboration across industry networks and partnerships, opening up their innovation processes in line with the open innovation framework [14]. One important assumption underpinning the concept of 'open innovation' is that an organisation cannot innovate in isolation [15] [16]. Under a turbulent business environment and hyper-competitive market condition, innovation is considered as a major engine to enhance business performance and to strengthen an organisation's competitiveness in the marketplace [17] [18] [19] [20]. In our *Faculty-Cooperative* model we are seeking to build on this principle by devising a model whereby the company structure and investment follows such an open framework by seeking to make the IPR, shareholding (investment) and strategy to be owned by the academic community in as transparent a way as is possible. In the following sections we describe this model from various perspectives, principally the faculty members, the students and the company personnel.

2.3. Perceptions of the Faculty Cooperative Model

2.3.1. A Non-Entrepreneurial Faculty Member Perspective

For a non-entrepreneurial member of University staff, the *Faculty-Cooperative* represents an opportunity for them to become stakeholders in the "tools of their trade". This stakeholding takes the form of being able to contribute to the specification and nature of an educational product and to share in a financial reward from the combined intellect of the academic system that they have committed their life to.

2.3.2. An Entrepreneurial Faculty Member Perspective

For an entrepreneurial member of University staff the *Faculty-Cooperative* provides all the advantages of the non-entrepreneurial member, described in the previous section but provides the academic entrepreneur with a source of finance by offering a large number of low cost shares to the academic community, thereby raising the required capital to fund the company, without seeding control to another single and dominant investor (which is often the case with venture capitalist funding). Furthermore, it offers

a pool of tangible and intangible resources to incubate any new ideas in an embryonic state for entrepreneurs aiming to start a new venture with/in the university.

2.3.3. A Non-Entrepreneurial Students Perspective

For a regular student, attending a university, they would be essentially unaware of this organisation but indirectly benefit from better-designed educational tools that arise from within the academic community.

2.3.4. An Entrepreneurial Students Perspective

For an entrepreneurial student, the *Faculty-Cooperative* represents an opportunity for them to apply their newly acquired knowledge, exercise their product innovation and entrepreneurial skills, enrich their CV and become stakeholders in one of the largest and most worthwhile global industries. Apart from that, there is the added bonus of earning some welcome income.

2.3.5. The Customers Perspective

From a customers' prospective (Universities, faculty members, students etc) they receive a better quality product, designed and tested by the leading educational experts. In the same way as there is some enthusiasm for green products that benefit the earths eco-system (the environment debate) then customers (the Universities) can feel good about supporting and improving their own *educational eco-system* via the mutually owned *Faculty-Cooperative*.

2.3.6. The Company Personnel Perspective

For company personnel, the *Faculty-Cooperative* provides a "feel good factor" of being associated with both a worthy cause (the education business, that transforms lives positively) and a secure profitable business (education generates more revenue than the music business) all of which contribute to job satisfaction.

2.3.7. The Business Perspective

With a global workforce of the order 100 million, and market value approaching $2.5 trillion, business prospects for the *Faculty-Cooperative* are good. Postgraduate education (MScs, PhDs) involves students working at the cutting edge of disciplines and companies made up of investors and workers drawn from such auspicious ranks must have some advantage over its competitors. Thus, the combination of a large market and a well qualified set of stakeholders' present a positive business perspective.

3. FortiTo – The *Faculty-Cooperative* Exemplar

In the following section we give an example of company, FortiTo, that we are proposing to operate based on thie *Faculty-Cooperative* model. FortiTo is a spin-off company from the School of Computer Science and Electronic Engineering at the University of Essex.

3.1. FortiTo Market

FortiTo is a company that aims to provide educational technology for the Intelligent Environments and related applications such as embedded-computing, the Internet-of-Things, Ubiquitous and Pervasive Computing etc [21] [22]. All of these applications are based around the use of network connected embedded computers, each which senses and controls (individually or collectively) some part of the built environment. Thus, for example when such systems are placed in a domestic home, and managed by software agents, the "*Smart-Home*" is created. Likewise, if a similar arrangement was used in a classroom (physical or virtual), an "*Intelligent Classroom*" could be created. There are no reliable estimates for the value of this market but a recent report suggested it could reach between 22 billion and 50 billion dollars by 2020 made up of some 16 billion connected devices [21]. These figures are given additional credibility by other findings that show the Chinese market has already reached 30 billion dollars [21].
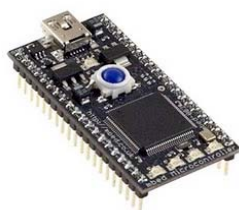
> The mBed is based on the ARM Cortex-M3 Core running at 96MHz, with 512KB FLASH, 64KB RAM and various interfaces including Ethernet, USB Device, CAN, SPI, I2C

> The Raspberry Pi is based on an ARM 1176JZFS, running at 700Mhz, in a Broadcom BCM2835 SoC. The current best specified model has 256Mb RAM, 2 USB port and an Ethernet port.

Figure 1a. mBed   **Figure 1b.** Raspberry Pi

The educational technology developed by FortiTo is used to train and teach students the basic skills required for developing products for new high-tech markets such as Intelligent Environments or the Internet-of-Things etc. The most basic component is an embedded computer, which is essentially a small integrated circuit. In order to make it useful for education or industrial prototypes it needs to be added to a carrier; an example is given in figure 1a which shows the popular ARM processor on a baseboard carrier called an mbed that was developed by Philips in partnership with ARM. Although primarily intended for rapid prototyping in industry, its keen pricing and versatility made it a popular choice for Universities.

The main problem with students using an mbed is that it needs a keyboard, display, power supply, I/O and software tools to do anything sensible. Adding such things takes a considerable time to build, considerably longer than most student lab periods allow. Alternatively, academic or technical staff would need to spend time making pre-assembled versions, which would limit the students flexibility and takes up valuable academic time. In some respects, the newly announced Raspberry Pi (see Figure 1b), with its headline grabbing "*$25 computer*" tagline represents such a preassembled system, needing only the addition of a power supply, keyboard and display to become a fully operational computer. While nobody can argue this is amazing value, to make this computer go beyond operating on data and to control real artefacts requires some time

consuming electronics design leaving it much in the same problem-space as the mbed for applications involving the Internet-of-Things, Ubiquitous and Pervasive Computing etc The FortiTo company solves these problems by providing a modularised scheme of educational hardware and software technology that offers a family of pluggable hardware boards (*Buzz-Boards*) that can be plugged together to enable students to construct a variety of embedded-computing applications within the timescales available in a typical computing laboratory session. The company assists busy academics by providing all the necessary pedagogical content such as example software and assignment templates that can be customised by the host institution.

3.2. Buzz-Boards

Figure 2. *Buzz Board* Examples (Audio, Midi, KeyPad, Processor, LED & Network Boards)
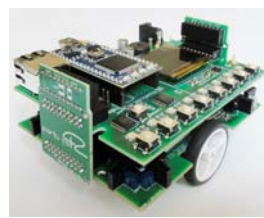

Figure 3a. An Internet Radio

Figure 3b. A mobile Robot

The company's main products are a set of computer boards that can be plugged together to make a variety of applications that are limited only by the students and instructors imaginations. Some examples include *Games* (eg Pacman, Mind Battle etc), *Music* (piano, guitar, tuner, MIDI synthesiser etc), *Media* (video camera, audio etc), *Medical* (fitness, heart rate, body temperature monitor, physiological sensing etc), *Navigation* (inertia 3D sensor, light seeker, GPS etc), *Network Services* (Bluetooth, Wifi, Wired), *Computing Basics* (simple calculator, storage etc), *Weird-Science* (brain wave monitoring, lie detection and emotion sensing systems, random numbers, 'quantum universe splitter' etc), *Mobile Robots* (light seeking, maze escapes, crazy eyes, chatterbox etc), *IT Tools* (multi-meter, oscilloscope, or logic analyser etc), *Product Prototyping* (a bread- & solder- Board for bespoke designs). A few examples of Buzz-Boards are shown in Figure 2.

Buzz-Boards are processor agnostic, in that they work with virtually any popular processor or educational ICT set such as Lego, Arduino and mbed, PIC, ARM, AVR. For programming *Buzz-Boards* work with standard C and C++, the most common

embedded-computing languages. The company are also planning a web-based
graphical programming environment (*Buzz-Blocks)* for less experienced people, and to
allow the products to be used in primary and secondary education. By assembling the
Buzz-Boards is different ways (ie plugging them together in differing combinations) it
is possible to create a variety of hardware application platforms that students can then
program to learn differing skills. Two examples are given in figure 3a and 3b.

4. An Implementation Model for the *Faculty-Cooperative*

4.1. The Faculty-Cooperative Principles

As discussed in section 1, much information and analysis exists on the principle
underpinning cooperatives, collective and other more modern mutual enterprises such
as shareware. From these we have selected the following mix that we feel are
appropriate to an academic or faculty cooperative. It would be fair to say we are still in
the early stages of developing our *Faculty-Cooperative* model, and one of the aims of
this workshop is to raise these issues at the workshop and beyond, so we can refine our
principles further; thus the table 1 represents or starting position on this path.

Openness	Support for open implementation standards (eg interfaces)
	Support for open source design standards (eg product specifications)
	Support for open sharing of related work (eg assignments)
Freedom	To use the product for in education without restrictions
	To study and modify the products (eg student project work)
	To profit from the contributors IPR and work (eg faculty or student remuneration)
Collective Stakeholding	A mechanism whereby academics across a number of differing Universities are able to share in the operation of the company.
	A mechanism whereby academics across a number of differing Universities are able to be shareholders (to invest and share in profits)
	A mechanism whereby academics across a number of differing Universities are able to influence the educational product specification
	A mechanism whereby academics across a number of differing Universities involved in the enterprise can receive benefits (eg discounts or direct profit share)

Table 1 – Principles of a *Faculty-Cooperative* company

With the above cooperative philosophy in mind, the questions arises how might this
Faculty-Cooperative model be implemented? Table 1 sets out the key principles we
advocate for the model namely, openness, freedom and collective academic
stakeholding.
    It should be noted that whilst a collective ethos underpins this model, it recognises
that the enterprise is competing in a free market and that the company should operate in
the normal way for a commercial company.

4.2. An Example of a Faculty-Cooperative Company Implementation (FortiTo)

Clearly, there are many ways that a *Faculty-Cooperative* model could be translated into an academic company. In the following we briefly discuss how that has been proposed for our exemplary company, FortiTo. Considering '*Openness*', FortiTo is adopting many industry standards such as mbed and RPi processors, I²C bus technology and C/C++ programming. Considering '*Freedom*' the company makes use of freeware software tools (eg gnu), has opened its interface specifications and computing architecture, so that students and faculty have the important details available for educational assignments and projects. In respect of the '*Collective Stakeholding*', the company is actively seeking to attract membership, gather funding, create product specifications, conduct evaluations and market products in cooperation with as wide a slice of the international educational community as is possible. For example, the company plans to offer members of the educational community 'resource units' (either work packages or financial investment) in return for a shareholding of FortiTo. Finally the company is committed to providing benefits in the form of product discounts and profit share to its members. FortiTo is at a very early stage of its life, having developed a complete product range but is scheduled to commence commercial operations in September 2012, so this paper (written in April 2012) is the first of a series that will follow the application of the *Faculty-Cooperative* principles to an academic start-up and will follow the story of how it fares over a series of studies and papers.

5. Summary

In this paper we have explained how universities have traditionally been based on the ideas of openness, freedom and mutual support that we argued share some of the characteristics of Western Cooperatives and Chinese Collectives. In this paper we have presented an entrepreneurial model for producing future intelligent educational environments and products that seek to embody these values by drawing on the strength of the university system in the form of its faculty and students as a means to innovate, fund and manage academic enterprise. The model is not restricted to future intelligent educational environments but can be used for any academic spin-off company. We have sought to illustrate the implementation of this model based on a company that was formed based on the *Faculty-Cooperative* principles that, although in its infancy, we hope will serve to illustrate the essential principles and form an ongoing case that we will study and report upon at its various stages of growth. Above all, we are presenting this paper so that, through the workshop, we can engage with the wider academic community on exploring the virtues or vices of the *Faculty-Cooperative* model as a means to support academic entrepreneurial enterprise, an approach we hope will prove beneficial to the academic community at large.

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