



# Cents & Sensibility <sup>1</sup>

## A Note on Transdisciplinary Education

### 金錢與感性<sup>1</sup>——關於跨領域教育

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There has been a flurry of activities concerning the higher education of tomorrow including the recent signing of the STEM Education Act by President Obama. Why is there such a need to address the future of higher education now? Well, one reason is that the world of tomorrow will be very different and is changing fast. For example, it will have many problems with complexities far exceeding what we can tackle by traditional means<sup>2</sup>. Highly notable is a report by the National Academy of Sciences on the Convergence of different branches of science:

“Convergence of the life sciences with fields including physical, chemical, mathematical,

最近有許多關於高等教育未來趨勢的討論，其中包括歐巴馬總統最近簽署的科學(S)、技術(T)、工程(E)、數學(M)-STEM教育法案。為何如此關注高等教育的未來？其中一個原因是，明日的世界將迥然不同而且變化快速，例如許多問題的複雜性將遠遠超出傳統方式所能解決的範疇<sup>2</sup>。因此，美國國家科學院一份關於科學各分支領域互相融合的報告相當值得注意：

「生命科學與包括物理、化學、

computational, engineering, and social sciences is a key strategy to tackle complex challenges and achieve new and innovative solutions.”<sup>3</sup>

We believe that the convergence of the life sciences, including the social sciences, as noted in the above report, is a wonderful first step towards tackling real, complex problems facing us today and in the future. To succeed in tomorrow's world, however, college graduates must have both cents and sensibility. When I say “cents” I mean the capability to accomplish whatever task is given in a certain context. When I say “sensibility” I am talking about meaning in life. To make cents, a college graduate must be competent, and to make sense, she must be able to find meaning for herself and help others to find meaning as well. When a person is equipped with both competence and meaning, she is able to find the proper balance to navigate between today's necessities and her long-term vision in life.

However, the report cited above, in our opinion, primarily talked only about the competence aspect. There are three distinctive types of competence:

**1. Technical:** In the face of the knowledge explosion, students need to learn how to learn fast so that they are prepared to continuously upgrade themselves in new contexts. To do so, they need to equip themselves with a broad base of knowledge.

**2. Relational:** a student must be armed with a *sufficiency mindset* as she enters into a global, diverse workforce. Such a mindset contrasts with that of deficiency/scarcity one which is pessimistic in nature and usually leads to competition. A sufficiency mindset, on the other hand, implies that one has enough and hence could more easily develop win-win relationships based on collaboration.

**3. Conceptual:** our students need to cultivate the ability to see both the trees and forest, or design thinking, i.e. an ability to understand a whole spectrum of ideas and their connections in order to connect the dots to find innovative solutions, utilizing both their left and right brains.

To develop that kind of competence, academic institutions need to provide a broad educational background for students to understand the basics of liberal arts and science as well as different cultures, so that they develop an appreciation of the relevance of a broad range of subjects from literature, art, philosophy and history, to mathematics, biology, and physics, as well as some key technologies. In other words, we must train our students to be trans-disciplinarians in the broad sense. Such students are efficient synthesizers of information who can put together the right information at the right time. They are effective facilitators who can make wise choices utilizing collective wisdom. Most importantly, their education provides them with the capacity to learn

數學、計算機、工程學和社會科學等各領域的融合，是應付複雜挑戰、開發創新方案的關鍵戰略。」<sup>3</sup>

正如上述報告所提，生命科學與包括社會科學在內的其他學科的融合，是當今和未來處理複雜問題極為重要的第一步。然而要在明日的世界拔得頭籌，大學畢業生必須具備「金錢」和「感性」。金錢，指的是在特定環境中完成任務的能力；感性，是要懂得人生的意義。要有「金錢」，就必須能幹、有能力；要有「感性」，就必須能夠幫助別人和自己找到人生的意義。當一個人同時具備這兩項特質，就能在獲取生活所需與實現人生長遠的願景之間，找到適當的平衡點。

不過在我們看來，上述報告只討論到能力。能力可分成以下三種類別：

**1. 技術性：**面對知識爆炸的時代，學生要懂得快速學習，以便在新的環境中不斷提升自我能力。要做到這一點，他們必須具備廣泛的知識基礎。

**2. 關係性：**學生在全球化、多樣化的工作環境中，必須具備「充裕的心態」。這樣的思維與「不足/缺乏」的心態不一樣，後者在本質上是悲觀的，因而通常導致競爭。「充裕心態」者覺得一切是足夠的，因此得以在合作基礎上，更輕鬆的開發出雙贏關係。

**3. 概念性：**學生須培養見樹又見林的能力，也就是「設計思維」，一種充分利用大腦左右半球的全方位思考方式，能夠連結看似不相關的點，而獲得創新的解決方案。

要培養這種能力，學術機構必須提供學生多元的教育環境，使其汲取文科和理科的基礎知識，以及認識不同的文化，進而能夠鑑別廣泛主題——文學、藝術、哲學、歷史、數學、生物學、物理學以及某些重要技術之間的關聯性。換句話說，我們必須對學生進行多元的跨領域培訓，這樣學生才能有效統整各種資訊，在正確時間提供正確訊息；同時也能結合團隊力量，利用集體智慧做出明智抉擇。最重要的，這種教育使他們具有快速學習能力，從而能夠幫助組織創造財富——在正確時機，為客戶提供適當的產品和服務，為員工提供良好的

fast. These people can help any organization to make cents – right products and services for customers at the right time, good benefits for employees, and profits for shareholders.

We do not, however, think that competence alone will do the trick. If we look at our society today, we see that there is a new religion, a belief that “science and technology will solve the problem” — whatever that problem may be. Such a belief is part and parcel of Western culture during the past half-century. However, the record of “cures” for these problems promoted by technology optimists provides little room for cheer—from *silent spring*<sup>4</sup>, widespread hunger, and oil spills, to climate disruption, the Fukushima’s nuclear reactor disaster—the potential advantages of claimed “fixes” have usually failed to appear or proved to be offset by unintended

negative side effects. Despite these disasters, many scientists and technologists are convinced that human ingenuity could solve any problems, while failing to take into account the potential “unintended consequences”.

Today, we are truly standing at a crossroad: as scientific and technological innovations are advancing exponentially, unintended consequences could lead to the elimination of the human race as we know it. Let’s just consider the possible effects of combining only three technologies, namely:

1. Artificial intelligence (AI)—the science of making “intelligent machines”, that is systems that can “perceive” their environment and take actions

that maximize their chances of success.

2. Nanotechnology—the manipulation of atoms and molecules for fabrication of micro-scale devices.

3. Synthetic biology—the design and construction of biological devices/systems.

While these technologies have the potential to advance medicine, prolong life, and create many “conveniences” for us, they also create fears as these machines gain an increasing intelligence and latitude to make decisions for us automatically. Here is where rubber meets the road — can we design intelligent machines that have built-in ethical commitments?

福利，為股東創造利潤等等。

然而，僅靠能力無法解決所有問題。環顧今日社會，我們看到一種新興的宗教信仰，就是相信「科學和技術可以解決一切問題」——不論什麼問題。這種信仰，在過去半個世紀成為西方文化的重要部分；然而，那些科技樂觀主義者所提供的「解藥」，卻沒什麼值得喝采之處——從「寂靜的春天」<sup>4</sup>、全球飢餓問題，到石油洩漏、氣候惡化、福島核反應堆的核災難等問題，不僅看不到所標榜「修復」的潛在好處，反而還意外地被負面的反效應所抵消。儘管發生這麼多災難，許多科學家和科技專家依然堅信，人類的智慧能解決任何問題，而疏於考慮潛在的「意外後果」。

今日人類正站在一個十字路口：科技發明飛速前進，然而正如你我所知，任何意外後果都可能導致人類的滅亡。讓我們思考一下，僅就以下三種科技結合可能帶來的後果：

1. 人工智慧 (AI) —— 製造「智能機器」的科技，例如能「感知」環境並且採取行動，以達最大成功機率的智能系統。

2. 奈米技術 —— 利用原子和分子製造微型設備。

3. 合成生物學 —— 生物設備／系統的設計與構建。

這些科技雖然具有推動醫學發展、延長壽命的潛力，為人類帶來許多「便利」，但隨著這些機器的智能不斷提高，開始自動為人類做出選擇的同時，相對也為人類帶來隱憂。而這正是關鍵之處——人類有能力設計出內置道德承諾的智能機器嗎？

科學與技術，通常不被認為具備倫理道德的特質，充其量只是擁有發明與製造的能力。但技術的發明者，以及決定如何使用某項技術的人，則能給一項科技植入大量的道德指令。因此，我們必須關注「科技倫理」這個概念，可從以下二個觀點來考慮：

- 有關新技術研發所涉及的道德問題——例如，一個科學家是否有道德義務來從事或拒絕生產核子武器？

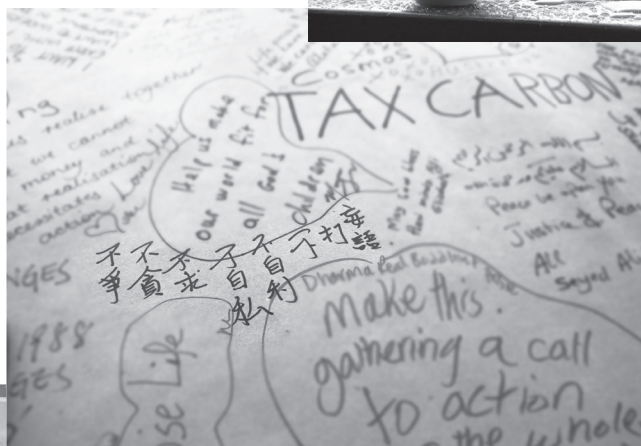
- 新技術的發明對人類道德標準的影響？





It is often held that science and technology are incapable of possessing moral or ethical qualities, since they are merely just capabilities of inventing and making tools. But the inventors of technology, along with those who decide how a technology is to be made and deployed, have the potential ability to endow a technology with a great deal of ethical commitment. As such, we now need to pay attention to the notion of “ethics of technology”. What we are referring to could be considered from two basic perspectives, namely:

- The ethics involved in the invention or the development of new technology—For example, whether a scientist has an ethical obligation to produce or refuse to produce a nuclear weapon?
- How each new piece of technology will



例如，完全由機器人從事生產的工廠勢必影響就業，由此衍生的道德問題是什麼？

不僅上述問題不易回答，人類還面臨著許多困境，包括：

1. 對大自然的快速破壞。
2. 貧富差距的擴大。
3. 普遍性的缺乏思考，導致在訊息即時傳遞的社會中，衝突一觸即發。
4. 心靈療癒的需求無所不在，因為人們缺乏安全感、孤獨、沮喪、無助，並且完全迷失在充滿虛假關係的世界裏。諸多問題，不勝枚舉。

眼前面臨的種種問題，許多是商業、金融、政府、工業各種領域中，領導失敗導致的結果。許多領導者之所以失敗，是因為所接受的精英教育只追求學

influence the way we look at ethics? For example, what are the ethical questions surrounding the “all robot” manufacturing plant that will certainly inhibit employment?

While the above questions are not easy to answer, humanity is facing a whole host of other enormous problems including:

1. The rapid destruction of our natural environments.
2. The increasing divide between “haves” and “have nots”.
3. The prevalence of deficit thinking that creates a highly conflict-prone society in an instantly connected world.
4. The need for healing everywhere as people feel insecure, isolated, depressed, hopeless, and totally lost in a world filled with fake relationships.

Much of what we face today is, in some sense, the result of failed leadership in all career domains: business, finance, government, and industry. Many of these failed leaders are products of elite academic institutions, who, unfortunately, put their focus primarily on academic excellence, neglecting the fact that leadership is essentially a moral act. It is now quite clear that while science and technology has become our near-universal object of faith, it is people who must provide the answers!

We believe that the answers lie in the core of spirituality, namely “compassion” and “wisdom”. Compassion comes from the understanding that “we are all one.”<sup>5</sup> As a consequence of the practice of compassion, it is necessary to think for others ahead or at least on a par with ourselves. Indeed, modern science, especially biology and quantum physics, have already gained a deep understanding that “everything is connected to everything else.”<sup>6</sup> Although we may perceive the natural environment as consisting of many different and isolated components and processes, these are all derivatives of the same cosmos, interrelated and linked together through mutual cause and effect. This understanding has profound implications for the application of technology in the form of “unintended consequences”.

Wisdom comes from a deep understanding of cause and effect, perhaps accumulated over many lives. Because the negative consequences of science and technology often occur in unanticipated forms and in distant locations—and sometimes after significant time intervals—they are often not perceived as related to their causes. This character of technology creates a serious intellectual challenge for scientists and technologists as they must weigh the immediate benefits over long term consequences when developing new technologies such as GMO and AI.

Indeed, science is silent when it comes to providing wisdom about how we should live. While the insight of science can help us change our world, it is only human thought that can enlighten us about the path we should follow in life. In this sense, spirituality could be considered a “science of the mind”<sup>7</sup> or contemplative science. It is this kind of science that, in our opinion, could help to bridge the seeming contradiction between the traditional view of objective reality that “phenomena exist out there” and more recent discoveries in quantum physics that have refuted such a notion. Such a science of the mind, in our opinion, helps humanity to create meaning in life.

術成績的表現，而忽略了領導本身的道德層面。現在已經很清楚，當科學技術已近乎成為大眾的信仰對象時，必須就上述問題提供答案的，就是人類自己了！

我們相信，所有的答案就在靈性的核心，也就是「慈悲」與「智慧」。慈悲，來自於對「我們皆為一體」的理解<sup>5</sup>；實踐慈悲的結果，就是先為別人著想，或者把其他人和自己考慮在一起。實際上，現代科學，特別是生物學和量子物理學，對於「萬物彼此相關」<sup>6</sup>的概念已有深刻的理解。雖然所感知的自然環境是由許多不同、孤立的元素和過程所組成，但這些都是同一個宇宙的衍生物，透過相互的因果關係彼此連接在一起。這樣的理解，對於因技術運用而造成「意想不到的結果」具有深遠的影響。

智慧來自對因果關係的深刻理解，或許得靠累世不斷積累而成。因為科技的負面效應經常以意外的形式、在相距遙遠的地點，有時甚至經過很長的時間之後發生，因此經常被忽略與其起因有關。而科技的這項特點，使得科學家和技術人員在開發諸如基因改造、奈米技術、人工智慧等新技術時，面臨嚴峻的智力挑戰，必須權衡眼前利益和長遠的後果。

實際上，論及人類如何生活的智慧，科學是保持緘默的。科學的洞察力雖然可以幫助人類改變世界，但是唯有人性的思考才能啟發生活之道。因此，被認為「心之科學」<sup>7</sup>或「沉思科學」的靈性，有助於在主張現象實有的傳統物理觀點和反駁這種觀念的近代量子物理學之間架起橋樑。而這樣一種「心的科學」，我們認為將有助於人類開創生活的意義。

在21世紀，一所優質的大學應當培養一群能夠創造意義的領導者——能夠幫助別人和自己找到人生的意義。意義可以來自三個不同方面：

A great university in the 21<sup>st</sup> century must cultivate a new crop of leaders who are also “meaning makers”—those who can find meaning for themselves and help others to find meaning. Meaning has distinct aspects:

1. Self-transcendence—meaning is the result of peace of mind knowing that one has made the effort to become the best one could be. While this is in line with psychologist Maslow’s notion of “self-actualization,”<sup>8</sup> we need to realize that this is a life long journey of inner transformation towards authenticity, an expression of compassion. In order to be authentic, one needs to forgive, and most importantly to forgive oneself. Forgiveness provides a key element in transcendence, that of helping to remove hostility, as beautifully observed by Henry Longfellow: “If we could read the secret history of our enemies, we should find in each man’s life sorrow and suffering to disarm all hostility.”

2. Purpose—Nietzsche said, “He who has a ‘why’ to live can bear almost any ‘how’.” Meaning makers are powered by purpose, and inevitably find the “how” that realizes their “why.”<sup>10</sup>

3. Service—there is no meaning without a mind for service. As such, meaning makers put other stakeholders first and make sure their needs are met.

Meaning makers can help an organization to make sense of it, which means the organization has good understanding of its collective identity, direction, working environment for employees, and social contributions to communities.

How to nurture meaning makers in an academic institution that primarily focuses on the development of competence for its students? Perhaps we can borrow a page from a revolution in the medical profession more than 100 years ago when the concept of a teaching hospital was introduced, as quoted from a report as follows: “...in addition to a scientific foundation, a clinical phase of education where thoughtful clinicians would pursue research stimulated by the questions that arose in the course of patient care and teach their students to do the same.”<sup>9</sup>

We propose that academic institutions consider the establishment of a “Service and Leadership School”<sup>10</sup> in line with that of a teaching hospital, in which research is conducted by the stimulation of problems arising in the course of serving businesses, communities, and non-profit organizations, to tackle their problems through transdisciplinary teams that include students as well as people from the “client” organizations. Such a professional school of Service must embody ethical behavior, service attitude, and innovation as its core culture through its course wares, decision-making processes, and other key functions.

Such a school is a place to experiment in complex problem solving, utilizing transdisciplinary teams. In these teams, which participants can experience the qualities of leadership and service in such a way that innovation occurs organically because the team contains the elements of diversity, interdependency and self-directedness. The school is a “living laboratory”<sup>11</sup> in which businesses communities and non-profits

1.自我超越——意義來自一顆平靜的心，知道自己已經盡力成為最好的人。雖然這點和心理學家馬斯洛的「自我實現」觀念一致<sup>8</sup>，但我們必須認識到，自我超越是內在轉化趨於真實的漫長生命旅程，也就是慈悲的展現。為了趨向真實，我們需要學會原諒，最重要的是學會原諒自己。寬恕是實現超越的關鍵因素，因為它能幫助一個人卸下敵意，正如亨利·朗費羅細膩的觀察：「如果我們知道每個敵人過去的秘密，會發現每個人的生命都有許多悲傷與痛苦，足以消弭我們所有的敵意。」

2. 目的——尼采說：「參透為何，才能迎接任何。」意義創造者以目的為動力，自然會發現實現目的的途徑。

3. 服務——意義不可能離開服務的心。因此，意義創造者會把其他利益相關者放在第一，確保他們的需求得到滿足。

意義創造者能幫助一個組織了解其存在的意義，這表示組織對於集體認同、發展方向、員工工作環境和對社會的貢獻等都有正確良好的認識。

那麼在致力開發學生能力的學術機構裏，如何培養這種意義創造者呢？或許可以從一百多年前醫學界的一場革命說起，在那場革命中，引入了教學醫院的概念，正如這份報告中的一段引述：

「……除了科學依據外，在臨床教育階段，體貼入微的臨床教師會根據病人照護課程中出現的問題進行深入研究，同時要求他們的學生也比照辦理。」<sup>9</sup>

我們建議學術機構考慮建立像教學醫院那樣的「服務與領導力學校」<sup>10</sup>，通過跨領域團隊，包括學生以及來自企業「客戶」的組織成員，針對企業、社群、非營利組織等機構在營運中所產生的問題進行研究。這樣一所服務性的專業學校，通過課程設置、決策過程和其他功能，便能在教學的核心文化中體現道德行為、服務態度以及創新能力。

換句話說，這樣的學校提供一個運用跨領域團隊解決複雜問題的場所，參與者在多元化、相互依存和自我導向等條件下激發創新，同時體驗領導力和服務的特質。因此，這種工作環境可說是企業、社群、非營利組織等通過全球



can produce innovative solutions, brought about by the world-wide collaboration of transdisciplinary team. Such an educational process help the participants to have a clear understanding of the relationship between the proposed solution and its impact to the society in terms of its possible ethical consequences.

We believe that the graduates of great institutions of tomorrow will be a new crop of broadly educated, thoughtful, moral leaders who are equipped with a sufficiency mindset and a good understanding of our mutual interdependence. They will help to create meaning and well-being (good sense) as well as shared prosperity (good cents) for humanity tomorrow. ॐ

化跨領域團隊，利用創新解決問題的「生活實驗室」<sup>11</sup>。這樣的教育過程，可以幫助參與者就其可能衍生的道德後果，了解所提出的解決方案以及對社會環境的影響。

我們相信，未來頂尖大學培養出來的社會新鮮人，將是一群受過多元教育、細心、有道德的新生代領袖。他們具有豐度思維，能相互理解、依賴，為明天的人類創造意義和福祉（美的「感性」），以及共享的財富（好的「金錢」）。 ॐ

#### Notes:

1. This article is based on a dinner talk at the 20th anniversary of Society for Design & Process Science (SDPS) as a tribute to Prof. C.V. Ramamoorthy, an exemplary trans-disciplinarian and a fellow co-founder.
2. Adam Kohane, Solving Tough Problems, Berrett-Koehler Publisher, 2004.
3. Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond. A Report by the National Science of Academy in 2014.
4. Rachel Carson, Silent Spring, Houghton Mifflin, 1962. The book inspired an environmental movement that led to the creation of the U.S. Environmental Protection Agency.
5. Dean Radin, Entangled Minds: Extrasensory Experiences in a Quantum Reality, Pocket Books, New York, NY, 2006.
6. The Web of Life: A New Scientific Understanding of Living Systems, by Fritjof Capra. Anchor Books, 1977.
7. Matthieu Ricard and Trinh Xuan Thuan, The Quantum and the Lotus, Three Rivers Press, New York, New York. 2004.
8. Abraham Maslow's well known hierarch of human needs developed in the 1940s.
9. Abraham Flexner, Carnegie Report, 1910.
10. An idea by Dr. Syed Shariq, Director of the Kozmetsky Global Col-laboratory at Stanford University, who actually established such a professional service school in India a few years ago.
11. The words were coined by Dr. Fuad Sobrinho Gattaz some 30 years ago when he was a director of EMBRABA, the famous Brazilian Agricultural research Institution.

#### 參考文獻:

1. 本篇文章是基於2015年國際設計與流程科學學會20週年晚宴上的演講，向卓越的跨領域學者、SDPS的共同創辦人CV Ramamoorthy教授致敬。
2. Adam Kahane著的「解決棘手問題（Solving Tough Problems）」，伯利特克勒出版社（Berrett-Koehler Publisher），2004年出版。
3. 「融合：促進生命科學、物理學、工程學等學科的跨學科整合」，國家科學院2014報告。
4. 蕾切爾•卡森（Rachel Carson）著的《寂靜的春天》，霍頓•米夫林出版社（Houghton Mifflin），1962年出版。該書引發了一場環保運動，促使美國成立環境保護局。
5. Dean Radin著的「糾纏的心：量子現實裏的超感官經歷」，袖珍書，紐約，2006年出版。
6. 生命之網：「對於活體系的嶄新科學認識」，佛里久福卡普拉所著。Anchor書局1977年出版。
7. 馬蒂厄理卡德& Trinh Xuan Thuan合著的「量子與蓮花」，三河出版社（Three Rivers Press），紐約，2004年出版。
8. 亞伯拉罕馬斯洛在1940年代提出來的、眾所周知的人類需求層次學說。
9. 亞伯拉罕弗蘭克斯納，卡內基報告，1910年。
10. 史丹福大學寇茲麥特斯基全球實驗室主任Syed Shariq博士提出的一個觀點。幾年前，他在印度創建了一所專業服務學校。
11. 這個名詞由我親愛的朋友Fuad Sobrinho Gattaz博士在大約30年前所創造，當時他是著名的巴西農業研究機構——巴西國家農業研究公司（EMBRABA）的主管。