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CURRICULUM RECOMMENDATION FOR BACHELOR'S AND MASTER'S DEGREES IN ENGINEERING/SCIENTIFIC ENTREPRENEURSHIP

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ABSTRACT

Entrepreneurship and Intellectual Property Rights (IPRs) form the core indicators of the developed world and India is lagging in both of them. A critical issue in this context in India is the profound lack of good Technology/Scientific Entrepreneurship programs, even though a few institutions have taken up early initiatives in this regard recently. This paper offers the curriculum for a comprehensive program in entrepreneurship in the Technology and Scientific areas at Bachelor's and Master's levels. The curriculum is aimed at enhancing the knowledge, skills and attitudinal profiles of the students. Besides offering both good breadth and depth of materials, the curriculum provides an extensive list of electives also. The curriculums are embellished with courses that expose the students to actual entrepreneurship practices both in-house and external environment. Several types of projects, besides a comprehensive capstone project, are tailored so that students gain practical experience in running a company by actually working with experts and real entrepreneurs.

Keywords: Bachelor's Program, Masters Program, Technology Entrepreneurship, Physical Sciences Technology Entrepreneurship, Biological Sciences Technology Entrepreneurship and Curriculum Recommendations.

1. INTRODUCTION

According to the Wikipedia [1], "Entrepreneurship is the process of starting a business, typically a startup company offering an innovative product, process or service [2]. The entrepreneur perceives an opportunity and often exhibits biases in taking the decision to exploit the opportunity. The exploitation of entrepreneurial opportunities includes design actions to develop a business plan, acquire the human, financial and other required resources, and to be responsible for its success or failure [3]. Entrepreneurship may operate within an entrepreneurship ecosystem which includes government programs and services that support entrepreneurs, entrepreneurship resources (e.g., business incubators and seed accelerators), entrepreneurship education and training and financing (e.g., loans, venture capital financing, and grants)".

Entrepreneurship leads to economic development, which is the backbone of the progress, freedom and prestige of a nation. Economic development is comprehensively the total effect of the development of labour force, the accumulation of physical capital and additions to the stock of knowledge and skills available in the country. Entrepreneurship is the key driver of a dynamic company and involves the recognition and evaluation of opportunities, where that means increasing the value of an existing product or service or creating mass markets with new technology.

Entrepreneurship, therefore, is the foundation towards significantly enhancing the national GDP of a country. Patents, IPRs (Intellectual Property Rights), Copyrights, Geo-Indexing are some of the bases on which developed countries of the First World dominate the rest. The talks at the GATT (General Agreement for Trade & Tariff) and the WTO (World Trading Organization) are dominated by the Western countries and their main weapons are controlling the use of IPRs and the like.

The thrust of the entrepreneurial development is to motivate people to accept entrepreneurship as a career. The talent of the prospective entrepreneurs is required to be guided and translated into practical application by i) initiating Entrepreneurship Development Programmes (EDP) and programmes relating to skill development, ii) exploitation of locally available resources, iii) utilization of science and technology offshoots for services and production of innovative devices, iv) converting new ideas into products or services, start-up support and incubation facility, and

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such activities. While the late Steve Jobs of Apple Inc. was an entrepreneur when he founded Apple, he no longer practiced entrepreneurship once he launched new innovations as a corporate manager. However, the founders of social networking websites Twitter and FaceBook are practicing entrepreneurship and hence supporting many related activities through their involvement in venture funding and angel funding mechanisms. It is noted that all these software systems are successful

This paper deals with the design and development of an entrepreneurship program that can be tailored to Engineering and Physical and Biological Sciences. One of the principal aims of developing a suitable curriculum for entrepreneurship is to identify people and encourage them to take up entrepreneurship in a scientifically foreseeable or predictable manner. We hope this paper addresses many of the important issues in this process. The rest of the paper is organized as follows: section 2 deals with the need for entrepreneurship programs in India, while section 3 details the international perspectives on scientific and technological entrepreneurship. In section 4 the nature of curriculum requirement for scientific and technological entrepreneurship is discussed and is followed by the suggested curriculum for scientific and technological entrepreneurship in section 5. A comparative set of discussions is offered in section 6, which is followed by conclusions and pointers for further work in this area in section 7.

2. NEED FOR ENTREPRENEURSHIP PROGRAMS IN INDIA

India, in particular, produces lot many graduates in engineering, science, agriculture, medical sciences, health sciences and animal sciences. Yet compared to the Western world, entrepreneurial activities in all of these areas are below par. Are we lacking in entrepreneurial culture? Do we seed programs in entrepreneurship that tailor to the needs of engineering, physical sciences, biological sciences, social sciences, arts and the like? Even the IITs lack a systematic educational program in entrepreneurship and only recently IIT-Bombay has started a B. Tech program in Engineering Entrepreneurship [4] – that too only as a Minor program. Less than a handful of educational institutions in India offer a comprehensive program in entrepreneurship. However, anecdotal evidences suggest that currently a number of entrepreneurship activities indeed take place – at least in India – through '*gut feels'* of a person (or a group of persons). Yet, the irony is that under the Hindu caste systemnearly a fourth of the Indian community belongs to the Vysya or business caste!

With a vast human capital and resources available in the country, there is a greater need for designing subject-specific and target-oriented programmes for entrepreneurship development – a matter to be taken seriously in the recently proposed**"*Digital India*"**of Prime Minister Modi [5]. We need to create awareness and organize programmes on entrepreneurship extensively among the youth, ambitious enough to venture in setting up small enterprise to begin with. Content of these programmes should be structured to include: available resources; potential areas for starting a small enterprise in manufacturing, services, franchising; strength and weakness of the identified project; supporting Government and private institutions, funding agencies or venture capitalists; marketing avenues; methods for identifying and evaluating business opportunities that support creativity; re-feasibility report preparation; knowledge about managing and growing the venture and all other details about the feasible projects necessary to motivate and generate confidence in the prospective entrepreneurs. We further believe that the Entrepreneurship Programmes should be built around the seven 'I's [6], namely: (i) Inspire, (ii) Ideate, (iii) Individualize, (iv) Incubate, (v) Innovate, (vi) Invest and (vii) Internationalize.

In our opinion, entrepreneurs need not be experts in the areas in which they work; however, they only need to have the acumen to see the business potential of a scientific discovery or technological development or innovation. They further need the ability to carry through such a discovery or innovation to productization and then to marketing them successfully to the masses. The potential areas in the India are wide enough to provide choice to the individual entrepreneur based on their background, risk taking capacity and self-confidence. Innumerable business opportunities are available in many areas of human activity in India. Twenty potential sectors deserve to be

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mentioned here in the Indian context for entrepreneurship opportunities as briefed in Table-1 (adapted from [7]) and elaborated further in Appendix-1

Table-I: Top 20 Entrepreneurship Opportunities in India

1. Packaging 2. Organic Farming 3. Toys 4. Tourism 5. E-waste Recycling 6. Floriculture 7. Corporate Demands 8. Social Ventures 9. Franchising 10. Education & Training	11. Software & Hardware Services 12. Biotechnology 13. Automobile 14. Food Processing 15. Media 16. Ayurveda & Traditional Medicine 17. Healthcare Sector 18. Engineering Goods 19. Energy Solutions 20. Textiles

The facts and figures of India clearly showthe need for a large number of entrepreneurs in the country. As per MHRD Annual Report 2014-15 [8], there are 665 Universities, 35,829 Colleges, 11,443 Institutions of Higher Education for a population of 14.88 crores in age group 18-23 years in higher education. The literacy rate of this age group of population is over 74% (2011). India ranks 135 out of 187 countries in Human Development Index (HDI) as per UNDP 2014-HD Report [9]. These figures clearly substantiate the huge scope of turning a significant part of the higher education population into entrepreneurs – an untapped potential. Therefore the need for entrepreneurship development, intensively and extensively, should be registered in clear and loud terms.

Impact of Information Communication Technology (ICT) on Entrepreneurship

Advances in Information Communication Technology (ICT) have led to major changes in the way businesses processes have changed. Indeed, the way technology has impacted entrepreneurship and small businesses is extremely transparent. For instance, virtual offices are taking over as technology is enabling more companies to shed their physical offices and set up virtual offices, complete with pseudo-virtual receptionists and brick-and-mortar address/es. For instance, the largest Commonwealth Bank of Australia has rented out his huge premises in the centre of the city of Sydney, instead creating several virtual offices around the Central Business District of Sydney. Equipped with modern communication software and computer technologies, these offices offer near-real experiences to customers of all ages and nature. Further, the virtual office concept enables self-employed workers to tap the potentials of cloud computing [45] and, for businesses to operate online without having to maintain their own servers, routers and other expensive hardware and software systems. In addition, it also helps self-employed workers to maintain the appearance of a larger enterprise.The power of social media has also contributed in a significant manner to entrepreneurship in IT, since sites such as the Facebook, Picasso, LinkedLN and Twitter have helped small enterprises to reach out to potential customers in greater numbers.

ICT is not only creating millions of jobs but also forms an important enabler towards innovation and development. In the US alone, ICT jobs are expected to grow by 22% leading up to 2020, thereby creating 758,800 new jobs [10]. In Australia, building and running the new super-fast National Broadband Network supports 25,000 jobs annually [11]. Naturally, the growth in different segments is uneven in various countries. In the US, for each job in the high-tech industry, five additional jobs, on average, are created in other sectors [12]. Apart from job creation, innovation in ICT contributes to GDP growth also. For instance, the doubling of mobile data use caused by the increase in 3G connections boosts GDP per capita growth rate by 0.5% globally and, the Internet accounts for 3.4% of overall GDP in some economies. Most of this effect is driven by e-commerce, wherein people advertise and sell goods online.

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Furthermore, ICT has enabled the emergence of a completely new sector such as the Appindustry. Research shows that Facebook apps alone created over 182,000 jobs in 2011, and that the aggregate value of the Facebook App economy exceeds $12 billion [13].

The workplace has also undergone transformation in many ways – e.g., new "***microwork***" platforms, developed by companies such as theDesk [14], Amazon and Samasource [15], help to divide tasks into small components,so they can then be outsourced to contract workers. The contractors are often based in emerging economies such as India. ICT has given boost to entrepreneurship, making it much easier for self-starters to access best practices, legal and regulatory information, marketing and investment resources. Indeed within the OECD (Organization for Economic Cooperation and Development) countries, more than 95% of businesses are having online presence [16]. Due to this, it has been possible to reach out to customers and competing for market share across the world.

Keeping in pace with the rapid transitions happening in ICT, over the last four decades, technology entrepreneurship has become an increasingly important global phenomenon.It has been perceived as one of the imperative areas necessary for growth, differentiation, and competitive advantage at the company, regional, and national levels. Technology entrepreneurship appeals mainly to leaders and top management teams of small and large firms and, also to personnel of regional economic development agencies that attract investments in productive technologies and talent that suit to a particular geography. Such people use technology to create, deliver, and capture value for their stakeholders [17]. Such technology entrepreneurship leads to the assembly of a combination of specialized individuals and heterogeneous assets in order to create and capture value for the company through collaborative exploration and experimentation. The combination, some of the assets, or the assets' attributes, may be unique and novel and that the initial combination may change over time.
As can be evidenced from the above arguments, technology entrepreneurship focuses on collaborative production, based on shared vision of future changes in technology. A shared vision of change in technology influences why, when, and how a company creates and captures value.Therefore the need for entrepreneurship development, intensively and extensively, should be registered in clear and loud terms in India, if the country wants to take a leadership role in various aspects of technology.

3. INTERNATIONAL PERSPECTIVES ON SCIENTIFIC AND TECHNOLOGICAL ENTREPRENEURSHIP

USA is the country of entrepreneurship and therein, Silicon Valley is the "***(Ad)venturer's Capital of the World***". The culture in Silicon Valley is that of inviting, imbibing and cashing-in on all aspects of life – be they relate to social, technical, scientific, arts, philosophy and others. In particular, the state of California is a multi-cultural society, where the Whites are minority. The concept of "Hire-and-Fire" (*aka* issue of Pink slip)is common, which leads to the survival of the fittest in the field. The Californian entrepreneurship culture permits experimentation, while trying to accommodate all points of views. The convenience of easy company culture, with an ability to interact with many people within and outside of an organization and a flat hierarchy aids the process of entrepreneurship. Companies permit risk taking and many types of risk takers are available – e.g., Venture capitalists, Angel investors, etc.

Indeed it is surprising to note that just one state of California contributes 25% of the GDP of USA and if it is taken as a country, California will be the eighth largest in the world in terms of GDP. The State seeds many types of entrepreneurial activities andformally supports many entrepreneurial initiatives such as, entrepreneurship meeting rooms, forums and the like [18]. The State also provides free training for prospective entrepreneurs on many aspects of entrepreneurship, including from the successful and unsuccessful ones. Indeed failure in entrepreneurship in California is glorified and the failed entrepreneurs are highly regarded for their rich experience. It is surprising to note that the state of Texas tried to emulate the Californian model, but in vain. Essentially it appears that the ensemble culture of California is unique and hence permits entrepreneurship of various nature [19].

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The leading EU countries of UK, Germany and France do have entrepreneurship initiatives of various types, but due to problems in linguistic and cultural differences and attitudinal disparities, individual multi-national entrepreneurship is somewhat nonexistent. The possible exception is the Airbus consortium and the Government funded ESPIRIT initiatives and the EU space program.

Japan was actively trying to catch up with the USA during the 1970s and 1980s when the economy was also booming, however, the present younger generations are uncertain about economic growth and the value of relentless work ethic. Clearly there is an ambition gap and, experts feel that such a climate does not bode well for entrepreneurship [22, 23].The factors hindering Japan's entrepreneurship activities include, but not limited to, monolithic culture and language, besides a seniority-based wage system (which is independent of worker's competency or productivity) and life-time employment (which in turn leads to risk-aversive behavior). As a consequence, the brighter employees tend to migrate towards larger corporates, which usually get a bigger share of the investments also. Indeed a Wharton report [21] says that the Japanese culture is "*not one that encourages risk-taking behaviors or the pursuit of unexploited opportunities*".This entrepreneurial gap is being narrowed down through addressing cultural gaps via integration of foreign skilled professionals in the Japanese workforce and addressing societal and educational and legal factors through appropriate education to Japanese managers [20]. This is in contrast to the USA, wherein entrepreneurship is deep-rooted in history and culture, wherein risk-taking is the norm – particularly in the state of California. Entrepreneurship lies in the fabric of American society with well-entrenched cultural and economic beliefs based on them. Unlike Japan, the fear of failure and resulting social alienation are not present in the US entrepreneurial culture. Instead, the US culture is about forgiving (or sometimes glorifying) failures with an open mind and foster debates in order that the failures are not repeated. According to research from Kaufmann Centre for Entrepreneurship, anywhere from 10% to 17% of adults in the USA are active participants in start-ups. Even in the landmark book "Venture Capital at the Crossroads" [46], William D.ByGrave and Jeffry Timmons refers to entrepreneurship as the secret weapon of the USA.

Neither students nor businesspeople take risks and "*the younger generation has become less ambitious*" [22]. During the 1970s and 1980s, the scenario was different and Japan Inc. was then aimed at catching up or even surpassing the USA. The younger generations are uncertain about economic growth and have come to question the relentless work ethic of the older generations. As a result, there is a clear ambition gap and, experts feel that such a climate does not bode well for entrepreneurship [23]. US-based venture capitalists generally view the Japanese market as too small and are willing to interact only with Japanese start-ups whose founders speak English proficiently or are interested in expanding their services outside the limited Japanese market.

According to the Global Entrepreneurship Monitor [24], nearly 25% of the adult population in China becomes entrepreneurs, twice as many as in the USA. Working with limited resources and against intense competition, these individuals have played a major role in the country's unprecedented growth. The Chinese government recognizes the crucial role entrepreneurs play in the country's rapid growth and tries to encourage entrepreneurial activity, in particular through increased access to funding. However, funding continues to be the greatest bottleneck for entrepreneurial growth. Writing in *Time* magazine in 2009, Beijing correspondent Austin Ramzy noted that China does not have a well-established system to rate credit, and banks often set standards that are too high for small businesses to meet. Furthermore, private entities may not operate banks, so commercial loans can be issued only by state-owned banks, which maintaina strongbias toward state-owned enterprises and other large, low-risk businesses. In addition, laws bar inter-company lending, preventing small businesses from obtaining loans from other businesses. Furthermore and in contrast to other countries, Chinese entrepreneurs focus largely on personal success, defined mainly by wealth and social status. They tend to pursue opportunistic, rather than passion-driven, industries and products.

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4. CURRICULUM REQUIREMENT FOR SCIENTIFIC AND TECHNOLOGICAL ENTREPREURSHIP

It is acknowledged in the literature that entrepreneurship knowledge and skills can be taught and developed provided the appropriate environment is provided (Gibb, 2005 [25];Kuratko, 2005 [26]) and that education plays an important role in the process of building entrepreneurial capacity (Hannon, 2013 [27]). There has been a notable expansion in the number of entrepreneurship programmes globally in recent times (Katz, 2005 [28]) although participation does not always lead to nascent entrepreneurship (Kuratko, 2005 [26]; Matlay and Carey, 2007 [29]). This has often been driven by the belief that education is best placed to equip students with the necessary knowledge and skills required to prosper in working environments (Kirby, 2003 [44]; Dhaliwal*et al.*, 2005 [30]). Existing entrepreneurship education literature however, still continues to question the successful integration of entrepreneurship into the curriculum (Gibb, 1999 [31]; Hannon, 2013 [27]), the extent to which it benefitsthe students (Chell and Allman, 2003 [32]) and the effectiveness of formal and informal entrepreneurship education (Hytti and O'Gorman, 2004 [33]).Fayolle*et al.*(2006) [34] also argue that entrepreneurship education varies widely acrosscountries and institutions in terms of objectives, audience, format andpedagogy.Furthermore, Hannon (2013) [27] submits that issues associated with quality, coherence and purpose can often dilute the effectiveness of entrepreneurship programmes. There has to be greater clarity regarding the purpose of entrepreneurship education; taking the local context into the design and development and imparting the entrepreneurshipprogramme.

There has to be greater mobility and exchange of experience, particularly in the development ofappropriate entrepreneurial learning models and the sharing of knowledge and good practice across sectors and national borders.It is generally argued that education and training programmes do not do enough to nurture entrepreneurial attitudes and skills, but rather prepare students for paid employment, despite some recent improvements in this area (Potter, 2008). Entrepreneurship skills can also be developed outside of the education system. Governments can partner with community and business organizations to bring students out of schools and into business. These programmes typically provide students with a first-hand look at the day-to-day operation of small firms. Alternatively, entrepreneurship mentorship programmes such as the '*Erasmus for Young Entrepreneurs*' programme[35] help new entrepreneurs acquire the skills for running a small business through interaction with other entrepreneurs (the next section includes more information on the role of mentoring in the curriculum). Youth business networks and associations are important for young entrepreneurs, because they provide mutual learning opportunities, business contacts and collective opportunities to represent youth interests to government and industry (Chigunta, 2002) [36].

In the light of the discussions above, we base our Technology and Scientific Entrepreneurship curriculum on three basic tenets, viz., Knowledge, Skills and Attitude. We believe that while all three of these attributes are important, attitude is what makes an entrepreneur. Therefore in our curriculum we emphasize and give more weightage to subjects that foster entrepreneurial attitude. Typically knowledge-inducing subjects will be 25% of the curriculum while skill-inducing and attitude-enhancing subjects will constitute 30% and 45% respectively.

As mentioned before, we believe that the potential entrepreneur can be "***Jack of All, Master of none***" and s/he need not be the expert at all in any one field. However, they should have the capacity to forward-think the potential applications of the invention/concept in science & technology to the wider community at large. We also emphasize skill sets such as oral and written communication, Team building ability, Leadership skills and exploring/exploiting available opportunities. In terms of attitude, the "***Do or Die***" and/or "***Success to Death***" (perseverance and aspiration) would be fostered in the curriculum through practical projects of various types (more in section 5.1.1 and 5.2.1). A great deal of emphasis is placed in the curriculum on ethics and its application to several practical contexts through experimentation and detailed examination of underlying social and cultural issues.

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Indeed, we also take exception to the CAT and GMAT type examinations often used for admission to various MBA programs in India and around the world. These exams evaluate a candidate's analytical/logical, verbal and arithmetic skills, and do provide a degree of measure of their ability to succeed in their MBA program/s. However, for the Scientific and Technology Entrepreneurship program, special entry tests – e.g., Entrepreneurship Aptitude Test [37], Entrepreneurial Potential Seal-Assessment [38], Entrepreneurial Aptitude Test [39] – need to be administered in order to evaluate their social attitudes and professional outlook. For our entrepreneurship program, our intake of students would have to undergo a battery of specialized attitudinal tests prior to commencing their program.

5. SUGGESTED CURRICULUM FOR SCIENTIFIC AND TECHNOLOGY ENTREPRENEURSHIP

The suggested curriculum for both scientific and technology entrepreneurship is provided in Table 2 for Bachelor's degree programs and in Table 3 for a Master's degree program. We describe the details of the curriculum and the need for various courses therein in the next two sections.

Curriculum For Bachelor's Program In Scientific/Technology Entrepreneurship

The Bachelor's program in Scientific/Technology Entrepreneurship – as provided in Table-2 – offers wide-ranging courses to augment the knowledge, skills and attitude of the person. The courses are indeed indicated accordingly with notations as **K** for Knowledge, **S** for Skills and **A** for attitude.

Table-2: Bachelor's Degree Program in Engineering/Scientific Entrepreneurship

Note: There will NOT be any prerequisites requirements for any of the subjects ONLY for this program. It is up to the students to judge his/her capability and take a particular subject.

Semester 1	**Semester 2**
• **A:** Psychology 101 • **S:** Communication Skills 101 + Lab • **K:** Computing 101 + Lab **Any THREE of the following:** • **K:** Mathematics 101 • **K:** Physics 101 + Lab • **K:** Chemistry 101 + Lab • **K:** Biology 101 + Lab	• **A:** Ethics 101 • **S:** Entrepreneurship Gaming 101 + Lab • **K:** Statistics 101 • **K:** Mathematics 201/Physics 201/Chemistry 201/Biology 201 • **K:** Core Engineering 101 (or) Core Science 101 • **K:** Engineering Practice 101 (or) Scientific Practice 101 (Lab based)

Semester 3	**Semester 4**
• **A:** Sociology 101/201 • **K:** Finance 101/201 • **A:** Applied Communication Skills 201 • **S:** Industrial/Product Design 101/201 • **K:** Specific Engineering 201 (or) Specific Science 201 • **K:** Specific Engineering 201 (or) Specific Science 201	• **K:** Economics 101 • **K:** Statistics 201/ (or) Small Business Management 201 • **A:** Intellectual History or History of Innovation • **K&S:** Business planning • **K:** Specific Engineering 201 (or) Specific Science 201 • **K:** Specific Engineering 201 (or) Specific Science 201

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• **S&A:** Guided Engineering Practice 201(or) Scientific Practice 201 (Year Long Course – to be run by an internal company)	• **S&A:** Guided Engineering Practice 201 (or) Scientific Practice 201 (contd. – Year Long Course – to be run by an internal company)

Semester 5	**Semester 6**
• **A:** Applied Ethics 301 + Lab • **S:** Project management 201/301 • **A:** Entrepreneurial finance& Investing • **K:** Specific Engineering 301 (or) Specific Science 301 • Elective • **S&A:** Mentored Engineering Practice 301 (or) Scientific Practice 301 (Year Long Course – to be run as an internal company)	• **S&A:** Understanding IPRs, Risks& Reliability (or) (or) Entrepreneurship in the Indian Context • **S&A:** Entrepreneurial marketing • **S&A:** Strategic decision making • **K:** Specific Engineering 301 (or) Specific Science 301 • Elective • **S&A:** Mentored Engineering Practice 301 (or) Scientific Practice 301 (contd. – Year Long Course – to be run as an internal company)

Semester 7	**Semester 8**
• **S&A:** Entrepreneurship Capstone Project(Year Long Course – to be run as an external company) – Fully mentored by external experts • Electives (up to TWO)	• **S&A:** Entrepreneurship Capstone Project(contd. – Year Long Course – to be run as an external company) – Fully mentored by external experts • Electives (up to TWO)

Electives (i.e., Advanced Courses)

- Entrepreneurial Economics 301
- Software Project Management
- Scientific Project Management
- Engineering Project Management
- Scientific/Engineering Leadership Development
- Operations Management
- Entrepreneurship Experience
- Company Law and Contract Law
- Advanced Industrial Finance
- Advanced Intellectual History or History of Innovation
- Strategic Management
- Advanced Industrial Design
- Scaling the Start-up – Legal, Finance, Management, Marketing& Filing for IPOs
- Organizational Mergers, Acquisitions, Integration & Restructuring
- Start-up Financing
- Metrics and Measures of Efficiency and Effectiveness

While a number of courses appear to be routine, several other courses have specific purposes. For example, courses such as Advanced Intellectual History or History of Innovation and Organizational Mergers, Acquisitions, Integration & Restructuring are highly specialized.

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Discussion on the Bachelor Curriculum

As noted before, the curriculum is articulated with the dominantly Knowledge, Skills and Attitudinal courses, with specialized courses on Technology/Science, various skills and attitudinal aspects. Besides foundational courses such as finance, economics and others, two courses, namely, Industrial/Product Design and Applied Ethics, have been included as core courses; these two courses combine advanced knowledge, skills and attitude into single entities. Several advanced electives – as listed above – have also been included in the curriculum. However three courses in the curriculum require further elaboration as noted below:

Guided Engineering Practice 201 (or) Scientific Practice 201 (Year Long Course): This year-long course provides the students with an opportunity to work as a team and manage all aspects of an actual in-house project. This project will be guided by one of the faculty members, who will account the work as part of an actual company.

Mentored Engineering Practice 301 (or) Scientific Practice 301 (Year Long Course): This year-long course is very similar to the previous one, except for increased complexity and requirement for advanced knowledge, skills and attitudes. Further, this will be a mentored course, thereby the faculty member will act only as a mentor and will not be directly involved in the day-to-day aspects of the internal company.

Entrepreneurship Capstone Project (Year Long Course): This year-long course will be fully mentored by external experts/entrepreneurs and this course will be run as an external company. As a consequence, real financing and accounting, development of an actual business plans, meeting with financing professionals (e.g., Venture capitalists and Angel investors), working with the Central and State Government bodies (e.g., Ministry of Industry at the State and Central Governments – see [40] for more details). This flagship project will actually lead to the establishment of a company that the student team will seed, shape, manage and evolve. This capstone course will call for the application of the students' knowledge, skills and attitudinal capacities to successfully complete. We expect at least 10% companies out of this to become real operational entities thereby providing an on-going entrepreneurial culture. The success of this course will be widely disseminated and celebrated through such mechanisms as seminars, workshops and interactive sessions with Venture capitalists and Angel investors.

Curriculum for Master's Program in Scientific/Technology Entrepreneurship

The Master's program in Scientific/Technology Entrepreneurship – as provided in Table-3 – offers focused courses to augment the knowledge, skills and attitude of the person. The courses are indeed indicated accordingly with notations as **K** for Knowledge, **S** for Skills and **A** for attitude.

Table 3: Master's Degree Program in Engineering/Scientific Entrepreneurship

Note: There will NOT be any prerequisites requirements for any of the subjects ONLY for this program. It is up to the students to judge his/her capability and take a particular subject.

Semester 1	**Semester 2**
• **A:** Industrial Psychology & Sociology 501 • **A:** Applied Communication Skills 501 • **K:** Industrial Economics and Statistics 501 • **S&A:** Project management 501 • **S&A:** Intellectual History or History of Innovation • **K:** Specific Engineering 501 (or) Specific Science 501	• **A:** Applied Ethics 501 • **S&A:** Entrepreneurship Gaming 501 • **S:** Industrial/Product Design 501 (or) Entrepreneurship in the Indian Context • **A:** Entrepreneurial finance & Investing • **K:** Specific Engineering 501 (or) Specific Science 501 • **S&A:** Mentored Engineering Practice 501 (or) Scientific Practice 501 (to be run as an internal

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	company)

Semester 3	Semester 4
• **S&A:** Entrepreneurship Capstone Project(Year Long Course – to be run as an external company) – Fully mentored by external experts • Elective	• **S&A:** Entrepreneurship Capstone Project(contd. – Year Long Course – to be run as an external company) – Fully mentored by external experts • Elective

Electives (i.e., Advanced Courses)

- Entrepreneurial Economics
- Understanding IPRs, Risks & Reliability
- Entrepreneurial marketing
- Strategic decision making
- Company Law and Contract Law
- Entrepreneurship Experience
- Software Project Management
- Scientific Project Management
- Engineering Project Management
- Scientific/Engineering Leadership Development
- Operations Management
- Advanced Industrial Finance
- Advanced Intellectual/Innovation History
- Strategic Management
- Advanced Industrial Design
- Scaling the Start-up – Legal, Finance, Management, Marketing& Filing for IPOs
- Organizational Mergers, Acquisitions, Integration & Restructuring
- Start-up Financing
- Metrics and Measures of Efficiency and Effectiveness

Discussion on the Master's Curriculum

At the Master's level, we expect the students to have sufficient background knowledge in the area/s of their expertise and, as a consequence, the number of courses covering the Knowledge part is less. Notwithstanding this, the students have the opportunity to take up a few advanced courses in their knowledge areas or closely interested areas. The emphasis at the Master's level is on the development of skills and attitudes and hence most of the courses are targeted against them. Courses such as Industrial/Product Design and Intellectual History (or History of Innovation) are intended to inculcate the spirit of entrepreneurship and enhance their lateral thinking abilities [41]. In addition, there will be a one-semester Mentored Engineering Practice 501 (or) Scientific Practice 501 course which will be run as an internal company along the lines described in section 5.1.1. Furthermore, the year-long Entrepreneurship Capstone Project will be run as an external company and will be fully mentored by external experts and will be along similar lines to the Bachelor's program. However, the degree of knowledge, skills and attitude set required in these cases would be at a higher level – i.e., levels called for at the Master's level. It is also noted that the program does offer several advanced electives that can improve the students' overall abilities to start, manage and run a company successfully.

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6. OVERALL DISCUSSIONS

The suggested curriculum for Bachelor's degree and Master's degree programs are comprehensive in terms of providing a sound degree of knowledge, skills and attitudes to the students as expounded in [43] for example.The curriculum offers both good breadth and depth of materials and an extensive list of electives also. The curriculums are embellished with courses that expose the students to actual entrepreneurship practices both in-house and external environment. Indeed at the Bachelor's level three sets of projects relating to entrepreneurship development are expected tobe completed – the first two being internally mentored, while the last one is externally supervised. Capstone projects are tailored so that students gain practical experience in running a company by actually working with experts and real entrepreneurs. The capstone projects call for real world interactions with many facets of entrepreneurship establishment such as, meetings with financial/banking executives, developing a strong business plan for a given target audience (e.g., angel investors, venture capitalists, etc). We expect even the in-take of students into the program be moderated by appropriate instruments that measure their entrepreneurial attitudes and predispositions. Our programs offer adequate core and advanced subject materials – in engineering and/or science – for the students to be aware of various calls for entrepreneurship activities. We also intend to evaluate their attitudes and dispositions in the '***spirit of entrepreneurship***' requirements so those who are unwilling and unable to jump the risk gap/s may be nudged to move onto other programs – this issue will be made aware to the students well in advance. Finally we anticipate at least 10% of our students at both Bachelor's and Master's levels to become actual entrepreneurs and succeed in their career. Indeed we wish to measure the success of our two programs through the number of entrepreneurs that these two programs seed and how they shape the culture and spirit of the society in and around our graduates. We do not want to create geniuses from of these programs, instead a set of people who can raise up to the challenges of human society through their abilities to motivate and manage people around them in order to accomplish their vision – in that process they will comprehend and work with risks for which a solution might not exist when they started, but a solution becomes viable as they work on and on and on their problems.

7. CONCLUSIONS

India is fast transforming from agrarian society to service oriented society – in 1960s over 90% of the working population was in agrarian activities, but now 49% are in that industry. Presently some 31% of the population is in service industry and this is likely to increase to around 60% by the year 2030 [42]. This implies that more entrepreneurs are required to take India to the world stage as a lead player. Further, entrepreneurship in Science and Technology is needed now in India, if she wants to lead the world in terms of its overall GDP and number of IPRs – two important measures that people associate with developed countries. With significant number of educated youth population, India is ideally suited for fostering entrepreneurship culture, provided steps are taken at the grass root level, namely, introduction of curriculum that is feasible when it comes to implementation and experimentation.

Science and technology offer a significant way forward – indeed, technology in particular can lead to many small time entrepreneurs, while science can give raise to large scale entrepreneurs. Biological sciences and IT provide the best options for seeding and shaping variousentrepreneurial activities. Agricultural sciences and defense technologies also offer many avenues for entrepreneurial activities.

This paper describes a comprehensive curriculum for both Bachelor's and Master's programs in Technology/Scientific Entrepreneurship. All courses are mapped onto three important parameters of Knowledge, Skills and Attitude. Several year-long courses have been the lynchpin of these programs, whereby students gain practical experience both in-house and also working with experts and actual entrepreneurs. We hope our programs offer a good way forward for India's entrepreneurship owes. The detailed syllabuses for each of the courses are available with the authors.

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