

Teaching engineering-based new product innovation and entrepreneurship to engineers and business professionals

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Abstract

Business and engineering students at Auburn University learn new product development and startup business-plan development in an established program. Using the author's new book on the subject of Technology Entrepreneurship, this session gives a total blueprint to teachers interested in teaching technology entrepreneurship to engineering and business students/professionals.

Keywords: Technology entrepreneurship, technology innovation, textbook

Introduction

Without a worthy product, there can be no technological innovation. Therefore, the first and foremost concern of technological innovators should be the idea (Phase 1, defined later) and the resulting product (Phase 2, defined later). Before the product is strongly defined, it is premature to worry about the business issues of innovation such as financing, marketing, incorporation, management teams, and other “frightening” aspects of the later Phases of technological innovation (Phases 4-7, defined later). The message of this paper is, “Engineers and scientists, please define and refine your technology first!”

Innovators’ paralyzing “fear of the unknown”

While invention is a new or different idea, innovation is a new or different idea that is successfully introduced for commercial use. Thus, innovation means a product containing one or more novel ideas or inventions that is useful to a customer, who pays for it. Successful innovation is a product based on an invention(s) that brings stable profits for a business based on the product.

As the director of an Auburn University program that teaches technological innovation to engineering and business students, and having mentored those wanting to start a business or writing patent applications, I have found that young innovators are prematurely intimidated by what they “fear” lies ahead of them—let’s call it, “innovator’s fear of the unknown.” As a consequence of some misplaced fears about unknowns about innovation, inventors/innovators frequently fail to move forward with their ideas.

A phased view of innovation reduces the “fear” of the unknown

A phase-wise view of technological innovation, at the heart of a new book by the author (Swamidass, 2013), introduces technological innovation (TI) in seven phases. According to this unique phase-wise view of TI, it starts at the idea Phase 1 and, to be considered a success, must reach Phase 6, when it produces stable profits for the company. Between these two Phases lie several critical intermediate Phases of technological innovation. In most cases, one Phase runs into the other, and the line separating one Phase from the next is blurry and porous.

The unique phase-wise view of technological innovation is easier to grasp initially for a new innovator; later, with more exposure to technological innovations, the same reader could digest a more integrated and homogeneous view of the seven phases of technological innovations.

Engineers and scientists play a vital role in the first two Phases of technological innovation, when the product idea is conceived and translated into a viable product with a potential target market. A business plan is the output of the third Phase and signals the end of Phase 3. The first three Phases are not strictly sequential but are often iterative. Phase 3 will need the assistance of people with business background. An inventor, who is on top of Phases 1 and 2, must bring in the expertise of people with entrepreneurial and business background to help with Phase 3.

There are several alternative avenues for embracing business expertise during the Third Phase. One approach would be to form a Board of Directors with partners who bring business and investment expertise to the Third Phase for preparing a business plan.

The pre-startup and execution phases of innovation

The first three phases are the **Pre-Startup Phases**. The success of the first two phases lies heavily on the shoulders of the engineer/scientist. The innovator must find and interpret customer needs during the product development in Phase 2.

The benefits of educating our business and engineering students more clearly about the early phases of technological innovation may enable aspiring innovators to move forward with their ideas without getting bogged down by the fear of unknowns of the **Execution Phases** 4 through 6.

Thus, innovative engineers and scientists must devote their time to Phases 1 and 2 without getting crippled by the fear of Phases 4-6. Further, the success of Phases 4-6 depends on the success of Pre-Startup Phases 1 and 2.

The seven phases of technological innovation/entrepreneurship

To those who are relatively new to technological innovation (TI), the biggest challenge is to understand where technological innovation begins and ends, and what lies in between. The Seven Phases in the long technological innovation journey are described in this paper to bring greater clarity to the technological innovation process, and prevent the premature abandonment of potentially successful innovations by aspiring innovators.

A technological innovator does not tackle all the seven Phases of technological innovation at the same time. Further, a lone technological innovator is not the one to tackle all seven Phases of technological innovation. As the innovation takes shape and

progresses, it will need the original inventor and others with different skills to reach the seventh Phase of the innovation cycle over many years.

There is no hard and fast line at the end of one Phase and the start of the next. Further, there are many parts of a Phase that may be iterative; for example, during Phase 2, product development goes through many iterations. Therefore, while a sequential progress is implied, it is not strictly a one-directional progress from start to the end of Phase Seven.

After crossing Phase 3, a fraction of surviving businesses are terminated in each of the subsequent phases; thus, only a fraction of businesses that emerge from Phase 3, survive until Phase 7.

A business plan is the finished product of the third Phase. For a new innovator looking ahead, Pre-Startup Phases 1-3 should appear more manageable and less threatening than Execution Phases 4-7. Phases 1-3 will set the stage for Execution Phases 4-7, which need the expertise of business professionals.

Phases 1-3: Pre-Startup

First Phase: Conceiving the product idea

1. Define market need or problem;
2. Define target market;
3. Define Problem solution—idea for a new product or service; and
4. Go to Phase 2.

Second Phase: Product development I; pre-startup

5. Develop the product; the heart of the business
 - a. Develop functions and features of the product;
 - b. Design and redesign of the product; components and parts;
 - c. Protect intellectual property through patent applications (trade secret is an option too);
 - d. Develop drawings, dimensions, specifications, and tolerances for components;
 - e. Select materials to be used; and
 - f. Select assembly and parts manufacturing processes or procurement options.
6. Go to Phase 3.

Third Phase: Business planning Phase—get input from business professionals/ partners/ board of directors

7. Clarify the business model—how the business would produce income?
8. Prepare a business plan that includes:
 - a. The need;
 - b. Clear description of the product, what is the value to potential customer?;
 - c. Intellectual property protection described;

- d. Target market, marketing, sales and distribution;
 - e. Manufacturing, or supply chain;
 - f. Cost estimation;
 - g. Projection of demand, breakeven analysis;
 - h. Management team on paper, staffing, and phased hiring;
 - i. Estimate cash flow, investment needed, and profits;
 - j. Financing options selected; and
 - k. Meeting state and federal regulations and costs.
9. Use business plan document in Phase 4 to raise capital from investors and others, use it as a draft blueprint for Execution Phases that follow; go to Phase 4.

Phases 4-7: Execution Phases—Financing the Startup and Beyond

Success in the execution Phases 4 and 5 are often a function of the first three pre-startup Planning Phases

Fourth Phase: Find capital (estimate, 1-24 months)

- 10. Firm up the board of directors, put together a management team gradually;
- 11. Form the legal entity for the new startup, incorporation, etc.; set target for funds needed to launch the startup; if funds are raised from private investors, prepare SEC approved papers for raising funds from investor in exchange for a share of company ownership;
- 12. Raise capital by marketing the business plan to:
 - a. Family, friends;
 - b. Early stage investors, angel investors; and
- 13. Refine the business plan as needed and go to Phase 5 (Phases 4 and 5 could merge in some cases).

Fifth Phase: Create startup (estimate, 3 to 30 months)

- 14. Facilities may be needed: build or rent (incur expense);
- 15. Establish staffing, functions, responsibilities, subcontractors to accomplish:
 - a. Order processing and fulfillment system;
 - b. Marketing, sales;
 - c. Production/procurement;
 - d. Personnel recruitment and policies;
 - e. Accounting/finance; tax and legal matters;
 - f. Get permits; meet local, state/federal regulations.
- 16. Produce goods and make sales, and produce revenue;
- 17. Continue research and development, and continue product development II** (new expense);
- 18. If sales is surprisingly strong, scale up the business promptly, and hire more professional managers and move to Phase 6** (Yahoo! and Earthlink experienced surprisingly strong

- sales instantly), if scale up is disappointing, the Board to review the product, market, business model, management; but
19. If the business is scaling up as expected or better, move to Phase 6.

Sixth Phase: Financial steady state/maturity (24-100 months)

20. Scale up production in terms of operation facilities, staffing of all kind (research, production, marketing, sales, order-taking, etc.); respond to competition; grow the business;
21. Raise additional capital through legal processes to raise private equity from individuals, angel investors/clubs, or venture capital firms;
- 22. Continue R&D and product development III;**
23. Try to understand and enhance the target market;
24. Develop the supply chain for efficiency, cost reduction and effectiveness;
25. Increase and stabilize profits; manage growth; use professional managers;
26. Two end-game options:
- g. Sell company for a good financial return to original investors and the innovators—this is the **end of the journey for the innovators with this startup**;
 - or
 - h. Launch IPO and **become a public company**, and list on the stock exchange with help from an investment banking company; IPO example: Yahoo!, Facebook, Google, etc.; innovators continue with the firm; go to Phase 7 as a public company;
27. If not sold, and no IPO issued, company remains private company, go to Phase 7 as a private company.

Seventh Phase: Beyond maturity (could be to perpetuity)

- 28. Product development-IV; in response to competition, continue to invest in R&D, and introduce new products for continued growth;**
29. Achieve stable and growing profits; satisfy investors;
30. Review the business model;
31. Revise and redirect the company as needed;
32. Expand, and grow through innovation and mergers;
33. In the perpetual technological company, bring new technological innovations steadily to the market—examples, IBM (founded more than 101 years ago in 1911), Intel (founded 1968) and HP (founded in 1939), are examples of perpetual public companies in the year 2012.
34. Founded in 1865, Cargill is the largest of all perpetual private companies in the US (\$119 billion revenue, 2010); Kingston Technology, founded in 1987 is a large private computer memory maker (\$6.4 billion revenue in 2010).

To an aspiring technological innovator, the above should come as a relief that only three Pre-Startup Phases are of immediate importance, while the other four Execution Phases, with all their unknowns and complexity, could wait.

For teachers of a course on technology innovation

One of the goals of the book by Swamidass (2013) is to equip teachers, who share the goal of training aspiring technological innovators in all three Pre-Startup Phases 1-3. A course outline is included in the Appendix of the book for interested teachers intending to offer a course on mastering Phases 1-3 to engineering/science and business students—it works well to teach the course to student teams made of business and engineering/science students. Such a course has been offered by the author, and the entire course content and teaching experience are captured by the book.

Conclusion

Young aspiring innovators among engineers and scientists must take the first step towards technological innovation by focusing on Phases 1 and 2 without being intimidated by what lies ahead in subsequent phases. This paper, in concrete terms, shows how the “fear of the unknown” that cripples young and new technological innovators could be overcome. Further, to those teachers, who wish to teach a course that gives the experience of completing Phases 1-3 to business and engineering/science students, the book by Swamidass (2013) is recommended.

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