Data Literacy for Entrepreneurs: Exploring the Integration of Pedagogy, Practice & Research at MIT

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1 Introduction

Innovation-driven entrepreneurship is essential and indispensable in the race to solve the world's major challenges, especially in the areas of health, information technology, agriculture, and energy. Discovering, accessing, and integrating information is critical to the success of innovation-driven entrepreneurship, and it is part of the Libraries' core role to improve the foundations for discovery, access, and integration.

¹ The authors describe contributions to this essay using a standard taxonomy (see L. Allen., Jo Scott, Amy Brand, Marjorie Hlava & Micah Altman, "Publishing: Credit Where Credit Is Due", *Nature* 508 (2014): 312-313). MA and NA provided the core formulation of the chapters goals and aims, and NA led the writing of the original manuscript. MA lead in developing methodology and data curation. All authors contributed to investigation and to conceptualization through additional ideas and through commentary, review, editing, and revision.

Education is a critical method of developing innovation-based entrepreneurs for the same basic reason that medical school and law school are necessary to develop successful doctors and lawyers. Most people believe that successful entrepreneurs are born that way, that they have a basic talent for creating companies that excel in the marketplace that can't be reduced and explained by training or education. According to Bill Aulet in his book *Disciplined Entrepreneurship: 24 Steps to a Successful Startup*, this is a tired myth, and the real ingredients behind successful entrepreneurs are "skills that increase the odds of success, such as people management, sales skills, and the topic of this book, product conception and delivery."² These skills can be nurtured and taught at places such as MIT, through classes, accelerators, and programs. A 2019 article in *Research Policy* identified startup accelerators as a rapidly growing and increasingly important part of the entrepreneurial ecosystem, and noted the existence of up to two thousand accelerator programs globally.³

MIT is a global leader in education supporting this type of entrepreneurship: a 2015 report from the Institute's Sloan School of Management estimated that active companies founded by MIT alumni produce annual revenues of \$1.9 trillion, equivalent to the world's tenth largest economy. In terms of the curriculum at MIT, over sixty courses in entrepreneurship were taught during the 2016-2017 academic year.

The presence of a vibrant community of entrepreneurs at MIT provided an opportunity to study the information needs of this community in detail. This paper describes our project to characterize the information skills, needs, and challenges of two groups of entrepreneurs-in-training through an analysis of their reference questions, responds to online surveys, and statements made during semi-structured interviews. Based on this analysis we are able to identify unanticipated activities and needs, including the increasing ubiquity of primary market research and the corresponding need for students to develop the knowledge, skills and abilities to design primary market research and to collect, manage, and analyze the resulting data. This understanding can inform strategies and methods to address these challenges and aid in the design of innovative methods of library instruction which move beyond small group lectures.

2 EXPLORING THE INFORMATION NEEDS OF ENTREPRENEURS IN TRAINING

Based on a review of the MIT curriculum, we identified two separate groups of students at MIT who were best representative of entrepreneurs in training: those enrolled in 2.009 and delta v. We describe these classes in detail in section 4.

² Bill Aulet, *Disciplined Entrepreneurship: 24 Steps to a Successful Startup* (Hoboken: Wiley, 2013), 3.

³ Cohen, Susan, Daniel C. Fehder, Yael V. Hochberg, and Fiona Murray. "The design of startup accelerators." *Research Policy* 48, no. 7 (2019) at 1781-1787.

We employed a mixed-methods approach to explore the timing, types, and intensity of information needs among participants in 2.009 and delta v. This approach involved a designed survey, semi-structured interviews, and manual coding of electronic reference questions.

We designed these measures to identify which stages of the information-gathering phase of entrepreneurship were most time consuming, which part of that process was the most challenging, the resources and tools they used during these stages and processes, and any perceived gaps.

In particular we aimed to measure five areas:

- Time spent on market analysis versus business model development and the most challenging part of each process.
- The relative challenge of identifying and evaluating sources and extracting and analyzing information.
- Resources, tools, and methods used by subjects to locate, extract, and collect information.
- Barriers and gaps, such as missing tools or restricted resources, that subjects recalled.
- Aspects of the information-seeking process that were most surprising to subjects.

To operationalize the first three conceptual areas we constructed closed ended questions that enumerated specific information skills and entrepreneurial process phases, using the taxonomies described in section 3. The remaining two areas were measured with open-ended questions, using standardized wording.⁴ The full list of survey measures is provided in

Appendix A.

We used three related approaches to collect measures.

- We implemented these measures in an online survey instrument by standardizing the closed ended questions to agree-disagree statements using five point Likert scales. This survey was distributed to all delta v participants as an opt-in experiment in the pilot phase, and was then used systematically to evaluate information officers in 2.009.
- We integrated these measures into semi-structured interviews with selected information officers in 2.009. These interviews were framed as informal narrative recollection of the information seeking process, in which the list of questions were used as focusing aids.
- The taxonomies used to measure questions 1 and 2 (see Appendix A, questions 1-3) were adopted as categories to manually classify reference questions submitted by all participants during the course of each class.

⁴ Generally in designing the survey and semi-structured interview instruments we adopt the methodology described in (respectively) Groves, Robert M., Floyd J. Fowler Jr, Mick P. Couper, James M. Lepkowski, Eleanor Singer, and Roger Tourangeau. *Survey methodology*. Vol. 561. John Wiley & Sons, 2011. and Leech, Beth L. "Asking questions: Techniques for semistructured interviews." *PS: Political science and politics* 35, no. 4 (2002): 665-668.

3 UNDERSTANDING THE PROCESS OF INNOVATION BASED ENTREPRENEURSHIP

In addition to a general framework regarding the information-related skills of entrepreneurs, we wanted a more general framework for entrepreneurial competencies.

The premier text for this is Aulet's [*Disciplined Entrepreneurship: 24 Steps to a Successful Startup*](#). It is the textbook for the delta v program, and its author is the Managing Director of the Martin Trust Center for MIT Entrepreneurship, one of the key parts of MIT's entrepreneurial ecosystem. Outside MIT, it has been translated into eighteen languages and serves as the text for three web-based edX courses taken by hundreds of thousands of people in countries all over the world.

In this text, Aulet outlines twenty-four sequential steps for teaching innovation-driven entrepreneurship and making your IDE (innovation driven entrepreneurship) startup successful. These steps are conceived as a toolbox for both entrepreneurs and educators and can be grouped into six themes presented as questions:

1. Who is your customer?
2. What can you do for your customer?
3. How does your customer acquire your product?
4. How do you make money off your product?
5. How do you design and build your product?
6. How do you scale your business?

3.1 LINKING THE ENTREPRENEURSHIP PROCESS TO INFORMATION-RELATED SKILLS

The primary article in terms of identifying key information-related skills for entrepreneurs was "21st Century Knowledge, Skills, and Abilities and Entrepreneurial Competencies: A Model for Undergraduate Entrepreneurship Education" by Trish Boyles.⁵ This delineated three broad categories of entrepreneurial competencies: cognitive, social, and action-oriented. The key information-related knowledge, skills, and abilities (KSAs) fell in the cognitive category, in particular:

- A habit of actively searching for information.
- The ability to conduct searches systematically.

⁵ Trish Boyles, "21st Century Knowledge, Skills, and Abilities and Entrepreneurial Competencies: A Model for Undergraduate Entrepreneurship Education," *Journal of Entrepreneurship Education* 15, (2012): 41-56.

- The ability to recognize opportunities when not actively looking for them by recognizing connections between seemingly unconnected things.
- The ability to critically evaluate information and distill it down to what is useful and relevant.

After identifying these KSAs, we then connected groups of skills to steps in Aulet's text:

Group 1:

Aulet Steps: Market Segmentation, Select a Beachhead Market, and Build an End User Profile

KSA's: Ability to critically evaluate information and distill it down to what is useful

Group II:

Aulet Steps: Calculate the Total Addressable Market (TAM) for the Beachhead Market, Quantify the Value Proposition, Calculate the TAM Size for the Follow-on Markets, Calculate the Lifetime Value (LTV) of an Acquired Customer, and Calculate the Cost of Customer Acquisition

KSA's: Launching a new venture often involves doing so in the absence of all the relevant data and requires utilization of some method of moving ahead successfully with the information available. Entrepreneurs are taught to develop and apply heuristics in these situations in order to act decisively in the face of uncertainty. Information, media, and technology literacy and inventive thinking are necessary KSAs needed to create these heuristics.

4 CHARACTERIZING ENTREPRENEURS-IN-TRAINING

4.1 MIT delta v

MIT's delta v accelerator program is widely considered the capstone entrepreneurial experience for students at MIT. Sponsored by the Martin Trust Center for MIT Entrepreneurship, delta v is offered during the summer in two locations, the MIT campus in Cambridge, Massachusetts, and the NYC Startup Studio in Manhattan. The purpose of delta v is primarily educational in nature, and neither the accelerator or MIT take an equity stake in the teams accepted, unlike many other accelerators around the country. The educational backbone of delta v is the twenty-four steps outlined in Aulet's *Disciplined Entrepreneurship*. Teams receive customized mentoring, working space, \$2,000 a month in living expenses for each qualified student, and up to \$20,000 in additional funding for those teams which achieve certain milestones. At the conclusion of the program, teams pitch their products and services at Demo Day in Cambridge, New York City, and San Francisco.

The most recent completed delta v cohort of 2019 consisted of eighty-three percent masters students, ten percent undergraduates, three percent doctoral students, and three percent post-docs. Sixty-five percent were from MIT, and of these thirty-six percent were from the Sloan School of Management and twenty percent were from the School of Engineering. Altogether, there were twenty-four teams total, with one hundred entrepreneurs participating in the program, and an average of four members per team.

Participants in the program work full time over the course of the summer on the following goals:

- Defining and refining their target market.
- Conducting primary market research about their customers and users.
- Running experiments to validate or invalidate hypotheses regarding potential customers.
- Building and nurturing their founding team.

4.2 2.009

All students enrolled in the Department of Mechanical Engineering at MIT are required to take the senior capstone course, and many of these students opt for the popular class Product Engineering Processes, known campus-wide by its course number 2.009. This course, typically taken in the final fall semester, requires students to work collaboratively to develop prototype products that are then unveiled in early December at a large event streamed worldwide. Over the course of fourteen weeks, approximately 150 students work on one of eight teams to ideate, design, test, and build products that are inspired by the overall theme for that semester. The teams are named after colors, and students all have specific roles on their team. As part of our work, we interviewed students who were the information officers for their respective teams.

At MIT, 2.009 is a unique opportunity for mechanical engineering students to gain hands-on experience in product design and development. It is also one of the few engineering classes where students develop skills related to entrepreneurship and business. Along with their product prototypes, students also must identify the market for their products, develop business models, and be able to effectively communicate the utility of their product. For many students, 2.009 represents a crash course in entrepreneurship.

A distinct aspect of the organization of 2.009 is the ‘information officer’ role. Each of the eight teams selects two information officers, who work together to coordinate information for the team. Information officers hold primary responsibility for sourcing, collecting, and curating information. Thus information officers are a natural focus for evaluating the information needs of the class.

Throughout the semester, student teams work towards six major milestones outlined below. For the first three milestones, the teams are split into A and B subteams (ie. Team Orange A or Team Orange B). The first milestone is the Three Ideas Presentation, where the subteams present three product ideas to the entire class. After these presentations, the subteams participate in the Sketch Model Review. At this event the subteams share low fidelity models of three potential products. The last milestone where the students are in subteams is the Mockup Review, at which time the subteams must address key challenges for two product ideas and identify ways to address these challenges in the next stage of product development.

After the Mockup Review, both subteams come together to decide on one product to pursue for the remainder of the semester. The teams share the designs for the product at the Assembly Review and then develop working prototypes as part of the Technical Review. After receiving feedback from instructors and peers, the teams develop a high fidelity, working prototype for their product, which is unveiled at the Final Presentations that occur at the end of the semester.

5 RESULTS

5.1 Delta v Pilot Results

The librarian for delta v is contacted directly by the program's startups throughout the summer as they progress through the steps of Aulet's *Disciplined Entrepreneurship*. An examination of the questions received in the summer 2019 delta v program revealed that the questions fall into the following broad categories:

- I. Questions on the size of a highly localized beachhead market of a very specific product or service, in the past, present and projected into the future.
- II. Questions on the process and timing of filing for patent protection.
- III. Legal questions related to founder and incorporation agreements.

The liaison for delta v receives roughly five to ten questions from the startup teams over the course of the summer, with the overwhelming majority coming early in the semester, usually within two weeks of the presentation he gives in early June. Nearly all of the questions are quick, one-sentence questions about where best to find information, although a good number of these lead to lengthy, in-person consultations. Roughly two thirds of questions fall into category I, with the remaining third mostly relating to category II.

We launched a pilot opt-in version of this survey at the conclusion of the program in September 2017, conducted over two weeks, in which six students participated.

The low response rate for this survey cautions against general conclusions; however, some suggestive patterns emerged. All of the entrepreneurs surveyed reported that market analysis

was the most time-consuming phase involving seeking, collecting and analyzing information, and all of them used a library resource in their search for information. Further, nearly all of the entrepreneurs found evaluating sources of information and summarizing, analyzing and mining those sources challenging or very challenging--and almost all relied on manual copying and pasting to extract or collect information they discovered.

5.2 2009 Results

The 2.009 course librarians receive direct emails from 2.009 teams throughout the fall semester as the course progresses through its milestones. An examination of the questions received in the fall 2019 semester revealed that the questions fall into the following broad categories:

- I. Questions on the national or global market size of a very specific product or service, in the past, present and projected into the future.
- II. Patent research questions meant to uncover whether or not a specific product already exists and is under patent protection.
- III. Standards or regulatory questions.
- IV. Benchmark costing questions.

The 2.009 course librarians receive an estimated twenty to twenty-five questions from 2.009 students over the course of the semester, usually in the days leading up to one of the course milestones, with questions increasing as the final presentation approaches. These questions tend to be either multipart, bullet-pointed questions or quick one-sentence questions asking for suggestions of where to look. Roughly half of the questions fall into category I with the remaining half distributed between categories II-IV. These questions often recur for each evolving product/service the teams are working on at a given point of the semester.

These patterns are reinforced by surveys and interviews of the information officers. Following completion of the class we contacted all information officers to participate in this evaluation. Information officers representing six of the teams (out of eight teams, representing 75% of the class) responded. From these responses, three patterns were immediately clear:

First, the majority of the respondents reported that their sketch model review (stage 1) was the single most information intensive stage of the project. While this is not surprising, it may be notable that no respondents identified the middle phases (technical review, assembly review) as the most challenging.

Second, clusters of respondents reported that the information-related objective they found the most challenging was calculating market size, benchmarking and pricing, and collecting information on potential adopters. The latter, reported through the "other (please specify)" response, was unanticipated and highlights the increasing importance of primary data collection.

Third, as illustrated in **Figure 1** , most information tasks were not found to be difficult challenges for most teams. Isolated teams found the characterization, extraction, summarization, collecting tasks to be moderately difficult.

Figure 1. Information task difficulty. Horizontal lines for each group show the difficulty of each task on a seven point scale. White boxplots show the distribution of responses for each task. Note: Only two responses received for the create task; missing values are set to the minimum response.

A notable element uncovered in our interviews and surveys of 2.009 information officers was the need to collect tailored information about potential adopters and the challenge they experience in conducting primary research to obtain this information. In the initial stages of product development, they often struggle to identify who the best target customer for their product will be. The information officers, and the broader teams of which they were a part, then have difficulty accessing industry experts on their given product or service. Lab instructors and mentors for 2.009 assist students with this, locating appropriate experts using their professional and personal networks. In the matter of surveys, choosing the most appropriate survey tool can be challenging and confusing, as is locating which tools are freely available to them as MIT students. This challenge on the primary market research side of things in some ways isn't that surprising as nearly all 2.009 students are mechanical engineering students, not business majors, and this may be the first exposure many of them have had to direct consumer research.

Information officers for 2.009 report difficulty with extracting data they needed and summarizing and analyzing this data in a way that answered the specific questions they had about a given product or market. The summary and analysis part can often be challenging for the type of products and services they're developing, as these are often highly specialized and cutting edge given the nature of education and research at MIT. Comprehensive market research reports don't usually exist for the exact product or service they're working on, requiring them to come up with market size, pricing, and revenue projections based on fragmentary data or data at a much higher industry level. The 2.009 students do attend workshops on pricing and benchmarking offered by mentors with an expertise in this area, but librarians could offer workshops, online modules and video tutorials on creating secondary market statistics and projections extrapolating from higher-level existing data.

Later stage startups at colleges and universities, represented by the cohort of MIT delta v teams, generally require much less guidance in the area of consumer research, as many of them have a business background or are MBA students. Delta v teams, outside of questions related to secondary research on highly localized beachhead markets, are often looking for help and strategic advice on the process and timing of filing for patent protection. A related need of these startups is guidance in the writing of founder agreements and the choice of the most appropriate legal structure for their business.

While information officers in 2.009 find extracting and interpreting data and/or information difficult, we found that most students are familiar with locating information through library databases and other web-based tools, and that the library website and course LibGuide are used by students. Students reported that they lacked skills related to assessing sources for relevancy and integrating found information into their own research. Additionally, teams utilized personal and professional networks to find information. Multiple teams employed targeted surveys of users or stakeholders for their project, but, as mentioned above, selecting survey tools and extrapolating from survey results was challenging for the teams. While these skills are integral to information literacy, many of these methods of collection and integration of information at the scale of the 2.009 project are new to students.

6 DISCUSSION

These case studies should not be viewed as typical of entrepreneurship training, but instead as a sample of the leading edge of scientific and technical entrepreneurship education. As such, the cases provide data about information needs that are emerging in the field and about gaps that the field has yet to address.

Cases such as the ones examined in this paper can probe the limits of current approaches and definitions. These cases illustrate the problems users experience in collecting information from or about people from primary sources, as well as challenges that information users encounter in assessing, curating, integrating, measuring and interpreting such information. The near-ubiquity

of mechanisms for running surveys, mining social media information, etc., contrasts with the lack of formal training across educational institutions for use of these sources.

This pattern implicates a much broader set of informational skills than is typical in information literacy support, although it is consistent with the core definition of information literacy as “the set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the information needed.”⁶ remains relevant, and with the existing frameworks (“research as inquiry” , as defined by ACRL, is particularly relevant to this form of literacy⁷).

Entrepreneurship librarians could assist early stage startups in the primary research process in a number of different ways. Creating a Libguide or wiki listing and annotating the free and subscription-based survey and data-collection tools available to them, along with introductory texts on conducting direct consumer research, would be an obvious choice. They could curate a list of relevant local and national industry associations or interest groups related to specific products and services and add these to course management systems. The ideal relationship for offering this type of assistance to entrepreneurs in the making is the embedded course librarian. The course librarian has a front-row seat where they can view the evolving nature of product and business development up close, editing and enlarging these curated lists and guides in real time. Embedded librarians could also offer hands-on classes in survey design and the ideal way to conduct user interviews as part of the normal schedule of workshops put on by classes like 2.009.

Many later stage startups don’t yet have the funds to pay for consultants or lawyers in the areas of patent strategy or business incorporation, so a curated list of free local resources in this area would be very beneficial. A number of universities have legal clinics where entrepreneurs can seek guidance in these areas free of charge. The broader entrepreneurship ecosystems located around universities often have experts in patent strategy who work with accelerators as mentors who could be listed in password authenticated resource guides

We hope these case studies will prompt other universities to investigate the specific information needs of entrepreneurs, particularly students in non-traditional settings like accelerators, incubators, and competitions as opposed to the classroom. As particular information needs are identified, librarians can better address them through targeted workshops and instruction.

⁶ Association of College and Research Libraries: <http://hdl.handle.net/10150/105645> American Library Association. "Information literacy competency standards for higher education." (2000).

⁷ Association of College and Research Libraries (ACRL), (2015) "Framework for Information Literacy for Higher Education", <http://www.ala.org/acrl/files/issues/infolit/framework.pdf> .

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8 APPENDIX - Survey Instrument

1. At what stage of your project did you spend the most time seeking, collecting and analyzing information?
 - a. Sketch model review
 - b. Mockup review
 - c. Assembly review
 - d. Technical review
 - e. Preparation for final presentation
2. During the stage which took the most time, what was most challenging in terms of information seeking, collection, and analysis?
 - a. Calculating the total market size for your product
 - b. Choosing a business model
 - c. Benchmarking/Pricing
 - d. Choosing a beachhead market
 - e. Other (please specify)

3. How challenging was each of these tasks?
 - a. Characterizing the information you needed
 - b. Identifying sources for that information
 - c. Evaluating information sources you identified (for completeness, credibility, etc.)
 - d. Extracting information from the sources you identified
 - e. Summarizing & analyzing information
 - f. Other (please specify)
4. Which of these resources and tools did you use to locate information?
 - a. Library resource or database
 - b. Government source
 - c. Article or report found by searching the web
 - d. Social media source
 - e. Other (please specify)
5. What were the most useful tools you used to seek, collect, or analyze information? Why?
6. If you know of existing information sources or tools that were not available, but would have been useful to you, please describe them.
7. If you sought assistance in locating, collecting, or analyzing information from others please describe. (What help were you seeking? What organizations or types of people did you ask for assistance?)
8. What were the biggest surprises you encountered when trying to seek, collect, or analyze information?
9. Do you have any other comments, questions, or concerns?

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