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From Lab to Market: Learning Entrepreneurial Marketing Through Multi-Semester, Stage-Gate, Capstone Project in STEM MBA

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Abstract

Entrepreneurs build successful businesses by taking innovative ideas from research labs to market. This article describes a pedagogical approach and its outcomes in utilizing a multi-stage, multi-course, and multi-semester capstone integrative project to teach entrepreneurial marketing (EM) of early-stage technologies. Herein we explain concepts and practices that enable the learning needed within STEM (Science, Technology, Engineering, Mathematics) MBA programs to commercialize and market products and services arising from new technologies. The pedagogy follows a four-course sequence that applies strategic frameworks and tools to develop opportunity space for a patented idea, develop the idea into product options, undertake customer discovery, build marketing and sales strategies, and translate opportunities into venture planning. These lab-to-market outcomes are accomplished by applying deliberate practice-based action learning methods to build students' knowledge bases and problem-solving process skills that increase their entrepreneurial expertise. Through learner engagement in a sequence of innovative, data-driven, analytical processes that focus on identifying, validating, and strategizing around scalable new ideas, this pedagogy enables students to learn EM skills that can be applied to different industries and companies at various stages of development but with an emphasis on early-stage technologies.

Keywords

entrepreneurial marketing, entrepreneurial expertise, lab-to-market, stage-gate process, research commercialization, new technology marketing, capstone project for STEM MBA

The *valley of death* is a term that has been applied in the field of entrepreneurship to characterize the chasm that often opens up, between the invention of technology and the efforts to commercialize it as a viable business, where the left side or entry to the valley of death is conceptualized as the discovery phase of the journey and the right side as commercialization (Markham, 2002; Ritter & Pedersen, 2022). Much is at stake here, given the 90% failure rate of new ventures in a global startup economy valued at $3 trillion (Ritter & Pedersen, 2022). The U.S. Federal government invests more than US$130 billion yearly in R&D at universities, federal laboratories, and companies. Therefore, it is expected that entrepreneurs will materialize and be motivated to transfer technologies from labs to markets, thereby enabling increasing innovation, job creation, societal impact, competitiveness, and economic prosperity (National Institute of Standards and Technology [NIST], 2022). Educational processes that enhance the entrepreneurial marketing (EM) skills and capabilities necessary to effect this transfer thus have an important role in taking lab inventions through the stages of productization, commercialization, marketing, selling, and scaling up of a business, to successfully cross the lab-to-market chasm.

Research on the educational processes that enhance EM skills and capabilities has developed well since it began in earnest in the 1990s. During the 1990s, there was a surge in interest in published research on education in entrepreneurship and small business management, with a growing number of courses and modules developed across business schools worldwide (Hills et al., 2010). During these early years, EM was confined to the context of small and medium businesses and new ventures (Kraus et al., 2010). More recently, given the broader scope of EM activities, scholars

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have been suggesting that EM can be applied to a wider variety of contexts, irrespective of company size and age (Alqahtani & Uslay, 2020; Kraus et al., 2010; Whalen et al., 2016). Thus, a consensus is growing among scholars that EM is a distinct discipline that can be the focus of EM education beyond explaining the interplay between entrepreneurship and marketing (Alqahtani & Uslay, 2022; Hills & Hultman, 2013; Whalen et al., 2016).

However, given the "rapid pace of technological change and disruptive innovation" (Worthington & Eggers, 2022, p. 127), there remains a need for further theoretical and conceptual exploration in the field of EM to create innovative and practical frameworks (e.g., Alqahtani & Uslay, 2022; Amjad, 2020; Etzkowitz et al., 2000; Gilmore et al., 2020; Stokes & Wilson, 2010), for "educating entrepreneurs, small business owners, and managers about EM concepts" (Worthington & Eggers, 2022, p. 127). For instance, the call for EM education to embrace uncertainty rather than certainty (Stokes & Wilson, 2010) may not yet be fully answered as scholars suggest that more work needs to be done to explore the role of concepts such as experimentation and agility within EM (Alqahtani & Uslay, 2022) to better enable both opportunity discovery and creation (Alvarez & Barney, 2007), and also the navigation of uncertainty (Fisher et al., 2020). It has also been suggested that EM generally is not part of graduate business administration curricula within business schools, although it is essential for the success of entrepreneurial efforts (Amjad, 2020; Etzkowitz et al., 2000; Gilmore et al., 2020). As a result, there is a need to find ways for EM to better integrate into the graduate business school curriculum. In addition, questions such as which topics to include in EM courses and who should take those courses are open-ended questions that warrant attention and further discussion (Alqahtani & Uslay, 2022; Uslay & Teach, 2009). Answers to these questions will help EM educators prepare entrepreneurs, would-be entrepreneurs, and managers for real-world practice, where they are facing, or will be facing, "rapid industry change and volatile competitive situations" (Worthington & Eggers, 2022, p. 127). Accordingly, in this article, we address the research question:

> **Research Question 1:** How can EM educators design and validate innovative and practical frameworks that can educate entrepreneurs, would-be entrepreneurs, and managers in a variety of ventures, thereby preparing for rapid industry change and volatile competitive situations?

Thus in this article, we present an innovative and practical pedagogical approach for educating STEM MBA students using the EM processes essential to technology commercialization, with courses that can form an integral part of the graduate business curriculum. We begin by providing background from the literature that addresses pedagogical aspects of EM under two headings (a) an examination of the literature on EM in the context of early-stage technology commercialization and (b) the need for pedagogical innovations in EM education. We then identify several emergent frameworks in an EM pedagogy that provides students with a more immersive and experiential learning platform to develop relevant skills. Following this, we propose the conceptual frame pertaining to the specific pedagogical approach that is the focus of this article; and we present particular aspects of this innovative approach to EM action learning, along with data supporting the efficacy and outcomes of the approach we offer.

As a result of this study, we hope to make at least three contributions to advancing EM education. First, we contribute to EM education theory by explaining how an action-learning approach based on the deliberate practice method of expertise acquisition (Charness et al., 1996) can progress learners toward acquiring the EM expertise needed to function under early-stage uncertainty. This answers the recent call for "EM pedagogies in business . . . [to] be developed focusing on active learning and skill enhancement, rather than merely providing the functional understanding" (Amjad, Rani, & Sa'atar, 2020, p. 6). Second, we contribute to EM pedagogy by offering an approach that better enables EM education to become an integral part of graduate business administration curricula within business schools. This, in part, addresses the call by Gilmore et al. (2020) for "senior leaders in universities . . . to seek new ways of ensuring that the teaching and practice of EM are integral to university education" (p. 196). Third, we contribute to EM practice by providing an educational platform that supports coordination and collaboration among a variety of EM practitioners. This speaks to the recent call by Alqahtani and Uslay (2022) for EM educators to teach EM practices by offering answers to "key questions" about content effectiveness and delivery for improved use in practice (p. 411). Therefore, we proceed to lay the foundation for our study by providing key background.

Background

Our study is set within the EM conversation that addresses the potential of the proactive, innovative marketing field to teach entrepreneurs, would-be entrepreneurs, and managers how better to tackle problems created by the rapid pace of technological change and disruptive innovation, often under conditions of limited resources and uncertainty. In this section, we develop the research context within which our article is set, under the previously noted two main headings (a) an examination of the literature on EM in the context of early-stage technology commercialization and (b) the need for pedagogical innovations in EM education.

EM in Early-Stage Technologies

Early definitions of EM emphasized creating competitive innovation advantages (Gardner, 1994). As the practical context has evolved, so has the research in EM (Table 1). We use

Table 1. Literature Review Entrepreneurial Marketing Education.

Year	Authors	Definitions and frameworks related to EM	Related to teaching entrepreneurial marketing
2002	Morris, M. H., Schindehutte, M., LaForge, R. W.	EM as: "the proactive identification and exploitation of opportunities for acquiring and retaining profitable customers through innovative approaches to risk management, resource leveraging and value creation." (p. 5)	
2008	Uslay, C., Teach, R. D	Review of established and competing conceptual frameworks that define and capture key constructs of entrepreneurial marketing and MEI. Unique entrepreneurial marketing theory instead of contextual testing of an extant theory developed with large organizations in mind.	We need to develop experiential exercises and realistic simulation models that can have students experiment with issues that differ between entrepreneurial/small firm marketing and large-scale firms' marketing efforts.
2010	Stokes, D., Wilson, N. C.	Three dimensions that distinguish entrepreneurial education: behaviors (entrepreneurial skills, characteristics, and attitudes), context (market sectors, social and environmental factors, business disciplines) and process (how to start a new venture and develop new product/ services)	Entrepreneurship education has a tendency toward certainties rather than a tolerance of uncertainty.
2010	Kraus et al.	"EM is an organisational function and a set of processes for creating, communicating and delivering value to customers and for managing customer relationships in ways that benefit the organisation and its stakeholders, and that is characterised by innovativeness, risk-taking, pro-activeness, and may be performed without resources currently controlled." (p. 26)	
2011	Hills & Hultman	"EM is a spirit, an orientation as well as a process of passionately pursuing opportunities and launching and growing ventures that create perceived customer value through relationships by employing innovativeness, creativity, selling, market immersion, networking, and flexibility." (p. 6)	
2013	O'Connor	There are three levels of entrepreneurial influence: Macroeconomic: competition, and innovation. Organizational level: enterprise activity and business activity. Individual level: entrepreneurial thinking, effectuation, entrepreneurial team	"Entrepreneurship education in this field would be designed to facilitate effectual and strategic entrepreneurs and the curricula would emphasize radical innovation and the models of entrepreneurial process that deliver innovation, new ventures and disruptive business models." (p. 556)
2013	Hills & Hultman	EM as "a spirit, an orientation as well as a process of pursuing opportunities and launching and growing ventures that create perceived customer value through relationships, especially by employing innovativeness, creativity, selling, market immersion, networking or flexibility" (Hills et al. 2010, p. 6).	"Unequivocally traditional MBA curriculum for running large companies like IBM, GM and Boeing does not work in start-ups. It's toxic. . .[there is] a radically different method that brings customers and their needs first into the process long before the launch" (Blank, 2013 p. 446)
2016	Whalen et al.	"EM is a combination of innovative, proactive, and risk-taking activities that create, communicate, and deliver value to and by customers, entrepreneurs, marketers, their partners, and society at large." (p. 7) "Key distinctions separate traditional marketing and EM regarding risks, opportunities and uncertainty." (p. 7)	
2020	Amjad et al.	Differences between entrepreneurial marketing and traditional marketing: EM follows bottom-up approach, the entrepreneurs first choose the target market or segment, after that, they get to know about the needs and demands of their targeted segment through personal relations, and then serve them in the best possible ways (Stokes, 2000)	"EM generally is not the part of business administration programs at business schools, despite being inevitable for SME entrepreneurs." (p. 6)
2020	Gilmore et al.	4 key questions: what should be taught? Where should it be taught? How should it be taught? Who should teach it?	EM educators need to seek new ways of ensuring that the teaching and practice of EM are integral to university education. This requires curricula and processes that enable action.
2020	Alqahtani & Uslay	EM: "EM is an agile mindset that pragmatically leverages resources, employs networks, and takes acceptable risks to proactively exploit opportunities for innovative co-creation, and delivery of value to stakeholders, including customers, employees, and platform allies." (p. 64)	

(continued)

Table 1. (continued)

Year	Authors	Definitions and frameworks related to EM	Related to teaching entrepreneurial marketing
2022	Alqahtani & Uslay	"The underlying premise is that EM is a distinct subdiscipline of inquiry and it is necessary to develop specific research priorities for it, beyond what is offered by MSI for the marketing discipline at large." (p. 406)	Teaching EM practices has received little attention. Key questions: What needs to be taught? Who should teach it? How does it need to be taught? Where is it supposed to be taught?
2022	Oyedele et al.	Resource dependence theory (RDT), network theory, and network competence perspectives can serve as lenses for developing and implementing experiential learning curriculum that accounts for crises and institutional challenges.	A dearth of research exists in the literature about refining and improving the experiential learning process.

Note. EM = entrepreneurial marketing. MEI = Marketing entrepreneurship interface; GM = General Motors; SME = small and medium enterprises; MSI = Marketing Science Institute.

the definition by Morris et al. (2002), who described EM as "the proactive identification and exploitation of opportunities for acquiring and retaining profitable customers through innovative approaches to risk management, resource leveraging, and value creation" (Morris et al., 2002, p. 5). This definition fits well with the context of the current pedagogical case, early-stage technologies, and the need to train graduate STEM students to identify and exploit commercial opportunities that create value for potential customers.

Key topics that separate EM from conventional marketing are concepts related to risks, opportunities, and uncertainty (Whalen et al., 2016). Conventional marketing relies on predictive and static market research to develop new products (Whalen et al., 2016). Another critical difference between EM and traditional marketing is opportunity recognition through value propositions and value creation. Marketing knowledge in the early stages of venture development, which includes understanding customer needs, is critical in entrepreneurial situations when there is limited time, money, and marketing talent to create strong value propositions and thus create value (Alqahtani & Uslay, 2022). Accordingly, the vital role of EM is to help the entrepreneur to define market opportunities, engage with prospective customers frequently, and gradually learn from these encounters.

Nevertheless, research studies have revealed that a lack of proper marketing knowledge and application is often the cause of many entrepreneurial venture failures (Eisenmann, 2021; Hisrich, 1992; Hisrich & Ramadani, 2018; Westgren & Wuebker, 2019). Many entrepreneurs neglect the basic marketing steps of researching customer needs before embarking on their engineering efforts (Eisenmann, 2021). The eagerness to develop and test a minimum viable product (MVP) before rigorous customer discovery and competitor analysis of existing solutions often results in wasting valuable resources on MVPs that miss their mark (Ries, 2011). In addition, entrepreneurs who ignore crucial marketing planning activities of specifying target market, product features and market positioning, customer value propositions, product delivery modes, potential partnerships, pricing options, and demand assessment are lowering the probability of the innovation leaping into market success (Lodish et al., 2001; Sá et al., 2022).

The crucial step for any innovation is identifying an unmet need and understanding the specific needs gap that needs to be filled (Susheela, 2020). Thus, before building a product and launching it into the market, entrepreneurs are strongly advised to undertake customer discovery, that is, interviews with prospective customers to probe their unmet needs and validate potential solution ideas (Blank, 2013; Eisenmann, 2021). Likewise, specifying some critical variables of a marketing plan, such as target customers, product solution concepts, value propositions, competitive positioning, product delivery modes, pricing models, and estimation of market size and forecasts, are crucial to avoiding "fast-failure" of the venture—where entrepreneurs (under pressure to move fast to capture opportunity) tend to truncate the critical phases of startup, thus setting themselves up for failure (Cantamessa et al., 2018; Pearce & Pearce, 2020; Shankar & Clausen, 2020).

The problem of lacking relevant marketing knowledge for bringing innovations to the market becomes acute when technical people focus on their discovery and scientific idea but do not understand the considerations and concerns of the customers or commercialization personnel who are most interested in how the idea solves customer problems and can be translated into a business proposition (Leatherbee & Katila, 2020). Thus, according to prior research, in the context of students from STEM backgrounds pursuing MBA degrees, these students are less willing to take risks than traditional business students (Nikitina et al., 2022). So it is reasonable to suggest for STEM students pursuing an MBA that a conscious effort is needed to expose and engage these students in activities where they interact with customers and other market actors, thereby assessing risks of marketplace realities and how to minimize them through, for example, pivot in case of roadblocks and other business challenges (Paço et al., 2017; Stenard, 2023; Winkler et al., 2015). In short, there is a need for pedagogical innovation when including EM in the MBA curriculum and in its teaching.

Need for Pedagogical Innovation in Teaching EM

Interest in EM education has evolved over the past three decades, indicating a plurality of content and methods (Gilmore et al., 2020; O'Connor, 2013). EM education encompasses learning about behaviors when entrepreneurs undertake marketing activities and processes of marketing-related activities. Regarding the scope of what should be taught, as previously noted there has been a discussion about critical differences between traditional marketing and EM (Whalen et al., 2016). Scholars thus have recognized that teaching EM practices has received little attention, and little is known about pedagogical approaches, especially in graduate programs (Alqahtani & Uslay, 2022; Gilmore et al., 2020; Uslay & Teach, 2009).

A review of the topics included in EM education indicates that a central theme has been the marketers' ability to design and execute a value-creating vision and their ability to perform value-creation processes when facing uncertainty (Gilmore et al., 2020). These topics include prescriptive and consulting-based frameworks such as business model canvas (McGrath, 2010; Osterwalder et al., 2014), design thinking (Brown, 2008), growth marketing (e.g., Bohnsack & Liesner, 2019), and lean startup and customer development (Blank, 2013; Leatherbee & Katila, 2020). Several innovative approaches have been suggested to teach EM (Gilmore et al., 2020; Stokes & Wilson, 2010), including talent exchanges from the industry (Wynne, 2016); skill-based curriculum modifications to teach more critical entrepreneurial skills (Amjad, 2020; Stokes, 2000); incorporation of case studies and case competitions (Tsang, 2014); work-based experiences (Lloyd et al., 2019); development of entrepreneurial networks (Engel et al., 2017; Kaandorp et al., 2020); real-life industry and market research (Amjad, 2020; Smith et al., 2017); and trading experiences (Lloyd et al., 2019; Manimala, 2017). Each approach offers useful techniques for developing EM skills. Yet based on our experience, none of these provide a sufficiently integrated approach to teaching and learning that applies in each phase of the innovation journey from the research lab to its commercialization.

It has been argued that such an integrative marketing approach requires careful analysis and strategic decisions regarding market selection (choosing segments and customers), market development (establishing accessibility and affordability), and market activation (creating acceptability and awareness; see, e.g., Parvatiyar & Sheth, 2021). An integrative marketing approach, in our view, thus requires a series of analyses and decision processes that would be extremely hard to accomplish in a single-semester course. Hence, we next review emergent frameworks in EM pedagogy to provide a foundation for the innovative approach that we describe in this paper. Several frameworks can assist educators in teaching EM. This list includes but is not limited to lean startup and action learning frameworks, each with content that can contribute to greater integration within the more specific pedagogies that comprise EM.

Emergent Frameworks in EM Pedagogy

The Lean Startup Method

The lean startup methodology suggests an agile process to reduce the risk exposure of an entrepreneur (Ries, 2011). The lean startup method involves careful testing of customers' reactions to a potential business concept or minimum viable product (MVP) to validate preconceived ideas (Leatherbee & Katila, 2020). To achieve this,

> the lean startup method aims to iterate business ideas, helping entrepreneurs make an early decision about their feasibility. To that end, it encourages entrepreneurs to make explicit their assumptions about a business idea (i.e., formulate hypotheses) and then probe them (i.e., interview customers). (Leatherbee & Katila, 2020, p. 574)

Thus, under the lean startup method, a business plan is broken into hypotheses, and learning-by-doing experiments are run to discover whether these hypotheses are true. The feedback gained in the fieldwork, where customers are consulted, helps determine whether a company should persevere with the same idea or pivot to take a revised direction that incorporates customer-discovery feedback. The lean startup method is most useful for a completely new, innovative product or service with zero precedent (Blank, 2020; Leatherbee & Katila, 2020). It enables the entrepreneur to get their product from the lab to market more quickly and with less risk (Yang et al., 2019). Recent evidence suggests positive impacts on the performance of startups using the lean startup method (Clarysse et al., 2015; Gonzalez-Uribe & Leatherbee, 2018).

Despite its usefulness for entrepreneurial risk reduction, the lean startup method has its weaknesses, as identified by its skeptics (e.g., Felin et al., 2020; Gans et al., 2019; Ladd, 2016). For example, there is criticism that the method utilizes a self-reinforcing loop that prevents scaling (Ladd, 2016), that the method has not been empirically tested, and that there is scant knowledge about boundary conditions (Leatherbee & Katila, 2020; Shepherd & Gruber, 2021). In short, in our view, the lean startup method does not provide a comprehensive and integrative template sufficient for a lab-to-market plan for new inventions. Accordingly, other frameworks and learning processes must be considered to address our research question. Examining programs and curricula on entrepreneurship at leading educational institutions suggests that most involve immersive, experiential, action-learning pedagogical approaches.

Action Learning: Immersive Approaches to Entrepreneurial Skill Development

Educational institutions have adopted varied approaches to teaching entrepreneurial skills to instill greater confidence among would-be entrepreneurs and to provide them with closer-to-real-world experiences of what is entailed in

entrepreneurship (Hägg & Gabrielsson, 2020; Mukesh et al., 2020; San Tan & Ng, 2006; Taylor et al., 2004). These approaches can be grouped under the heading "action learning," where students engage in a learning process where they work on real-world tasks by acting and then learning from their successes and failures. Action learning happens in real time as entrepreneurs use *real options reasoning* to engage irreducible uncertainty through an act-and-learn approach (Alvarez & Barney, 2007; McGrath, 1999).

For example, leading academic institutions, such as the Massachusetts Institute of Technology (MIT), Stanford University, and several others, have embraced action learning as the primary approach to teaching entrepreneurial skills (Eesley & Lee, 2021; Lüthje & Franke, 2002). In these courses, students are immersed in complex real-life business situations to sharpen their problem-solving skills, leadership abilities, adaptability, professional and personal growth, and collaborative team mindset. The G-Lab and MIT (global entrepreneurship lab) further engage students on international projects, partnering with global entrepreneurs to tackle emerging market challenges (MIT/Sloan, 2023). Similarly, Stanford University has several action learning courses where students are immersed in experiential projects to solve entrepreneurial challenges and apply design thinking—such as Startup Garage and Stanford LEAD (learn, engage, accelerate, and disrupt) program (Stanford/LEAD, 2023). Examples of action learning in entrepreneurship can be found at institutions worldwide (e.g., Diensberg, 2008; Jones-Evans et al., 2000; Pittaway et al., 2009; Taylor, 2008).

One of the more innovative approaches that can apply to action learning in EM has grown out of research that has focused on the development of expertise through experiential learning based on deliberate practice (e.g., Baron & Henry, 2010; Charness et al., 1996; R. K. Mitchell, 2005, 2014; R. K. Mitchell & Chesteen, 1995). This approach has been well documented to apply to acquiring expertise in sports, games, and the arts (e.g., Ericsson, 1996) that comes from deliberate practice based on intensity, duration, and correct content (Charness et al., 1996) and can form the basis for a comprehensive and integrative model of EM pedagogy, as we next explain.

In the next section, we, therefore, describe a unique pedagogical approach developed at a major research university in the United States for its STEM MBA program to employ the best parts of lean startup and action learning approaches in a theoretically coherent manner. The MBA degree-long "Integrative Project" is an extended and extensive capstone project consisting of four courses extending over the entire MBA program: (a) Technology Commercialization, b) Marketing Concepts and Strategies (which includes the NSF I-Corps program as further described below and in Appendix), (c) Advanced Professional Selling, and (d) Strategic Practicum. The Project uses a Stage-Gate™ approach (Cooper et al., 2002), with stages and gates that students follow to validate their ideas with the support of different stakeholders, as illustrated in Figure 1.

Each course teaches business and marketing strategy aspects in research commercialization and EM. Students use the act-and-learn approach of action learning to work through each term to understand and apply relevant analytical frameworks and tools from these courses to develop a business viability and commercialization plan for an innovation brought forward by the University Office of Research Commercialization (ORC) in the form of a recently granted patent. Once the business viability of various products stemming from that innovation idea is established, the same student groups undertake customer discovery in their subsequent courses to develop a marketing strategy, complete the sales and customer relationship strategies for their respective product service ideas, and create an overarching global strategy.

The STEM MBA Case: Key Definitions and Conceptual Background

In this STEM MBA case, students with a background in science, technology, engineering, and math pursuing their MBA provide a suitable context for teaching EM through hands-on action learning. As shown in Figure 1, in this study, we concentrate on the seven dimensions of EM suggested by Morris et al. (2002), which include: (a) Opportunity-driven; (b) Proactiveness; (c) Innovation-focused; (d) Customer intensity; (e) Risk management; (f) Resource leveraging; (g) Value creation as they animate the key deliverables from the project across its four stages to provide both the knowledge base and the problem-solving processes that lead to student expertise. This focus on both the knowledge base and the problem-solving processes (Figure 1) is theoretically consistent with the aforementioned approaches to performance excellence in sports, games, and the arts (Ericsson, 1996). Specifically, this dual-objective focus is compatible with the deliberate practice approach to giving learners the mental software of a "cognitive system" upon which the acquisition expertise depends—a "knowledge base" and "problem-solving processes" (Charness et al., 1996, p. 53). We describe how this deliberate practice occurs as follows.

Students work with an early-stage technology, which refers to nascent scientific or technical knowledge that has left the lab and is partially codified (Molner et al., 2019), such as in a new patent. At this stage of development, these new technologies are based on novel physical, biological, mechanical, or chemical properties, but there is a lack of clarity about their commercial applications (Molner et al., 2019), specifically possible new products. Here, students face the *intensity* of market ambiguity and uncertainty characteristic of early-stage technologies. By market ambiguity, we refer to the lack of clarity about the nature, number, and commercial viability of potential products and applications derived from the technology; market uncertainty refers to the

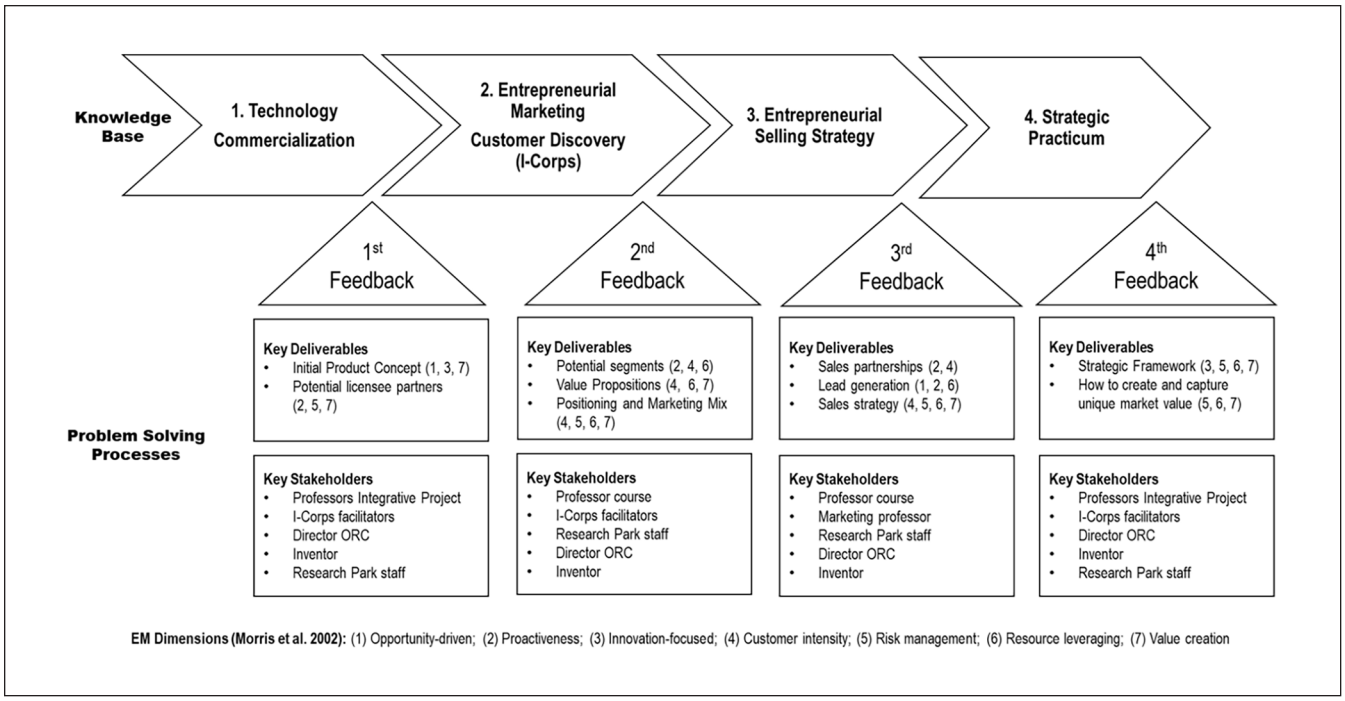

Figure 1. From Lab to Market: A Stage-Gate "Integrative Project".
Note. ORC = Office of Research Commercialization; EM = entrepreneurial marketing.

difficulty of predicting specific outcomes, such as consumer demand (Molner et al., 2019).

More precisely, market uncertainty under these conditions comprises two specific types: relational and resource uncertainty (J. R. Mitchell et al., 2012). Given the scientific origins in labs of early-stage technologies, they are usually more "technology push" innovations than "market pull" ones (Molner et al., 2019, p. 39). In potential commercial relationships between buyers and sellers (i.e., potential startups) of products related to these technologies, there is difficulty in predicting the extent to which buyers will trust sellers and vice versa. Hence, relational uncertainty "reflects the heterogeneity in the degree to which trust needs to be developed in light of the possibility of moral hazards and distrust" (J. R. Mitchell et al., 2012, p. 100). Likewise, with early-stage technologies, there are difficulties in knowing the resources needed to produce goods and services that would create superior value. Thus, resource uncertainty refers to difficulty comprehending the combination of resources and skills required to produce and deliver goods and services (J. R. Mitchell et al., 2012). Both of these uncertainties are addressed in the four courses in the Integrative Project that provide *duration* in the deliberate practice model, and also through the scientific method of the customer discovery approach adopted by the I-Corps™ National (Innovation Corps) program, developed and promoted by the National Science Foundation (NSF) in 2012 (Huang-Saad et al., 2017)—included in the second course of the Integrative Project (see Appendix for more detail).

Teaching EM in a Stage-Gate Approach Using an Integrative Project in a STEM MBA

As a general business degree with a concentration on STEM applications, this STEM MBA aims to complement the technical background of a STEM student by providing the business skills needed to be effective in business—essentially the *content* required by the deliberate practice approach. This program offers an ideal opportunity to establish an Integrative Project focused on integrating EM education that can help with the technology commercialization challenge in crossing the "valley of death" that plagues new inventions. The premise of the project is that entrepreneurs, would-be entrepreneurs, and managers working on technology commercialization must resolve relational and resource uncertainties (J. R. Mitchell et al., 2012). Thus in response, the objective of the Integrative Project is to learn to overcome (reduce) the uncertainties pervasive in new business and early-stage technologies, using as much of the knowledge and skills taught in all courses in the STEM MBA as possible. In the following paragraphs, we briefly outline the processes involved in technology selection, curriculum, and an assessment of project effectiveness.

Technology Selection

The selection of technologies for use in the Integrative Project is made with the full cooperation and assistance of

Table 2. Integrative Project Student Learning Objectives.

1. Has sufficient confidence to work in the business world.
2. Can translate theory/concepts/abstracts into practice.
3. Has business acumen
4. Can integrate skills across disciplines—STEM with business and across business disciplines.
5. Has decision-making ability (e.g., pivot) within a dynamic environment.
6. Can engage the environment to obtain relevant information
7. Can communicate effectively with stakeholders.
8. Can collaborate effectively (e.g., as both leader and follower)
9. Can examine and incorporate societal implications.

Note. STEM = science, technology, engineering, mathematics.

the ORC. Initially, this office would provide four to six new patents or patents pending to the lead instructor, with layperson descriptions. Then, students would form commercialization working groups by selecting the technology they prefer to work on. But this proved impractical because common understanding and maintaining interest were complex.

Thus, the instructor would share these multiple technologies with the class in the next iteration of the selection process. Then, a cluster voting approach would be used whereby each student had three "votes" indicating their preference for working with that invention. As each technology was read, students interested in that as one-of-three preferences would raise their hands; a tally was kept. Finally, the technology with the most votes was selected for the class. It thus solved the common understanding and interest problem.

Nevertheless, as the class progressed, it became necessary to refine the selection further and delegate it to the ORC specialists to make a choice. In addition, this delegation was done to enable better logistical efficiency (e.g., timeliness sensitivity, commitment and availability of the inventor, likelihood to be of interest to STEM MBA students, etc.). As a result, presently, each new cohort has a current invention, access to the inventor(s), and high student interest as well as a common understanding of the technology being introduced.

The Curriculum—Stage-Gate Approach

The Integrative Project curriculum builds on a series of stages and gates throughout the academic program of the STEM MBA. The practical objective of the project is for students in the program to help the University's ORC identify potential avenues for licensing one of the technologies available in this office, showing the commercial value of the technology. The Integrative Project student learning objectives are included in Table 2. The four courses noted previously are integrated through the project to help students accomplish the practical and student learning goals at the end of the STEM MBA Program. Consistent with the definition of EM that we have used in this paper, Figure 1 also maps the seven dimensions of EM suggested by Morris et al. (2002), which include: (a) Opportunity-driven; (b) Proactiveness; (c) Innovation-focused; (d) Customer intensity; (e) Risk management; (f) Resource leveraging; and (g) Value creation) as they animate and are manifest in the Key Deliverables shown in Figure 1.

The first course is Technology and Commercialization. In this course, students form teams and learn their roles and responsibilities when working with the Office of Research Commercialization (ORC). Here students, together with ORC, engage the technology and learn about and sign non-disclosure agreements with the ORC. The student learning objectives for this class are related to learning how to solve unstructured technology commercialization problems using one available real-life technology provided by the ORC. In this class, students learn frameworks that help them reduce relational, resource, and consequent informational uncertainties (J. R. Mitchell et al., 2012). For example, they learn and use constraints analysis (Goldratt, 1994), organizational creativity skills (R. K. Mitchell et al., 2015), and resource assessment skills (Mainprize et al., 2003). The students use these tools to create three potential new products and select the most likely to create new value for a potential licensee. The pedagogical scaffold for this course is a series of readings, lectures, and practical application presentations to develop the initial assessment of technology commercialization feasibility.

The first stage or deliverable from the first course is a group report and presentation on the compilation of different learning tool applications to solve unstructured problems when attempting to commercialize one technology, emphasizing initial product concepts and a list of potential licensee partners. Next, students present in front of a panel of experts. The expert panel comprises the managing director of licensing for the ORC, the managing director of the ORC, a patent attorney, an entrepreneur-in-residence in the B-School, the inventor(s) of the technology, professors of the current class and other classes in the Integrative Project. Moreover, I-Corps facilitators and representatives of the University's research park also form part of the panel of experts. Students experience questions from this panel of experts, with different emphases resembling beyond-the-classroom market feedback about the students' proposals. This panel of experts forms the first "gate" in the project. Thus, students learn to incorporate that feedback into the second stage of the project.

The second course or stage is Marketing Concepts and Strategies. At this stage, the practical objective is to help students become strategic marketers for early-stage technologies to develop and gain support for marketing strategies of these technologies. The students continue to work with their teams and the technology from the previous course. The primary learning objectives are identifying market opportunities and challenges, emphasizing customer segments, and determining value propositions per segment. In this context, the teams will advance their projects by reducing relational uncertainty in the I-Corps process, which emphasizes customer segments and the value propositions of the business model canvas (BMC). With the help of the University's Research Park and the I-Corps facilitators, the students participate in a 3-week program where they learn the customer discovery methodology with falsifiable experiments (i.e., hypotheses) about customers and value propositions (Blank, 2013). Each team is challenged to collect qualitative information to falsify at least one experiment/hypothesis about the target segment and one about the value proposition. The goal is for each team to complete at least 25 interviews with potential customers of possible ORC licensees of the technology and critical participants in the market space regarding possible applications of the technology. Other core concepts in this course are positioning strategies, BMC, lean startup, and customer discovery methodology.

Regarding traditional marketing concepts such as a positioning strategy and marketing mix (price, promotion, place, and product), the emphasis is to adapt these frameworks to an entrepreneurial context. First, determine the "need gaps" for the chosen target segment(s). And second, to develop a set of value propositions (e.g., product concept and pricing strategies) and the method to deliver and communicate the value propositions (e.g., place and promotion strategies).

The deliverable or gate in this course is a team presentation where the students share the customer discovery interviews and experiment results. The students learn to design these experiments to test assumptions related to customer segments and value propositions of an initial BMC for the specific technology and product concepts. The audience in these presentations is another panel composed of the professor of the class, I-Corps facilitators, and staff members of the University's Research Park. The students receive developmental feedback to help them find product-market fit for the product concepts. The next deliverable or gate is a team presentation describing an EM mix for their products, where general ideas about pricing, promotion, and delivery considerations start taking shape. At this stage, the students use the insights from the customer discovery interviews to focus on pricing, promoting, and distributing a potential product using the technology.

The third course or stage is Advanced Professional Selling. Building on the information in the I-Corps Regional 3-week program and previous courses, the learning objective of this class is for the students to develop a personal selling strategy and sales management approach in the Integrative Project. Here, student groups create a sales strategy for their product(s) that matches the buying behavior of a group of likely buyers—customers of potential technology licensees. Next, the students targeting the identified customer segments determine the sales offering, sales lead generation technique, customer prospecting, and qualification of potential customers of possible ORC licensees. They also develop a persuasion strategy emphasizing value creation relationship building, a sales closure plan, and the required sales administration for ensuring customer satisfaction and a follow-through sales plan. The deliverable or gate is a team presentation where the students share a sales strategy.

The fourth and final stage is the Strategy Practicum, where students develop an overarching strategy to help bring the innovation to the market—through licensing to potential producers of the products identified, based on the technology provided by the ORC, integrating previous course deliverables. In this last stage, the students develop a strategic framework that specifies how to create and capture unique market value from their potential products, designed from the technology throughout the Integrative Project. The strategic frameworks cover a description of the market(s) to position the products, the differentiators of their products that help the teams develop unique advantages in the market, how the groups plan to generate revenue, and the approaches for disseminating the products. The final gate is the last team presentation, where the team presents its strategic framework to a similar panel of experts as those in the first course to close the project cycle. The expert panel must decide whether they would hire, not hire, or maybe hire the team presenting to keep working on the project. The experts would also include the reasons that support their answers.

Project Assessment

Table 3 summarizes the technologies used in the project and the customer discovery work done by the students between Fall 2020 and Summer 2022. More than 160 students have worked with diverse technologies to proactively identify opportunities for acquiring profitable customers for possible ORC licensees through innovative approaches learned throughout the Integrative Project. Around 36 potential product descriptions are included as part of the work done by students. In addition, the students have conducted approximately 900 customer discovery interviews, where they learned the methodology to formulate customer segments and value proposition hypotheses and assess their falsifiability. All 36 groups successfully defended the final presentations as part of their STEM MBA business degree requirements.

Regarding more qualitative assessments, to capture an initial evaluation of the project, we interviewed around 13

Table 3. Integrative Project Technologies, Products, and Customer Interviews.

Semester	Technology	No. of students	No. of groups	Example of product concept	No. of customer discovery interviews	Product descriptions	Potential market segments	Examples of segments
Fall 2020	Immunomodulation using spores and pollen grains	32	7	"Planning a vacation but concerned about how to keep you and your family safe from diseases? Try an easy, hassle-free way to prepare for your trip and save time by skipping the doctor's office. In just three easy steps: sign up, fill out a questionnaire, and get specialized orally-administered vaccine kits in the mail. The kit you will receive is assembled and approved by licensed physicians, customized to your needs and destination. Utilizing the new pollen grain technology patented by Texas Tech University which will be FDA-approved prior to release, these vaccines will be orally self-administrable. The kit includes easy to follow instructions and a timeline on how to safely administer each dose. Next time, skip getting pricked at the doctor's office; choose Safe Nomad Kit: the easier, safer way to get your vaccines."	165	1. Customizable oral vaccination kit that can be sent through the mail. 2. Subscription service of door-to-door delivery of vaccination kits. 3. Oral delivery system for vaccines mixed into animals' food. 4. Pill for allergy immunotherapy solution. 5. Popsicle that will allow for the ease of vaccinations to both kids and adults. 6. Oral vaccination and multivitamin solution. 7. Method to administer a suite of vaccinations orally	9	B2C: Word travelers (Business and Causal) B2B: International Programs
Summer 2021	Novel Antagonists of Opioid Receptors	23	5	Stop opioid addiction and take back your life with Cure-Aid. Cure-Aid is a dissolving powder meant to be taken with any drink to curb and combat opioid reliance. It also works to stop opioid overdoses in their tracks. The powder has been produced using our patented technology that blocks the opioid receptors in your brain. This technology is a medically approved, therapeutically effective, and pharmaceutically acceptable compound. Cure-Aid is simpler to transport, easier to ingest, and longer lasting than other available products. The dry powder can be taken anywhere that has a drink and a cup. Cure-Aid is simpler to take than pills or needles. It can be stored for long periods of time at home or in your travel bag. Cure-Aid will leave you smiling and content for years to come.	134	1. Patch to combat opioid addiction. 2. Gum to combat opioid addiction. 3. Non-addictive opioid recovery medication. 4. Passive treatment that offers psychological comfort, and simultaneous therapy. 5. Dissolving powder for any drink to curb and combat opioid addiction	10	B2C: Individuals suffering from addiction and seeking recovery B2B: Rehabilitation Centers

(continued)

Table 3. (continued)

Semester	Technology	No. of students	No. of groups	Example of product concept	No. of customer discovery interviews	Product descriptions	Potential market segments	Examples of segments
Fall 2021	Machine Learning Predictive Logistical Algorithm	25	5	Streamlined is a software optimization service that caters to various departments within airline companies. Streamlined's unique algorithm creates a hub that connects each departments' current software to make communication of vital information more streamlined.	134	1. Inventory Manager for Restaurants. 2. A stress reducer/time saver for people who do not have the time. 3. Inventory prediction platform. 4. Software optimization service for airlines. 5. Insulin finder platform.	22	Passengers/Airline Crews
Spring 2022	Dynamo Torque Analyzer	32	7	With the assistance of Fearless Horsepower, owners all over the world could interpret the overall health and strength of their team to ensure they are able to perform at the highest level of competition, without putting a human or horse at risk of injury. In addition, this product could be used in equine rehabilitation facilities to track the progress of injured horses, along with physical therapy for their riders. With this data, veterinarians and health professionals could gauge when a team is fully ready to compete again, as well as analyze the likelihood of reoccurring injuries to predict the future of a teams' career	186	1. Compact muscle measurement technology. 2. Equine muscle assessment. 3. Short-range info app utilizing Bluetooth technology for quicker and more versatile transmission of torque values and examination results. 4. Device that calculates peak torque and rate of torque development of joints. 5. A handheld strength measurement device that can instantly display results and be transported easily to your desired location. 6. Fun and competitive game that measures the amount of power/torque that users can produce. 7. Portable device that measures muscle strength.	16	Equine veterinarians with a focus on performance and racehorses

(continued)

Table 3. (continued)

Semester	Technology	No. of students	No. of groups	Example of product concept	No. of customer discovery interviews	Product descriptions	Potential market segments	Examples of segments
Spring 2021	Synthesis of Portable X-ray Fluorescence Spectrometry	31	7	The Moo Monitor gives the agricultural industry the instant ability to know how efficiently their livestock digest feed. Thus, allowing us to alter feeding habits according to the animal's individualized needs. The Moo Monitor helps create healthier livestock and more money for farmers.	161	1. Excrement scanning diagnostic device for veterinarians. 2. Smart field narcotic identification device. 3. Soil scanner and analysis device. 4. Chemical analysis device for wine. 5. Chemical assessments for powder and liquid solutions. 6. Soil nutrient testing and reporting. 7. Characterization of cuttings and fluids present in the lithology on exploration wells.	27	Law Enforcement, Research Institutes
Summer 2022	Base Mounted Piezoelectric Vibration Energy Harvester	23	5	SmarTech car window that automatically open when a certain temperature or carbon monoxide level is reached.	157	1. Smart training mask. 2. Smart tent with climate control. 3. Active noise-canceling headphones. 4. Smart car window with temperature and carbon monoxide level detection. 5. Anti-fogging Goggles for sports.	15	Factory Workers, Truck Drivers, Aviation Workers
Fall 2020 to Summer 2022	Totals	166	36		937	36	99	

alums from the STEM MBA program, one I-Corps instructor, and the lead person in the ORC. Table 4 introduces comments made by these different stakeholders. Stakeholders might pose various claims, creating tensions (R. K. Mitchell et al., 1997). A key stakeholder in the project is the STEM MBA student. STEM MBA students have various backgrounds and expectations when starting the program, which might raise issues when working together. Some participants recognized the inevitable challenges of learning to structure unstructured problems such as developing teamwork and of working with some technologies that did not resonate with their personal preferences/past experience. For example, one of the interviews suggested that the real-world experience of being called upon to work on technology outside their comfort zone posed a substantive challenge: "I know that for some other classmates, the project was dreadful because they said, 'I am doing a project where I do not have any experience or background on it.'" Another interviewee said: "I remember complaining a lot while I was doing the Integrative Project." Another interviewee acknowledged: "I did not like the patent we used." In these ways the Integrative Project provides *intensity as* students confront uncertainty.

Helpfully, when subsequently comparing participant answers to the Integrative Project learning objectives (Table 2), participants indicated the accomplishment of intended learning *content* outcomes over the *duration* of the Integrative Project (Table 4). They said, retrospectively, that the project builds confidence to tackle complex and uncertain situations: "but now that time has passed and that I am working, I appreciate that we needed to talk to different people and put ourselves out there. I feel more confident now that I have to talk to different people." Another interviewee mentioned: "customer discovery has really helped me gain confidence in my current field to be willing to get out of my comfort zone to learn from the elders around me." The interviews suggest that communication with different stakeholders is another learning objective fulfilled thanks to the project. For instance: "The Integrative Project had a lot of opportunities to work on presentation skills (as well as actually making slide decks); this was helpful in my work, where I would regularly present proposals to project teams" (Interviews with alums in Table 4).

We also captured some comments made by one of the I-Corps facilitators and the lead person in the ORC. These stakeholders have expertise in STEM-related fields, and their opinions could validate the work done by students. Initial comments suggest that business acumen and communication are critical learning outcomes students achieve (see interviews Table 4). Overall, the preliminary information gathered for the Integrative Project assessment suggests that educators can design and validate innovative and practical frameworks to prepare would-be entrepreneurs and managers to function better in the face of change and competitive uncertainty, providing an initial answer to our research question, subject to the limitations discussed in the next section.

Discussion

The *valley of death* for new ventures occurs during the initial stages when substantial resources and capital are depleted by new enterprises unable to convert the discovery into a viable business. Even enterprises with resources for technology development (the left side of Death Valley) and resources for commercialization (the right side of the alley) fail to cross the valley. Reasons for this include a lack of marketing knowledge, expertise, and methods for customer discovery (Jolly, 1997; Kakati, 2003; Patel et al., 2021), which can be fatal in times of rapid industry change and volatility in competitive situations. Thus, there is a need to better conceptualize the pathway from lab to market so that EM educators have additional effective instructional options, leading to increasing technology commercialization and transfer through new ventures (Festel, 2015). In the scholarly conversation surrounding EM pedagogies, the research agenda is increasingly becoming focused on research priorities surrounding "experiential learning" and innovation and creativity in marketing pedagogy" (Alqahtani & Uslay, 2022, p. 415).

Therefore in this article, we have sought to answer the specific research question: *How can EM educators design and validate innovative and practical frameworks that can educate entrepreneurs, would-be entrepreneurs, and managers in a variety of ventures, thereby preparing for rapid industry change and volatile competitive situations?* To answer this question, our article explains in detail how an Integrative Project that functions in many ways like an in-class incubator (Oyedele et al., 2022) can more fully demonstrate how to incorporate innovation and creativity into marketing pedagogy. Below, we briefly discuss our anticipated contributions to theory, educational pedagogy, and practice; we highlight some of the future research opportunities; and we note the limitations that bound our research.

Contributions to Theory

Ten years ago, Hills and Hultman (2013) suggested that "important challenges for future research lie in establishing the distinctive characteristics of EM and [in creating] foundations for a solid theoretical base to build a more comprehensive theoretical structure" (p. 440) to meet the need in the field of EM to create innovative and practical frameworks (e.g., Alqahtani & Uslay, 2022; Amjad, 2020; Gilmore et al., 2020; Stokes & Wilson, 2010). As earlier noted, scholars who have moved the field forward have answered this call in various ways. But in this article, we further suggest that additional room exists for EM education, based upon new combinations in teaching EM, especially those that can address a skill/expertise-based aspect of EM for early-stage technologies using deliberate practice (e.g., Baron & Henry, 2010; Charness et al., 1996; Magretta, 2002; R. K. Mitchell, 2005,

Table 4. Program Assessment.

Stakeholder	Comment (some paraphrasing for clarity)	Learning objective
STEM Alumnus, graduation Fall 2020	1. As we progressed through the courses of the Integrative Project, our confidence [as a group] went up. In the beginning, you are intimidated but excited to participate in the project. 2. There is a fine line because you do not want to come up with ideas you know are not practical just to complete the assignment because [you will use those ideas in future classes]. There is an important realization "Oh! We are actually interviewing people!" My confidence went up as we kept working on the ideas in future courses. When we got to the marketing course and met with the I-Corps team, we knew we were on the right track with our technology commercialization ideas and you felt more confident taking on these uncertain and complex problems. 3. I also learned the right questions to ask when dealing with customer research and being comfortable working with people [with different backgrounds].	1. Confidence 7. Communication 8. Teamwork
STEM Alumnus, graduation Summer 2021	I remember complaining a lot while I was doing the integrative project, but now that time has passed and I am working, I appreciate that we needed to talk to different people and put ourselves out there. I feel more confident now that I have to talk to different people.	1. Confidence 7. Communication
STEM Alumnus, graduation Summer 2021	1. The Integrative Project had a lot of opportunities to work on presentation skills (as well as actually making slide decks); this was helpful in my work, where I would regularly present proposals to project teams. 2. Learning about the technology commercialization process was fun, and gave me great exposure to the work I wanted to be doing both in product management and law. Contribution by teammates was very unequal.	2. Communication 8. Teamwork
STEM Alumnus, graduation Summer 2021	Patience and project management. Patience in the sense that there will be projects wherever you go which will have resources that will be miss allocated and that the project will need to be completed successfully regardless of whether the project is fruitless, because leadership has a "vision". Project management, the integrative project did hone my skills to project manage and to deal with adverse team members. I run dozens of projects with different clients a year and that is something positive I can take from the integrative project.	6. Engage the environment to find information 8. Teamwork
STEM Alumnus, graduation Summer 2021	I am currently working on developing an automatic defibrillator for a project in medical school and my experience in the STEM MBA integrative project has given me clear experience that has assisted me with this process.	1. Confidence 2. From theory to practice
STEM Alumnus, graduation Fall 2021	1. The project prepared me to be comfortable asking questions to people in the industry. I have received positive feedback from my supervisors here. Something that they always comment on is my being inquisitive and asking questions. 2. The project also exposed me to different industries I had never thought I would be interested in. 3. For my personality, I like to be in control, but I am working in a space that is new to me and I have learned to be comfortable not knowing everything because I have the tools to go and find out answers. I remember learning about structures to tackle complex scenarios. 4. I know that for some other classmates, the project was dreadful because they said, "I am doing a project where I do not have any experience or background on it." But I think that the interviews can bring a lot of personal and professional value. At the end of the day, we are in business and we tend to work with people that we like and trust. Even though we are in a time with much communication is done digitally, a lot of communication is lost. So, I think it is important to be able to talk to other people [to create that trust]. The project puts you in those positions and if you can handle those situations, you are already a step further ahead than the people without confidence when talking to people. We live in a time where doing a little bit of that [talking to people] can set you apart.	1. Confidence 6. Engage the environment to find information 7. Communication

(continued)

Table 4. (continued)

Stakeholder	Comment (some paraphrasing for clarity)	Learning objective
STEM Alumnus, graduation Fall 2021	1. Sales; pitching myself or my ideas. During my interviews, I was so prepared that I was anticipating questions about my experience and I had compelling ways to answer. 2. Starting a project from scratch while working with others and managing our differences in opinion and background.	2. Communication 6. Engage the env. to find information 8. Teamwork
STEM Alumnus, graduation Summer 2022	I feel there are both hard and soft skills to take away from the integrated project. For me, being able to discuss ideas and gain insight from respected individuals in their industries during customer discovery has really helped me gain confidence in my current field to be willing to get out of my comfort zone to learn from the elders around me. Also, my job puts significance on having a learner mindset. Through the program, I was able to continuously grow and push myself with the help of those around me. It has helped with developing good habits to help me complete any task I have on my list.	1. Confidence 2. Communication 6. Engage the environment to find information
STEM Alumnus, graduation Fall 2022	1. The integrative project helped me learn to think more like an entrepreneur. I can understand the pitfalls and difficulties of launching a product, even if it is one that the industry actually wants. 2. I think that it has significant personal benefits, it took the learning we did inside the classroom and anchored it to real-world experiences which made the content more relevant and harder to forget.	2. From theory to practice
I-Corps Instructor	The STEM MBA student presentations for I-Corps closing workshop showed a better understanding of concepts such as segments and value propositions compared to presentations done in a regular I-Corps regional program. Perhaps it is because they are business students, so they get these concepts faster than people outside businesses.	3. Business Acumen
Office of Research Commercialization	I think the main stakeholder of the Integrative Project is the students doing their STEM MBA. The main objectives of the project are educational. In some situations, the researcher [inventor] also benefits from the creative process of exploring different applications. The researcher can return to the lab and continue researching these different applications. From the projects I have seen in the first course and the last, I see students' improvements in communicating and presenting their ideas and business concepts.	1. Confidence 3. Business Acumen 7. Communication

Note. STEM = Science, Technology, Engineering, Mathematics.

2014; R. K. Mitchell & Chesteen, 1995) to better embrace uncertainty rather than certainty (Stokes & Wilson, 2010).

Specifically, expertise enhancement theory suggests that intense, deliberate practice (practice hard), for a significant duration (practice long), and with the right content (practice correctly) is essential for progressing learners toward acquiring skill/expertise (Charness et al., 1996). This theoretical foundation provides an underlying rationale for the knowledge base and problem-solving process acquisition delivered by the Integrative Project we outline to enhance EM skill/expertise. As students participate in the activities specified by this pedagogy, we argue that the deliberate practice mechanisms of expertise acquisition are invoked. Therefore, we suggest that the Integrative Project described herein demonstrates a theoretically exciting way to create foundations for EM in situations with rapid industry change and volatile competition (Worthington & Eggers, 2022). In particular, we suggest that deliberate-practice-based theory can be used to integrate the core ideas of EM into a practical pedagogy. As illustrated in Figure 1, the four-course stages provide the knowledge base. The four feedback gates provide real-world practice with stakeholder-based problem-solving processes (Mitchell et al., 2021). Furthermore, the practical pedagogy we propose is animated by each of the core dimensions of EM (Morris et al., 2002).

Contributions to EM Education

In response to the problem that EM generally is not part of graduate business administration curricula within business schools—although it is essential for the success of entrepreneurial efforts (Amjad, 2020; Gilmore et al., 2020)— in this article we have sought to explain how EM can better be integrated into the graduate business school curriculum. Presently integrative approaches are being used in a variety of ways in higher education generally. For example, virtual environments are used in integrative assignments (Netland et al., 2020); integrative groups of stakeholders are gathered to provide input to more holistic views of teaching and learning

(Allen & Simpson, 2019); integrative class exercises are used to enable multidisciplinary learning in leadership development (Clapp-Smith et al., 2019) and also in cross-functional integrative thinking (Carter & Stickney, 2019). Most integrative models rely on system-based approaches (e.g., Boulding, 1956; Lazlo, 1972; von Bertalanffy, 1968); and helpfully, such models have one attribute in common in that they are based on, and reveal, both an underlying social structure that applies across contexts (Merton, 1957) and a common purpose that enables integration (Holzner, 1967). Hence, in developing our model, we have used an umbrella concept—deliberate-practice-based development of the expertise needed to effectively tackle uncertainty—that meets both criteria and thereby can serve as both the social and the integrative common denominator for learning and teaching. This selection is especially relevant, given the call for EM education to embrace uncertainty rather than certainty (Stokes & Wilson, 2010) that, as we have noted previously, may not yet have been fully answered.

Such integration is important as business schools have been increasingly subject to external and internal pressures to devote more serious attention to their value proposition (e.g., Bunch, 2020; Nikolova & Andersen, 2017; Nonet et al., 2016; Thomas & Ambrosini, 2020). One core suggestion that has been developing in higher education is embracing entrepreneurship and technology commercialization education (Amjad, 2020; Gibb, 1996; Siegel, 2009; Wynne, 2016). But by adopting a more entrepreneurial lens when enacting their missions and visions, business schools face challenges in designing entrepreneurial-related programs. For instance, MBA-level programs have been argued to teach business concepts and administration of functional areas, emphasizing analysis and prediction more than entrepreneurial experimentation (Bennis & O'Toole, 2005; Bhatia & Levina, 2020; Hoppe, 2016; Mintzberg, 2004). In addition, even with much commonality, technology commercialization, and entrepreneurship education are two literature streams that have developed separately (Nelson & Monsen, 2014), suggesting that the educational materials on both topics are at least somewhat disconnected, thereby creating unnecessary silos and knowledge gaps, and reducing practical and realistic applications of the learning experience in the classroom (Amjad, 2020; Athaide & Desai, 2005; Smith et al., 2017).

We propose that the deliberate practice-based approach to EM pedagogy has the potential to contribute to bridging the gap between technology commercialization and EM education through an integrative approach. During new venture phases in technology industries, understanding how to create and deliver value to a group of customers is among the most fundamental functions entrepreneurs need to perform (Molner et al., 2019; Politis, 2005). Under conditions of uncertainty like those in early-technological development, traditional marketing tools rooted in static analysis become ineffective (Whalen et al., 2016). EM-based tools such as the deliberate-practice-based Integrative Project pedagogy that we have utilized (Figure 1) can fill the gap. The pedagogy demonstrates the value of integrating courses in marketing and management fields (e.g., Athaide & Desai, 2005; Parvatiyar & Sheth, 2021), and the usefulness of entrepreneurial marketing education for the larger research and academic community within the University, especially where research labs are continuously developing new technologies and are keen to bring them to the market. Thus, this educational approach promotes inter-scholastic collaboration between science and technology faculty and marketing educators within the university.

Contributions to Practice

The practical significance of the interscholastic collaboration that is affected by the Integrative Project can be seen both in practice that affects graduates and practice that affects technology faculty. This assertion is confirmed in Table 4, where both alums and the ORC suggest that the value of the Integrative Project affects students—through skill/expertise development—but also inventors, whose vision for their invention is expanded (Huang-Saad et al., 2017; Kirchberger & Pohl, 2016; Wynne, 2016): two practical outcomes of the Innovative Project pedagogy.

In addition, changes in technology and society have increased the rates at which entrepreneurs start new ventures (Ambos & Birkinshaw, 2010; McKendrick, 2017; Si et al., 2023); and these changes then have affected the university role in promoting economic development via entrepreneurship (Huang-Saad et al., 2017). But in engaging community stakeholders in economic development, the technology commercialization process requires coordination and collaboration among a variety of stakeholders, creating additional challenges and opportunities for university-based real-world-connected pedagogies to contribute (Kirchberger & Pohl, 2016; Nelson & Monsen, 2014). With new technologies being included in the real-world-based experiential learning of the Integrative Project, the Project pedagogy that we have described herein explains—at least in part—how such collaborations can be mobilized, thereby also contributing to practice.

Future Research

Current literature suggests that the direction of EM education we are proposing can be valuable as a foundation for future research. For example, in a recent article, Amjad, Rani, and Sa'atar (2020) suggested that

> key areas of future research [would include] . . . exploring the contemporary EM challenges and integrating them with EE

> literature to develop EM pedagogy models to bridge the pedagogical gaps in EM education. As for the practical gap, we have recommended academic authorities at business schools to incorporate EM in all types of business programs as this is much needed and would increase the impact of EE on a wider range of students, ultimately developing entrepreneurship in the economies. (p. 6)

In this article, we, therefore, directly address the call for an EM-based pedagogy model. By situating our work within a STEM MBA program, we aim to increase the impact on a much more comprehensive range of students. We call upon other interested scholars to thus engage as well. Lopes et al. (2021) have emphasized the importance of such research by arguing that

> the EM concept has been studied for the past three decades. For companies and academics, it is important to expand the entrepreneurship/marketing interface (Kraus et al., 2012) . . . [where new] lines of investigation may serve as a basis for further studies. (p. 310)

They also have encouraged scholars to "check the value that comes from co-creating the perspective of external Stakeholders" (Lopes et al., 2021, p. 311). Helpfully, the Integrative Project we have presented also includes the NSF I-Corps™ approach (Appendix) as a part of the first marketing course (second in the series). In this way—especially using the "customer discovery" requirement—it responds effectively to the call for co-creation from the perspective of external stakeholders. This line of research, we believe, also holds promise.

Limitations

Our research is limited to a single case study of one university that has developed a unique pedagogical approach to teach various phases of EM through an extended, extensive, and integrative capstone project. Hence, our findings are limited in generalizability because the results obtained and reported here could be idiosyncratic to the institution, instructors, or the overall structure of the STEM MBA program. At the very least, though, it provides a glimpse of an innovative pedagogical approach to teaching EM at a time when the pace of technological change and disruptive innovation is rapid (Worthington & Eggers, 2022). When more samples of institutions following similar integrative multi-semester projects on EM become available, comparative work could be undertaken to its pros and cons relative to other immersive learning techniques of teaching EM, such as case discussions, simulations, and competitions. Such directed case study research has been very effective in identifying and making more general, core processes that solve real problems (e.g., Santos & Eisenhardt, 2009), and, therefore, could benefit from future research that adds more cases to the investigation of this approach.

In addition to the limitations of a single case study, the project assessment data within the case study is based on a relatively small group of informants. Hence, program assessment by its stakeholders must be considered as exploratory but nonetheless also as indicative. Future research therefore could impanel stakeholder respondents such that the data gathered would lend itself to meaningful statistical analysis. Such future studies also should examine the extent to which program graduates can readily apply the frameworks and principles of EM in new venture settings. In other words, it would be pertinent to know whether graduates from the program are demonstrating better-learned skills in applying the dimensions of EM proposed by Morris et al. (2002) in their careers. Tracking and engaging graduating students in a continuous process of data elicitation could prove valuable in measuring program effectiveness.

Conclusion

We suggest that as society and technology change, so should the content and methodology of programs at the intersection between technology and business education. We believe, along with many others, that the EM discipline provides ideas and methods that can "better prepare all forms of ventures—from lifestyle companies to aspiring unicorns—to increase the rate of success and to stimulate economic growth" (Worthington & Eggers, 2022, p. 127). Thus, we argue that it is important to understand how best to teach EM in graduate education—in technology-related degrees such as education at the STEM MBA level—where the primary approach in the past has been more analytical, but needs more field interactions for customer discovery, customer needs definition, skill/expertise acquisition, value proposition establishment and their testing.

In this article, we propose a stage-gate process for teaching EM in a STEM MBA program, following a deliberate-practice-based skill/expertise enhancement approach that emphasizes experimentation and discovery. Despite study limitations, we maintain that our study demonstrates the value of continuing to integrate the curriculum and courses in marketing and management disciplines with science and technology research lab partnerships, into collaborative learning initiatives for the design and implementation of interdisciplinary marketing/management courses on technology and innovation management (Athaide & Desai, 2005). We hope our work is taking a helpful step in this direction. To conclude with reference to our initial metaphor, we now can see possibilities for the chasm that opens up between the invention of a technology and the efforts to commercialize it, as, perhaps, the valley of *not quite so much* death.

Appendix

The I-Corps Program

The I-Corps program's objective is to accelerate the commercialization of science-based research (Youtie & Shapira, 2017). In I-Corps training, an entrepreneurial team consists of members with three key roles (a) the principal investigator, usually the inventor; (b) the entrepreneurial lead; and (c) a mentor with experience in the related field. The team starts with business development and customer discovery basics based on the BMC (Osterwalder & Pigneur, 2010), a simplified version of a conventional business plan, which supports the deliberate practice approach by developing both a student's knowledge base, and their problem-solving processes (Figure 1). The BMC has nine elements that focus on the value proposition, customer relationships/ channels, and internal factors such as key partners, activities, necessary resources, potential revenue streams, and cost structures (Osterwalder & Pigneur, 2010).

As previously noted, in following the scientific customer discovery method (Blank, 2013), one of the most critical aspects of lean-startup-based I-Corps training is testing the market through hypotheses about customer segments and their value propositions. The experiments/ hypotheses are tested through conversations with potential customers, key business partners, and investors without "selling" the product to avoid biasing the information collected. After each conversation, the entrepreneurial team reviews the evidence to see whether the assumptions are right or wrong. In this way, the team can iterate or "pivot" (Blank, 2013) their experiments/ hypotheses to better match the products offered with the customer needs. This approach gives participants a better idea about business model viability as a stand-alone business, a technology that could be licensed to other companies, or as not worth pursuing as a business venture (Youtie & Shapira, 2017).

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