HOW INTELLECTUAL MOVEMENTS AMONG EXTERNAL AND INTERNAL ACTORS SHAPE THE COLLEGE CURRICULUM: THE CASE OF ENTREPRENEURSHIP EDUCATION IN ENGINEERING

by

Sergio Celis Guzmán

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Doctoral Committee:

       Professor Janet H. Lawrence, Chair
       Associate Professor Michael N. Bastedo
       Professor James Paul Holloway
       Professor Lisa R. Lattuca

To Francisca and Santiago

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LIST OF ABBREVIATIONS

ASEE	American Society for Engineering Education
CEEPS	Committee on Entrepreneurial Environment and Programs for Students
CFE	Center for Entrepreneurship
CoE	University of Michigan's College of Engineering
CSG	Central Student Government
CWEE	Campus-Wide Entrepreneurship Education
EDA	ElectroDynamic Applications
EECS	Electrical Engineering and Computer Science
E^3	Entrepreneurship education in engineering
I-Corps	Innovation Corps program
IOE	Industrial and Operations Engineering
KEEN	Kern Entrepreneurship Education Network
LSA	University of Michigan's College of Literature, Science, and the Arts
MIC	Medical Innovation Center
MINT	Michigan Investment in New Technology
MIT	Massachusetts Institute of Technology
NACIE	National Advisory Council on Innovation and Entrepreneurship
NCIIA	National Collegiate Inventors and Innovators Alliance
NSF	National Science Foundation
OTT	Office of Technology Transfer
Ross	University of Michigan's Stephen M. Ross School of Business
SI	University of Michigan's School of Information
SIMs	Scientific and intellectual movements
SPH	University of Michigan's School of Public Health
STEM	Science, technology, engineering, and mathematics
STVP	Stanford Technology Ventures Program
UC	University of California
UIUC	University of Illinois at Urbana-Champaign
UM	University of Michigan
ZLI	Zell Lurie Institute for Entrepreneurial Studies

ABSTRACT

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Chair: Janet H. Lawrence

This study focuses on key aspects of curricular change that are often overlooked in the engineering education literature. Specifically, attention is directed to the contextual factors and the collective action of multiple actors that shape the change process as the actors frame and reframe a new curricular idea. In order to analyze this process, the study employs the social movement theories of scientific and intellectual movements and collective action frames. Using a case study method, this investigation examines the emergence of entrepreneurship education at the University of Michigan's College of Engineering (CoE). Over two years, the researcher conducted 27 semi structured interviews, collected over 300 documents, and observed 17 events. The case study is presented in four periods, the latent (late 1990s-2006), the launch (2006-2008), the start me up momentum (2008-2011), and the branching out from engineering (2011-2013). Over these periods, entrepreneurship education went from few individual and scattered efforts to a collective action that mobilized multiple actors, including student organizations and alumni groups. This collective action established new curricular programs and numerous co-curricular activities. More important, it built an entrepreneurial ecosystem and moved the CoE and the entire university towards a pro-entrepreneurial culture. In general, when the emergence of entrepreneurship education in the CoE is viewed as a movement, four processes can explain its success. First, senior faculty promoted a new vision for engineering education, one that could be accomplished alongside the traditional curriculum. Second, structural conditions in the university and in local and state government gave the movement access to key resources. Third, various micromobilization contexts served as spaces where movement participants came into frequent contact and where new members could be recruited. Fourth, movement participants framed and reframed curricular ideas in a way that both internal and external actors to the university could identify with and bridged differences between them. Overall, this research contributes to curricular change theories in engineering education by illustrating how contextual factors and collective action influence change. The study concludes with recommendations for both curricular change advocates and curricular decision makers.

Chapter 1: Introduction

"It's gone viral. It's all across campus. It's not an app, but in recent years, it's a movement buzzing with energy all across phone screens, Facebook profiles, posting walls. And it's rapidly evolving." *The Michigan Daily.* (Wassman, 2014, January 6, p. 4B)

Engineering education has been the focus of reform over the last three decades. Numerous national and global organizations, public and private, have pushed for reform in engineering education, calling for a curriculum that provides a broader set of knowledge and skills through the use of active learning methodologies in and beyond the classroom (Crawley, Malmqvist, Ostlund, & Brodeur, 2007; Duderstadt, 2008; National Academies, 2004, 2005, 2010; Sheppard, Macatangay, Colby, & Sullivan, 2009). Multiple initiatives and resources have been devoted to changing the engineering curriculum (e.g., Clark, Froyd, Merton, & Richardson, 2004; Crawley et al., 2007; Graham, 2012). However, the effectiveness, sustainability, and diffusion of these efforts have been questioned (e.g., Borrego, Froyd, & Hall, 2010; Graham, 2012). Critics are concerned that research explaining why certain changes in engineering education take hold and others do not lags far behind (Clark et al., 2004; DeHaan, 2005; Henderson, Beach, & Finkelstein, 2011; Kezar, 2012). Inquiries into this question are important as the answers will help to improve engineering education through effective and sustainable processes of change.

When engineering schools change or attempt to change their curricula, their main strategies follow a top-down approach, guided by big streams of research funding (Leslie, 1993; Noble, 1977) or through regulatory powers, such as accreditation (Bjorklund & Colbeck, 2001; Prados, Peterson, & Lattuca, 2005; Splitt, 2002; Volkwein, Lattuca, Harper, & Domingo, 2006).

Little is known about curricular change in engineering that comes about primarily from initiatives that emerge and are shaped through interactions among students, faculty, and external constituencies. Hence, this dissertation examines a curricular change that did not follow from alterations in accreditation standards or funding agencies but through the combined efforts of actors internal and external to the university. The goal of the case study is to enhance research on curricular changes in engineering and other science, technology, engineering, and mathematics (STEM) fields by analyzing the emergence of entrepreneurship education in engineering at the University of Michigan. Theories of social and intellectual movements that are used to explain the success and failure of curricular changes in other disciplines and fields guide the case analysis. Specifically, the inquiry considers the social and political dynamics of the change process, asking how contextual factors and interactions among groups and individuals influenced the undergraduate curriculum, how the curricular ideas were framed and reframed in these interactions, and how the curricular ideas created at the local level relate to those at the national level.

Curricular Change in Engineering Education

Scholars who study the influence of external forces (e.g., industry, government, and the military) in engineering education focus on top-down approaches to change. One mechanism for influencing the curriculum has been selective research funding as industry or the military or both provide generous streams of resources for studies related to their interests (Leslie, 1993; Noble, 1977; Thelin, 2004). This funding then sets the research agendas of engineering faculty, who ultimately modify the graduate and undergraduate curricula according to these interests (Leslie, 1993; Noble, 1977). Over the last two decades, accreditation standards have also become an

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effective instrument for promoting curricular change across and within engineering schools (Bjorklund & Colbeck, 2001; Prados et al., 2005; Splitt, 2002; Volkwein et al., 2006). Little is known about alterations to the curriculum initiated from the interaction among actors external to the university (e.g., alumni, employers) and internal actors (e.g., faculty, students).

Scholars have closely examined the role of internal influences on curricular change in engineering school settings (Colbeck, 2002; Harper & Lattuca, 2010; Seymour 2002; Stark, Briggs, & Rowland-Poplawski, 2002; Stark, Lowther, & Hagerty, 1987a) and provide valuable insight about campus and departmental dynamics. Study findings indicate that faculty ties with external actors—primarily employers—influence their perceptions of the environment (Briggs, Stark, & Rowland-Poplawski, 2003; Colbeck, 2002) and their actions towards the curriculum (Harper & Lattuca, 2010). Within engineering departments and schools, research also documents that curricular discussions occur through formal and informal interactions, and that interest groups can emerge when curricular decisions are at stake (Briggs, 2007; Eckel & Hartley, 2008; Wright, 2005). Administrators, such as program chairs, are most likely to negotiate with these groups (Stark et al., 2002; see also Conrad, 1978). The political nature of these negotiations explains in part why the diffusion and adoption of curricular ideas occur at a slow rate and do not necessarily follow evidence of success (Clark et al., 2004; DeHaan, 2005). This is important because change initiatives in engineering education are often based on validation through program evaluation, a development and testing strategy, which assumes if a change works in one academic unit, it can be successfully transferred to others within a campus and across engineering schools (DeHaan, 2005; Henderson et al., 2011). Henderson et al. (2011) argues "that the common strategy of developing and testing 'best practices' curricular material and then making these material available to other faculty does not work" (p. 271). Kezar (2012) argues

that such models fail to account for the myriad contextual influences at play during the curricular change process in engineering and other STEM fields.

In summary, previous research gives us important clues and evidence of how the engineering curriculum changes in response to shifts in the larger sociocultural and economic contexts. The research also demonstrates how vested interest groups form within universities and the tactics they use to influence curricular decision-making. However, two important dimensions are overlooked. First, how these social and economic shifts impact campuses not only through large research funding or regulatory powers but also through collective action among multiple actors, internal and external to the university. Second, minimal attention has been given to the nature of interactions between external and internal actors that defend and challenge the curricular status quo, call for reform, and foster networks and resources that support particular initiatives. We miss how curricular ideas are framed and debated at the boundaries between universities and their external environment—the location of intensive activity around engineering education where the external actors do not have direct sanction authority over curricula.

Social Movements and Curricular Change

Social movement theories have extensively studied bottom-up changes in higher education, primarily in the humanities and social sciences, and the influences of external actors and broader social issues on these changes. These studies take into account the crafting of arguments in support of particular curricular changes (e.g., Arthur, 2011; Boxer, 1998) and interactions that occur in various sites between external and internal actors, for example faculty and student participation in local community movements (e.g., Boxer, 1998; Messer-Davidow,

2002) and interactions between actors at the local and national levels (e.g., Boxer, 1998; Messer-Davidow, 2002). They also attend to the construction of interdisciplinary boundaries (e.g., Messer-Davidow, 2002; Small, 1999) and the effects of institutional culture on movement outcomes (e.g., Arthur, 2011; Gumport, 1990; Olzak & Kangas, 2008; Rojas, 2006; Small, 1999; Yamane, 2001).

Social movement studies encompass a large range of theoretical perspectives (McAdam, McCarthy, & Zald, 1988; Snow, Soule, & Kriesi, 2004). In particular, this study proposes two social movement theories for understanding curricular change in engineering education: scientific and intellectual movements (SIMs) (Frickel & Gross, 2005) and collective action frames (Benford & Snow, 2000). Like social movements, SIMs promote particular scientific or intellectual programs that seek to break with the past, require collective action, vary in scope, and are inherently political and episodic phenomena. SIMs are usually led by high-status senior scientists and intellectuals and tend to be smaller in size, less revolutionary, and less risky than social movements. Frickel and Gross (2005) suggest that SIMs are more likely to emerge when high-status actors harbor complaints against mainstream intellectual tendencies and are more likely to be successful when SIMs have access to both key resources and sites where new ideas can be discussed and new members recruited. Finally, Frickel and Gross (2005) point out "the success of a SIM is contingent upon the work done by movement participants to frame movement ideas in ways that resonate with the concerns of those who inhabit an intellectual field or fields" (p. 221). This last proposition is of chief importance, since the focus of this study is on how curricular ideas are framed and reframed in the interactions among internal and external actors. This proposition connects with the collective action frames, the second central theoretical piece of this study.

Collective action frames, along with resource mobilization and political opportunity, are integral to the study of social movements, (Snow, 2004). Frames are the action-oriented beliefs, metaphors, and symbols that activists use to convey a particular issue to others (Benford & Snow, 2000). Collective action frames have three core tasks: *diagnostic framing*, *prognostic framing*, and *motivational framing* (Benford & Snow, 2000). *Diagnostic framing* explains the problem, what is wrong and why, and assigns blame or responsibility. *Prognostic framing* articulates a solution to the problem and an action plan. Finally, *motivational framing* provides a rationale for engaging in collective action to carry out the plan. The framing perspective also proposes several socio-cognitive mechanisms, or strategic framing processes, that actors use to accomplish their goals (Benford & Snow, 2000). These processes refer to the ways issues are communicated to achieve specific goals, such as recruiting new members or acquiring resources. The most basic strategic framing processes are those intended to produce alignment between movement leaders and prospective resource providers. Among the most studied processes are frame amplification, frame bridging, and frame extension. For instance, bridging occurs when two structurally unconnected sets of action-oriented beliefs are linked to a particular issue.

In the context of curricular change in engineering education, this study seeks to understand the characteristics and dynamics of collective action and the role of multiple actors through the theoretical lens of SIMs and collective action frames. This inquiry is explored by studying the case of the emergence of entrepreneurship education in engineering (E^3). This case represents an extraordinary opportunity to understand the complex dynamics among multiple actors who surround a curricular change.

The Rise of Entrepreneurship in Engineering Education

Making engineering students more entrepreneurial is just one of the many ideas circulating around colleges and universities. What makes E³ particularly interesting, however, is its relatively fast-growing adoption among engineering schools, even though professional organizations have not yet taken a formal stance regarding E³. Entrepreneurship has become a ubiquitous term in our post-industrial society (Drucker, 1985), celebrated by the media and preached by policymakers nationally and worldwide (Aldrich & Yang, 2012; Radu & Redien-Collot, 2008). Public and private organizations, policymakers, business leaders, faculty and students advocate for entrepreneurship education in engineering and science fields (Mars & Metcalfe, 2009). Interestingly, ABET (formerly Accreditation Board for Engineering and Technology), the main accreditation agency in engineering, does not mention entrepreneurship in its general criteria for student learning outcomes, nor is entrepreneurship mentioned in the well-known report *The Engineering of 2020: Vision of Engineering in the New Century* (National Academies, 2004).

Arguably, the history of E³ began when Dwight Baumann, a mechanical engineer, taught the first entrepreneurship course for engineers in 1958 at the Massachusetts Institute of Technology (MIT) (McMullan & Long, 1987; MIT Museum Collection, 1957). Yet, it was not until the late 1990's that collective action around entrepreneurship gained momentum across colleges of engineering. In the mid-1990s, the National Collegiate Inventors and Innovators Alliance (NCIIA) was established, creating a network within which ideas and resources were shared. Since 1995, NCIIA has funded more than 350 entrepreneurship courses in the United States, primarily in engineering schools (e.g., Bilén, Kisenwether, Rzasa, & Wise, 2005; Mendelson, 2001; Ochs, Watkins, & Boothe, 2001; Ohland, Frillman, Zhang, Brawner, & Miller,

2004). During the first decade of the twenty first century, entrepreneurship continued its expansion among colleges of engineering and was included among the expected knowledge and skills set for the engineers of the new century (Crawley et al., 2007; Creed, Suuber, & Crawford, 2002; Duderstadt, 2008; Standish-Kuon & Rice, 2002).

Social movement studies describe several curricular change processes that seem to be at work in the rise of E^3. First, multiple frames of the E^3 curricular idea coexist and its definitions vary, depending on the institutions or the actors involved in the promotion of entrepreneurship education (Mars & Metcalfe, 2009). Concepts such as "engineering entrepreneurship" (Nichols & Armstrong, 2003), "technology entrepreneurship" (Beckman, Eisenhardt, Kotha, Meyer, & Rajagopalan, 2012; Dorf & Byers, 2008), and "entrepreneurial mindset" (Kriewall & Mekemson, 2010) imply different emphases, for instance, on business or engineering knowledge. Second, external actors to colleges and universities play a significant role in the promotion of E^3 in higher education. Many authors maintain that it is the local community, in which universities are key members, that is responsible for creating an entrepreneurial *ecosystem* (Feld, 2012; Fetter, Green, Rice, & Sibley Butler, 2010). In these ecosystems, multiple exchanges of information and people occur through blurred boundaries between the university and the local startup community (Castilla, Hwang, Granovetter, & Granovetter, 2000; Potter & Miranda, 2009). Third, national networks are created to support E^3 initiatives across colleges and universities. For instance, in 2011, the Stanford Technology Venture Program (STVP), with a $10 million grant from the National Science Foundation (NSF), launched Epicenter, whose mission is "unleashing the entrepreneurial potential of undergraduate engineering students across the United States to create bold innovators with the knowledge, skills and attitudes to contribute to economic and societal prosperity" (Epicenter, n. d.). Finally, highly rated engineering schools have embraced E^3,

signaling its support from intellectual leaders in the field. These schools tend to lead initiatives for teaching entrepreneurship to their undergraduate students in contrast to those institutions where entrepreneurship programs are led by business schools (see Appendix I).

The processes listed above do not exhaust the ways the evolution of E^3 can be viewed as a social and intellectual movement. Although many E^3 programs publically refer to themselves in terms of grassroots movements or revolutions, scant evidence exists about the similarities and differences between E^3 and the most studied social and intellectual movements in higher education, such as the rise of Women's Studies and African American Studies. To my knowledge, no research has explored the framing of ideas and the interactions of multiple actors in the rise of E^3 within colleges and universities. This unexplored territory makes the case of E^3 a unique opportunity for understanding how curricular change occurs in engineering schools from the bottom-up, and how internal and external actors collectively influence these changes.

This study consists of an in-depth single case study that draws together data from interviews, observations, archival and published documents to examine, through the lens of SIMs (Frickel & Gross, 2005) and collective action frames (Benford & Snow, 2000), the emergence of E^3 within a university campus. The focus on a single campus offers the depth of analysis necessary to identify the underlying processes and social mechanisms (Gerring, 2004), without stripping away the local context (Miles & Huberman, 1994).

The University of Michigan's College of Engineering (CoE) was the chosen research site. At the University of Michigan (UM), entrepreneurship education was primarily restricted to its Stephen M. Ross School of Business (Ross) until the Center for Entrepreneurship (CFE) was established at the CoE in 2008. The CFE launched a series of curricular and co-curricular initiatives, such as a certificate program for engineering students, and a master's of

entrepreneurship, in a joint effort with Ross. The CFE also supported multiple student organizations and initiatives that expanded the notion of entrepreneurship on the engineering campus and throughout the entire university. In the national context, the CoE is neither one of the E^3 pioneers nor one of its more recent adopters. However, in only five years, entrepreneurship went from being almost unheard of to a buzzword on campus, with over a thousand students enrolled in entrepreneurial courses and many more being touched by any of multiple entrepreneurial initiatives held at the university and in the local community. Thus, UM attracted national attention and became acknowledged as an eager advocate for E^3 (U.S. Department of Commerce, 2013). E^3 campus leaders often describe the emergence of entrepreneurship as a grassroots movement that attracted the support of many external actors.

Contribution of the Study

This study has several research and practice implications. As to research, it contributes to the understanding of a collective and dynamic approach to curricular changes in engineering education and STEM education in general. The case study also extends the traditional research focus on faculty to the interactions among internal actors, such as students and university staff, and actors external to the university, such as alumni. Since the case study is not detached from the rich university environment, the case study discusses the impact of local and national contexts in curricular change efforts. Moreover, this research has the potential to expand the use of social movement perspectives to the study of curricular change in higher education. As to practice, the case study benefits advocates of curricular change as well as curricular decision makers. Advocates may learn strategies to lead and support bottom-up or grassroots initiatives and communicate curricular ideas that resonate with engineering schools' stakeholders.

Decision-makers may draw some insights into gauging and managing the multiple discourses that continuously flow into engineering schools.

Dissertation Overview

The overall structure of the study starts by introducing the theoretical perspectives and discussing the research methods employed and is followed by an in-depth narrative describing the emergence of E^3 in the CoE. From this narrative, the study draws results, discussions and conclusions. In particular, Chapter 2 presents the literature review and conceptual framework of the study. This chapter examines a wide range of literature. First, the literatures of higher education, engineering education, and entrepreneurship education are used for describing what is known about curricular change in engineering and about E^3 in particular. Then, the general theory of SIMs and collective action frames are presented as the theoretical lens of the study. At the end of the chapter, the research questions are stated. Chapter 3 explains the research methods. This chapter includes an extensive justification of a single case study. Chapter 4 presents the case of the emergence of E^3 at the CoE. For the most part, this chapter is a chronological narrative based on facts and interpretations of events given by the study participants. The case is presented in four stages: the latent state (late 1990s-2006), the launch (2006-2008), the start me up momentum (2008-2011), and branching out from engineering (2011-2013). To some extent, this chapter is self-contained. Readers interested only in the affairs of engineering education or entrepreneurship education can read this chapter in isolation from the rest.

Chapters 5 through 6 elaborate on the answers to the research questions. Chapter 5 describes the strategies (e.g., leadership, access to resources, and access to micromobilization context) that internal and external actors used to advocate for E^3 within the CoE and at other

schools at UM. This chapter analyzes the case using concepts from SIMs as well as previous

research on social movements in higher education. Chapter 6 examines the case through the lens

of the collective action frames. In particular, the chapter discusses what framing strategies were

used by multiple actors to promote E^3 and how these strategies changed over time. Finally,

Chapter 7 presents the conclusions of the study and its implications for future research and

practice.

Chapter 2: Literature Review and Conceptual Framework

Understanding curricular change in engineering education from a collective action perspective requires a synthesis of multiple branches of literature. This effort also requires precise definitions about what is being changed, what actors play a role in the change efforts, and across what organizational boundaries. This chapter begins by defining what will be understood as curriculum and curricular change throughout the study. After the key definitions are set, the chapter summarizes what we have learned about the role of external and internal actors that shape the engineering curriculum, from history and from empirical research, and identifies limitations to our current understanding. These limitations will serve as a gateway for introducing the conceptual framework of the study, which is primarily drawn from the social movement literature. In particular, studies that focus on how social movements have changed the curriculum in higher education are discussed. The conceptual framework consists of two specific theoretical perspectives, a general theory of SIMs and collective action frames. The chapter concludes with a brief history of E^3 to illustrate why framing this case of curricular change using constructs from social movement theories is appropriate.

Definition of Curriculum and the Actors who Influence It

Curriculum scholars in higher education, as well in education in general, study questions that focus on aims, activities, and results of formal instruction (Dillon, 2009). For example, Bastedo (2005) summarizes some questions that have guided curriculum change in higher education: What do we count as knowledge? What is the knowledge most worthy to be taught?

What are the most appropriate organizational forms? What do students need to learn to be educated members of society? Similarly, García and Ratcliff (1997) urge academics to rethink "what they teach, how they teach, and why they teach it" (p. 119) in order to respond to shifts in society. Using a critical perspective, Tierney (1990) asks: How do we define knowledge? Whose interests have been advanced by these forms of knowledge? Whose interests have been superseded or ignored by such forms? What is the method used to determine what counts for knowledge? Who controls the decision making? These questions show that curriculum inquiries are intended to answer a wide range of questions and might be approached by several perspectives, methods, and theories (Short, 1991). Consequently, it is important to explain the theoretical grounding of this inquiry regarding what is understood to be curriculum and curricular change.

Lattuca and Stark's (2009) model of *curriculum* as an academic plan implies planning of educational processes that involve decisions about at least eight elements: purpose, content, sequence, learners, instructional resources, instructional processes, evaluation, and adjustment. This model has been used and referenced in theoretical and empirical studies in higher education, especially in engineering fields. Lattuca and Stark (2009) also identify two types of influences that shape college curricula: external and internal. *External influences* are pressures exerted by society through specific actors such as governments, disciplinary associations, corporations, and alumni. *Internal influences* are composed of school and university norms, resources, infrastructure, governance, and relationships among programs of study. Unit level influences include faculty, students, the discipline, and the mission of a specific program. It is important bear in mind that distinctions between external and internal actors can break down. For instance, faculty who are internal to one institution may be also part of disciplinary associations or

accreditation boards, which in turn may be considered external influences to that institution. Other higher education authors conceive the curriculum as a contested territory, where partisan interests are always at stake (e.g., Conrad, 1978; Rhoades, 2000; Rhoads & Rhoades, 2005; Slaughter, 2002). Tierney (1989; 1990) proposes that the curriculum is not a model, but rather an abstraction for organizing knowledge that cannot be codified. Tierney (1990) sees the curriculum as an organizational puzzle, a puzzle that is constructed by actors who hold different interpretative pieces and understand the complete curricular picture in manifold ways.

In the literature, multiple terms are associated with changes in the curriculum, such as curriculum planning, curriculum-making, curricular innovation, curricular reform, and curricular change. These terms have similar meaning, but they reflect different scopes. For instance, when using *curriculum planning*, the focus is on making small adjustment or continuing the processes of improvement (e.g., Briggs et al., 2003; Harper & Lattuca, 2010; Lattuca & Stark, 2009); when using *curriculum-making*, the focus is placed on the decision-making process (e.g., Conrad & Pratt, 1983; Slaughter, 2002). *Curricular innovation* refers to the implementation of a novel curricular idea that often follows a path of designing, implementing or piloting, evaluating, and disseminating (e.g., Borrego et al., 2010; Sunderman, 2011). *Curriculum reform* seems to involve a large scale innovation within an academic unit (e.g., Arnold, 2004; Conrad, 1978). The term *curricular change* is often used to describe more general processes, such as cultural change (e.g., Tierney, 1990) or changes connected to broader shifts in society (Brint, Proctor, Murphy, Turk-Bicakci, & Hanneman, 2009). Therefore, in this case study, *curricular change* refers to shifts in the institutional culture, purposes, and myriad alterations to a curriculum, including the creation of a new minor or certificate.

Engineering Curriculum: The Role of External and Internal Influences

Engineering education is historically tied to the social, economic, and security needs of society (Grayson, 1993). Indeed, engineering programs emerged as an offshoot of military engineering in the nineteenth century (Jørgensen, 2007; Thelin, 2004). In that century, particularly in Europe, engineering was considered a public service profession, working for the improvement of societal living standards: building or designing roads, bridges, dams, electrical systems, engines, and other innumerable contributions (Moore & Voltmer, 2003; Vernoiry, 2001). At the beginning of the twentieth century, engineering and other professions moved from being perceived as second-class members to leading actors at U.S. campuses (Cheit, 1975; Thelin, 2004). During that period of the industrial revolution, corporations, universities, and professional societies consciously formed a "social matrix" (Noble, 1977, p. 50) and worked to reshape the engineering curriculum "around the technical and managerial challenges of long-distance power networks" (Leslie, 1993, p. 17). During World War II and the Cold War, the military overtook the place of industry in the relationship with engineering schools (Ferguson, 1992; Leslie, 1993; Thelin, 2004). In this era, new technological demands, such as electronics, aerodynamics, automated control, and nuclear physics led to a main shift in engineering education (Emmerson, 1973). Since the 1990s, external actors have demanded better congruence between engineering education and the new challenges of the knowledge economy in a globalized world (National Academies, 2004, 2005, 2010). These demands call for engineers with a greater focus on design and innovation and with a broader set of social skills (Crawley et al., 2007; Duderstadt, 2008; Graham, 2012; Sheppard et al., 2009).

This history suggests that external actors have constantly influenced engineering education. Researchers have suggested that since the twentieth century, one mechanism for

influencing the engineering curriculum has been selective research funding as industry or the military or both provide generous streams of resources for studies related to their interests (Leslie, 1993; Noble, 1977; Thelin, 2004). This research set the research agendas of engineering faculty, who finally modified the graduate and undergraduate curricula according to these interests (Leslie, 1993; Noble, 1977).

Empirical studies that follow environmental perspectives (Aldrich & Pfeffer, 1976; Davis, 2010), such as resource dependence theory (Pfeffer & Salancik, 1978) or institutional theory (DiMaggio & Powell, 1983), suggest other mechanisms through which external actors affect universities and their curricula (Arnold, 2004; Brint et al., 2009; Gumport & Snydman, 2002; Kraatz, 1998). For example, Arnold (2004) suggests that curricular reform results from mimetic isomorphism and serves as a useful symbol indicating that a university enacts change in accordance with the standards and values of other peer institutions. Brint et al. (2009) propose that institutions adapt their curricula in response to the influence of external actors, such as demands for accountability by state legislatures and regional accrediting boards. In a study of several engineering schools, Volkwein et al. (2006) found evidence that new accreditation standards were reflected in new generations of engineering graduates. This result is consistent with the opinion of academic leaders that accreditation standards are an effective instrument for promoting curricular change across and within engineering schools (Bjorklund & Colbeck, 2001; Prados et al., 2005; Splitt, 2002). Gumport and Snydman (2002) point out that universities not only react to changes in the environment—e.g., by adding or closing programs based on student demand— but also seek to influence it—e.g., by adding new programs for cultivating new student demand.

Other scholars suggest pervasive societal changes shape the college curriculum. For example, Slaughter (1997) proposes social movement theory and power theories of professionalization to study the university curriculum. The former explores how new fields and new curricula entered to universities, such as, women's studies, Latino studies, or gay and lesbian studies. The latter explains why some curricula and fields achieve more success than others. Slaughter suggests that the ties between the curriculum and the environment define curriculum success, understood as enrollment, academic and financial resources, and social prestige. The ties that bring this success are those connected to government, foundations, and corporations. Slaughter and Rhoades (2004) proposed the theory of academic capitalism to describe how universities have become servile to market forces utilizing a variety of public resources, including the college curriculum, for private interests. Since the new economy promotes entrepreneurial behaviors in faculty and students and favors organizations that facilitate exchanges between universities and markets, academic capitalists predict that entrepreneurship education will continue to expand in higher education (Mars & Metcalfe, 2009; Mars, Slaughter, & Rhoades, 2008; Mars & Rhoades, 2012). However, this literature focuses on macro-level societal factors and does not consider the micro interactions that occur when curricular ideas are framed, debated, and negotiated between actors external to and within the university. These interactions can be particularly conflictive when external actors represent ideas in market terms and academic decision makers are guided by values and by a pace that are different from those governing market decisions (Birnbaum, 2004).

Scholars have closely examined the role of internal influences on curricular change in engineering school settings (e.g., Colbeck, 2002; Graham, 2012; Harper & Lattuca, 2010; Seymour, 2002; Stark et al., 2002; Stark et al., 1987a) and provide valuable knowledge about

campus and departmental dynamics. Study findings indicate that faculty ties with external actors—primarily employers—influence their perceptions of the external environment (Briggs, Stark, & Rowland-Poplawski, 2003; Colbeck, 2002; Stark, Lowther, & Hagerty, 1987b) and their perspectives, behaviors, and actions towards the university curriculum (Harper & Lattuca, 2010; Stark et al., 2002). Research also documents that curricular discussions occur through formal interactions—e.g., committees, task forces, or course coordination—as well as informal ones— e.g., hallway conversations (Briggs, 2007; Briggs et al., 2003; Eckel & Hartley, 2008; Stark et al., 2002; Trinkaus & Booke, 1980; Wright, 2005). Both formal and informal contacts are crucial for promoting or blocking curriculum formation and change (Brigg, 2007; Eckel & Hartley, 2008; Trinkaus & Booke, 1980; Wright, 2005). Cliques or interest groups can form when curricular decisions are at stake (Stark et al., 2002; Trinkaus & Booke, 1980), but not all faculty participate in curricular discussions (Briggs et al., 2003; Colbeck, 2002; Trinkaus & Booke, 1980; Stark et al., 2002). Therefore, these faculty interest groups develop strategies, such as alternating participation, to help keep their control over the curriculum (Stark et al., 2002). They also use one or several members as brokers or representatives to negotiate with other groups in internal formal or informal networks. Academic administrators, such as program chairs or department heads, are most likely to perform this function (Graham, 2012; Stark et al., 2002). The political nature of these negotiations helps to explain why empirical studies in engineering education also find that the diffusion and adoption of curricular ideas occur at a slow rate, if at all (Borrego et al., 2010; Clark et al., 2004; DeHaan, 2005). Surprisingly, the influence of students is rarely discussed in this literature. Graham (2012) found engineering students often played a lesser role than expected by reform leaders.

In summary, the higher education literature gives us important clues and evidence of how the college curriculum changes in response to shifts in the larger sociocultural and economic contexts and the roles that external actors play in this process. The research also demonstrates how vested interest groups form within universities and the tactics they use to influence curricular decision-making. However, minimal attention has been given to the nature of interactions between external and internal actors that defend and challenge the curricular status quo and the emergence of networks and resources that support particular initiatives. We miss how curricular ideas are framed and debated at the boundaries between universities and their external environment—the location of intensive activity around engineering education where the external actors do not have direct sanction authority over curricula.

Limitations to Inquiries into Curricular Change in Engineering Education

Models of change in engineering education often assume a development and testing strategy (Clark et al., 2004; Henderson et al., 2011; Seymour, 2001). This approach assumes a curricular change is a product to be developed, tested, and disseminated to other schools. This strategy fails to take into account the political and cultural dimension of the context within which it is implemented and evaluated and that can affect adoption in other settings (Kezar, 2012; Seymour, 2001). Even scholars who use a development and testing strategy as a conceptual starting point conclude that a more context-sensitive approach to the study of curricular change may better explain transformation in STEM education (Borrego et al., 2010; Clark et al., 2004: Hazen, Wu, & Sankar, 2012; Pundak & Rozner, 2008). In engineering education, scholars who use Rogers (1995) model of innovation diffusion often report informal networks (Borrego et al., 2010) and the capacity to tailor curricular ideas to campus norms (Hazen, Wu, & Sankar, 2012;

Pundak & Rozner, 2008) are critical for promoting curricular change. Clark et al. (2004) concludes that after a process of curricular change, campus leaders learn "that curriculum is an agreement between all of its constituencies and curricular changes are negotiations, not just constructions of syllabi and learning activities" (p. 45).

Some authors also indicate that successful changes contain the right combination of top-down and bottom-up approaches (Kolmos & de Graaff, 2007; Graham, 2012; Seymour, 2001). Kolmos and de Graaff (2007) adopted Kotter's model for successful change to describe the adoption of problem and project based learning methods in engineering promoted by these two approaches. Kotter (1996) suggests eight key processes: establishing sense of urgency, creating coalition, developing a vision, communicating the change vision, empowering employees, generating short-term wins, consolidating gains, and anchoring new approaches in culture. However, the prescriptive list presented by Kotter sees grassroots action—in particular the processes of empowering employees—as a strategy of leaders for achieving change, rather than a more organic process of change.

Graham (2012) conducted multiple interviews with engineering education leaders and six case studies for successful curricular changes in engineering. Many interviewees pointed out that in order to stick, changes must be radical and widespread. In many cases, a "degree of serendipity" (p. 19) made it possible for many interests and resources to come together for a change effort. The case of iFoundry at the University of Illinois Urbana-Champaign (UIUC) was selected by Graham (2012) as an example of a grassroots initiative (see also Sunderman, 2011). iFoundry, which stands for the Illinois Foundry for Innovation in Engineering Education, was established in 2007 by a group of faculty who were involved in conversations about change in engineering education. Although the changes were introduced as a curricular incubator

(Sunderman, 2011), its growth was characterized as "organic and entrepreneurial" (Graham, 2012, p. 39). Unfortunately, Graham (2012) and Sunderman (2011) focus on the implementation and effectiveness of iFoundry rather than its emergence, which could have illuminated the collective formation processes, the interactions among individuals and the collective framing of curricular ideas (see Goldberg & Somerville, 2014 for a firsthand account of the origins of iFoundry and its early connection with Olin College). Undoubtedly, more research is needed about collective and context-sensitive approaches to change in engineering education. The next section, discusses how the social movement literature has understood grassroots initiatives in higher education.

Social and Intellectual Movements

Social movement studies encompass a large range of theoretical perspectives (McAdam, McCarthy, & Zald, 1988; Snow et al., 2004). This study draws from two theoretical perspectives in particular: scientific and intellectual movement (Frickel & Gross, 2005) and collective action frames (Benford & Snow, 2000). According to Snow et al. (2004), *social movements* are conceptualized as "collectivities acting with some degree of organization and continuity outside of institutional channels for the purpose of challenging or defending extant authority" (p. 11). The emergence of new academic programs, especially in the humanities and social sciences, is one of the most studied topics in social movement research in higher education settings (Rojas, 2012). These studies have examined interactions between external and internal actors surrounding curricular change as well as the mechanisms produced by these interactions (Rojas, 2012). One of the main findings is that the local community plays a prominent role in the emergence of a new curricular program (Boxer, 1998; Messer-Davidow, 2002). For instance, the

idea of women's studies in higher education was incubated in local non-academic activist groups that advocated for a broad range of women rights, from domestic violence to health care issues (Boxer, 1998; Messer-Davidow, 2002). Many faculty were members of these groups and brought ideas, materials, and speakers from them when the first women's studies programs and courses started (Boxer, 1998; Gumport, 1990; Messer-Davidow, 2002). According to Messer-Davidow (2002), these interactions with the local community explain the large variance of topics in programs across the country. Boxer (1998) also points out that once the academic programs were established, their strong connections with women in the community translated into important endowments and gifts.

The social movement literature suggests a progression of changes that occurs in college curricula. After the first programs emerge, national academic networks are formed to share resources and ideas and to legitimize the new programs in the academic world (Boxer, 1998; Messer-Davidow, 2002). In the early stages, how the new curricular ideas are framed influences the level of adoption and institutional commitment to the idea (Arthur, 2011; Boxer, 1998; Messer-Davidow, 2002). Asian American studies, women studies, and queer studies were successfully adopted when campus activists connected the movement goals with institutional cultures. For instance, Arthur (2011) suggests that framing strategies on a single campus were a key factor in the approval of Asian American studies and the failure of queer studies. Activists for Asian American studies "focused on the importance of learning one's history for understanding one's experience" (p. 114), a message that resonated with the institutional mission and legitimated the program's academic merits. On the other hand, the queer studies movement was not able to develop a "resonant framing strategy" (p.145) that would have attracted academic support, "faculty could not agree on common intellectual grounding for a program, and

students claimed that queer studies would resolve campus problems for queer students but never explained how" (p.145). Even the naming of new curricular ideas can affect levels of institutional commitment. For example, Boxer (1998) points out the concept of women's studies trumped feminist studies and other alternative wordings because women's studies was a concept that sounded more objective and more comprehensive. In addition, Messer-Davidow (2002) suggests that early women's studies programs were strongly shaped by campus culture and the department that took the lead in its diffusion—usually English, history, and sociology—and that the "curriculum resembled a multidisciplinary mélange rather than a disciplinary hybrid" (p. 154) despite the prominent academic discourse of interdisciplinarity.

Social movement studies also suggest that the main characteristics of a new curricular program and its supporting rationale are shaped by the discipline that takes the lead in introducing it within a particular campus (Boxer, 1998; Messer-Davidow, 2002). In addition to the framing of the idea, movement actions and leadership also influence the adoption of new curricular programs. Research on the effectiveness of different types of movement actions is mixed. For example, Yamane (2001) argues that students' violent actions were an effective form of pressure for curricular change in the case of multiculturalism. Rojas (2006) found that non-disruptive protests were more effective than disruptive protests in the adoption of African American studies. In terms of leadership, studies suggest movements that are led by faculty held in high regard by their peers are more likely to be persuasive (e.g., Boxer, 1998; Messer-Davidow, 2002; Small, 1999).

The studies described above considered cases only in the humanities and social sciences. Frickel and Gross (2005) integrated this social movement literature with the sociology of science (Zuckerman, 1988) to create a Theory of SIMs. Like social movements, SIMs promote particular

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scientific or intellectual programs that seek to break with the past, require collective action, vary in scope, and are inherently political and episodic phenomena. SIMs are usually led by high-status senior scientists and intellectuals and tend to be smaller in size, less revolutionary, and less risky than social movements. In history, there are many accounts of successful SIMs; for instance, the movement of engineers for industry standards (Murphy & Yates, 2011) and the emergence of fields such as statistics (Cullen, 1976; Schweber, 2006), genetic toxicology (Frickel, 2004), biochemistry (Kohler, 1982), and biotechnology (Rabinow, 1996).

Frickel and Gross (2005) suggest four propositions about SIMs:

> *Proposition 1:* A SIM is more likely to emerge when high-status intellectual actors harbor complaints against what they understand to be the central intellectual tendencies of the day.
>
> *Proposition 2:* SIMs are more likely to be successful when structural conditions provide access to key resources.
>
> *Proposition 3:* The greater a SIM's access to various micromobilization contexts, the more likely it is to be successful.
>
> *Proposition 4:* The success of a SIM is contingent upon the work done by movement participants to frame movement ideas in ways that resonate with the concerns of those who inhabit an intellectual field or fields (pp. 209-221).

The notion of micromobilization contexts (Proposition 3) refers to those sites where movement members and potential recruiters come into frequent interaction with one another (McAdam, McCarthy, & Zald, 1988). In the general theory of SIMs, examples of these micromobilization contexts are conferences, symposia, research retreats, academic departments and laboratories, and classrooms (Frickel & Gross, 2005). It may well be that how curricular

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ideas are framed and reframed in these interactions (Proposition 4) plays a key role in shaping curricular changes. Proposition 4 is therefore a key connecting point with the theoretical perspective of collective action frames.

Collective Action Frames

Collective action frames, along with the theories of resource mobilization and political opportunity, is integral to the study of social movements (Snow, 2004). Frames are the action-oriented beliefs, metaphors, and symbols that activists use to convey a particular issue to others (Benford & Snow, 2000; Noakes & Jhonston, 2005). Collective action frames have three core tasks: *diagnostic framing*, *prognostic framing*, and *motivational framing* (Benford & Snow, 2000). *Diagnostic framing* explains the problem, what is wrong and why, and focuses blame or responsibility. *Prognostic framing* articulates a solution to the problem and an action plan. Finally, *motivational framing* provides a rationale for engaging in collective action to carry out the plan. The overall credibility of any framing will depend on its consistency, empirical trustworthiness, and the authority of the frame articulators (Benford & Snow, 2000). Interestingly, individuals responsible for crafting arguments have been conceptualized as *social movement entrepreneurs* by social movement scholars (Noakes & Jhonston, 2005). Those who theorize movement arguments and communicate them across local and global movement networks are known as *epistemic brokers* (Herring, 2010). When one frame is shared by numerous collective action groups and operates as a cultural symbol, it is known as a *master frame* (Snow & Benford, 1992).

The framing perspective proposes several socio-cognitive mechanisms, or *framing processes*, that actors use for accomplishing their goals (Benford & Snow, 2000). According to

Benford and Snow (2000), strategic framing processes have received the most empirical attention. They refer to the ways issues are communicated to achieve specific goals, such as recruiting new members or acquiring resources. The most basic strategic framing processes are those intended to produce *alignment* between movement participants and prospective resource providers (Snow, Rochford, Worden, & Benford, 1986). These basic processes are *frame bridging*, *frame amplification*, *frame extension*, and *frame transformation*. *Frame bridging* occurs when two unconnected collective action frames are linked to a particular issue. *Frame amplification* involves highlighting an issue, idea, or event as more important than others. *Frame extension* consists of expanding the initial articulation of an idea to include issues that are important among prospective adherents. Finally, *frame transformation* refers to changing old interpretations of an issue by replacing them with new ones. Other similar alignment strategies have been developed since Benford and Snow's (2000) conceptualization, including *framing translation*, which happens when activists modify and adapt frames to local contexts (Campbell, 2005; Frickel, 2004), or *bricolage*, which refers to the recombination of multiple elements (e.g., beliefs, metaphors, and symbols) into one collective action frame (Rao, Monin, & Durand, 2005).

For instance, Frickel (2004) identified three strategic framing processes in the case of the rise of genetic toxicology. This field emerged, in the late 1960s, as a group of genetic scientists promoted genetic toxicology as an interdisciplinary field among biologists, industry toxicologists, pharmacologists, and others. Framing amplification occurred when champions for genetic toxicology stressed the genetic hazards of chemical mutagens and urged biologists and other scientists to use their knowledge to address this critical environmental problem. Framing extension was evident in the wide "rhetorical net" (p. 278) that scientists used to connect the

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importance of genetic toxicology in different arenas, such as the effects of chemical mutagens in environmental pollution that attracted researchers in the environmental and health sciences. Frame translation consisted of efforts by small groups of scientists to connect genetic toxicology with established research areas on cancer and developmental abnormalities. This translation happened by meticulous scientific crafting of the idea that chemical mutagenesis could give answers to complex problems, such as birth defects.

The collective action frames perspective is not immune to criticisms. Oliver and Johnston (2000) point out that framing perspectives downplay the role of ideology and other political phenomena. Benford (1997) mentions, in an insider's critique, that numerous empirical studies have a descriptive bias that privileges the identification of new framing types, instead of conducting analysis of processes and dynamics. These descriptions tend to oversimplify the multilayered complexities of framings activities and neglect the human agency and the role of emotions in social movements (see also Morris, 2000). Benford (1997) also criticizes the elite bias of most framing studies, which privilege the points of view of movement leaders without attending to low-rank participants, potential recruiters, and bystanders.

In line with this criticism, several authors have proposed complementary conceptual frameworks in order to strength the collective action frames weakest points. Baldez (2002) presents the *tippin* model, which combines framing perspectives with a temporal dimension. This model aims to understand the emergence of collective action, when diverse groups or individuals join together under a common frame to challenge the status quo. Baldez (2002) suggests, "A tip occurs when political entrepreneurs frame the need for mobilization in terms that resonate with an array of people at a particular point in time" (p. 6). Miethe (2009) goes to Goffman's (1974) and Bateson's (1972/2000) seminal works on framing to propose the concepts of keying.

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According to Miethe (2009), keying is the process in which movement participants transform a primary framework into something else. By successive keying processes, movement participants add or remove different layers of the movement activities. Thus, by analyzing keying processes, researchers will not overlook the multilayered complexities of these activities. Capturing biographical perspectives is a fundamental strategy for unveiling keying processes as they connect framing strategies with individual actor's motivations for involvement in a particular movement. Therefore, the keying model, avoids the reduction of collective farming processes into mere marketing strategies. These critical perspectives and the concepts of tipping and keying are considered in the study in order to reduce the risk of bias, as well as to contribute to the framing perspective in the higher education context.

Brief Introduction to the Emergence of E^3

Entrepreneurship has become a ubiquitous term worldwide. Policy-makers conceive entrepreneurship as "the engine fuelling innovation, employment generation and economic growth" (World Economic Forum, 2009, p. 6). It is a cultural code that has touched different spheres of society, such as public policy, education, and media coverage (Aldrich & Yang, 2012). Academics from multiple disciplines have tried to understand this phenomenon at multiple levels of analyses (Spinosa, Flores, & Dreyfus, 1997). Traditionally, entrepreneurship has been understood as the creation of new business processes, practices, and products that create value (Drucker, 1985). The contemporary use of entrepreneurship emphasizes the creative destruction of established social structures and markets (Audretsch, 2007; Schumpeter, 1975; Spinosa et al., 1997). Entrepreneurship is thus often related to novelty, creativity, turbulence, innovation, flexibility, networks, and "thinking out of the box" (Bonnet, Desjardin, & Madrid-

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Guijarro, 2012). To some extent, this is a radical shift from the post-World War II American society described in Whyte's (1956) *The Organization Man*. The promise of long-term employment as "a gateway to lifetime security" (headline from the Journal of College Placement, quote in Whyte, 1956, p. 72) has been banished to allow a more diverse, flexible, and all but secure professional path (Bauman, 2007; Sennet, 2006).

Entrepreneurship has been taught from different disciplinary perspectives that emphasize different levels of analyses (Alvarez, Agarwal, & Sorenson, 2005) and conceptualize entrepreneurship as a social ecosystem (Carroll & Khessina, 2005), an institutional transformation force (Hwang & Powell, 2005), and a psychological type (Miner, 1997). Authors have identified the roots of the entrepreneurial society in the social revolutions of the 1960s (Audretsch, 2007; Boltanski & Chiapello, 2007), the fall of communism in the late 1980s (Audretsch, 2007), and the emergence of the Internet in the 1990s (Lewis, 2000). A discussion of the emergence of entrepreneurship in society and the evolution of its definitions is beyond the scope of this study. Thoughtful analyses of this phenomenon can be found elsewhere (e.g., Aldrich & Yang, 2012; Ma & Tan, 2006). Hereafter, this study assumes entrepreneurship as a master frame (Snow & Benford, 1992) that exists in society and attempts to transform governments, industries, and educational institutions.

Making engineering students more entrepreneurial is just one of the many ideas circulating around colleges and universities. What makes E^3 particularly interesting, however, is its relatively fast-growing adoption among engineering schools, even though professional organizations have not yet taken a formal stance regarding E^3. According to Brad Osgood, associate dean at Stanford's School of Engineering, this is unsurprising since entrepreneurship has become a ubiquitous term in our society—a term that "is very much in the air these days"

(Epstein, May 14, 2010). Public and private organizations, policymakers, business leaders, faculty and students advocate for entrepreneurship education in engineering and science fields (Mars & Metcalfe, 2009). However, ABET, the main accreditation agency in engineering, does not mention entrepreneurship in its general criteria for student learning outcomes, and entrepreneurship is not mentioned in the well-known report *The Engineering of 2020: Vision of Engineering in the New Century* (National Academies, 2004).

The first entrepreneurship course was taught at Harvard's Business School in 1947 (Katz, 2003), and entrepreneurship scholars regard Joseph Schumpeter and Peter Drucker as the intellectuals who conceptualized entrepreneurship as a set of knowledge and teachable skills (Katz, 2003, Kuratko, 2005). Thus, it is assumed that entrepreneurial skills and knowledge can be learned and taught, and since the 1990s entrepreneurship has become a curricular and research subject in almost every business school (Aldrich, 2012; Finkle & Deeds, 2001; Katz, 2003; Solomon, 2007). However, it has not achieved the same status and level of institutionalization (e.g., numbers of tenure track faculty) as other sub-disciplines in business (Finkle & Deeds, 2001; Kuratko, 2005). Moreover, Kuratko (2005) argues that business schools are failing at making entrepreneurship education relevant and that most innovation in this area is happening in other disciplines, especially in engineering. Vesper (in McMullan & Long, 1987) even suggested that engineering students are more likely to become entrepreneurs than business students because of engineering's capacity for developing new products.

Arguably, the history of E^3 began only about a decade after the first course was taught at Harvard, when Dwight Baumann, a mechanical engineer, taught the first entrepreneurship course for engineers in 1958 at MIT (McMullan & Long, 1987; MIT Museum Collection, 1957). Yet, it was not until the late 1990's that collective action around entrepreneurship gained momentum

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across colleges of engineering (see Table 1). In the mid-1990s, NCIIA was created and served to create a network within which ideas and resources were shared. Since 1995, NCIIA has funded more than 350 entrepreneurship courses in the United States, primarily in engineering schools (e.g., Bilén et al., 2005; Mendelson, 2001; Ochs et al., 2001; Ohland et al., 2004). During the first decade of the twenty first century, entrepreneurship continued its expansion among colleges of engineering and was included among the expected knowledge and skills set for the engineers of the new century (Crawley et al., 2007; Creed et al., 2002; Duderstadt, 2008; Goldberg, 2006; Standish-Kuon & Rice, 2002).

Table 1. Chronology of Entrepreneurship Education in Engineering in the United States

1958	MIT's entrepreneurship course offered by Dwight Baumann (Katz, 2003)
1983	The Engineering Research Center (now known as Mtech) is established at the University of Maryland, College Park. (University of Maryland, 2008)
1983	First entrepreneurship course in an engineering school at the University of New Mexico (Katz, 2003)
1993	The Engineering Entrepreneurs Program is initiated under the sponsorship of the Southeastern University and College Coalition for Engineering Education at the College of Engineering, North Carolina State University
1995	NCIIA is founded with support from the Lemelson Foundation
1996	The National Consortium of Entrepreneurship Centers is founded. From the ten original members, five were universities with large science and engineering programs (Standish-Kuon & Rice, 2002)
1996	STVP, the center for entrepreneurship within Stanford's school of engineering, is founded (Eesley & Miller, 2012)
2000	The Technological Entrepreneurship Center is created at the College of Engineering, UIUC
2000	The Technology and Entrepreneurship Center at Harvard is founded at the Harvard School of Engineering and Applied Sciences
2001	Pennsylvania State University launches the Engineering Entrepreneurship Minor

2001   STVP launched the website Entrepreneurship Corner, which features over 2,000 podcast and videos (Eesley & Miller, 2012)

2004   The Harold Frank Entrepreneurship Institute is founded at the College of Engineering and Architecture, Washington State University

2004   The number of members in the Entrepreneurship Division of the American Society for Engineering Education (ASEE) grew to over 500 from less than 20 in 2000 (Bilén et al., 2005)

2005   The Keller Center is founded at Princeton School of Engineering and Applied Sciences

2005   The Center for Entrepreneurship & Technology is established at University of California (UC) Berkeley College of Engineering

2005   The Kern Entrepreneurship Education Network (KEEN) is founded

2008   The Center for Entrepreneurship (CFE) is founded at the College of Engineering, University of Michigan

2008   The Farley Center for Entrepreneurship and Innovation is endowed at the McCormick School of Engineering, Northwestern University

2011   Epicenter (National Center for Engineering Pathways to Innovation) is funded at Stanford by a $10 million grant from the NSF

2014   The Dartmouth Engineering Entrepreneurship Program received the 2014 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education

This chronology suggests that the curricular idea of E^3 has become more prominent in the engineering world, although there is little consensus about its definition. Furthermore, several mechanisms for curricular change described in previous research on the role of social and intellectual movements seem to be at work. Professional associations, such as ASEE, have incubated faculty groups around the idea of entrepreneurship and highly rated engineering schools have embraced E^3, signaling its support from intellectual leaders in the field. Symbiotic relations with the local communities serve to nurture curricular ideas and the intellectual leadership within the university moves ideas from abstract notions to practice. Private and public organizations (e.g., NCIIA and NSF, respectively) provide funding and disseminate curricular

resources. In the following pages, these characteristics of E^3 are briefly elaborated as a social intellectual movement.

E^3 at the National Level

National actors include organized networks of individuals and organizations whose missions and actions target multiple schools across multiple regions. In the case of E^3, examples of these external national actors are NCIIA, Epicenter, and the Entrepreneurship Division of ASEE. These actors are primarily academic. NCIIA's mission states, "We support technology innovation and entrepreneurship in higher education to create experiential learning opportunities and successful, socially beneficial innovations and businesses" (NCIIA, n. d.). Its website claims a membership of about 200 colleges and universities in the United States, and in 2013 NCIIA held its 17th annual conference, which gathers over 300 faculty. NCIIA, founded by the Lemelson Foundation, receives funding from the National Science Foundation (NSF) and the Meyer Memorial Trust. In 2001, STVP launched the website Entrepreneurship Corner, which features more than 2,000 videos and podcasts, which are among the most downloaded higher education media in the world (Eesley & Miller, 2012). In 2011, STVP, with a $10 million grant from the NSF, launched the initiative Epicenter, whose mission is "unleashing the entrepreneurial potential of undergraduate engineering students across the United States to create bold innovators with the knowledge, skills and attitudes to contribute to economic and societal prosperity." (Epicenter, n. d.). Another space that congregates engineering faculty interested in entrepreneurship education is the Entrepreneurship Division of ASEE, which has grown from 20 to over 500 members in less than five years (Bilén et al., 2005). This is a remarkable fact, since ASEE is the largest professional association of engineering educators, and since, historically, the emergence of new engineering curricula usually parallels the creation of new professional

societies (Grayson, 1993). These three professional networks are the largest and most relevant national alliances promoting entrepreneurship education in engineering.

However, there are also smaller networks that are important for specific groups of schools. Consider, for example, the case of Global Venture Lab Network, which had only 6 members from the United States and 18 from other world regions that are committed to "share best practices for foster innovation and entrepreneurship in a university environment with the intent to create new companies and industries" (Sidhu, Tenderich, & Broderick, 2010, p. 22). This network was established by engineering schools of prestigious institutions world-wide, such as India Institute of Technology, Pontificia Universidad Católica (Chile), Stanford University, Tsinghua University (China), UC Berkeley, the University of Cambridge (United Kingdom), the University of Melbourne (Australia), and UM. Another example is KEEN, a network of 20 engineering schools that focuses on instilling an entrepreneurial mindset to undergraduate engineering students.

External Actors and the Networks with the Local Community

Many authors maintain that it is the local community, in which universities are key members, that is responsible for creating an entrepreneurial ecosystem (Feld, 2012; Fetter et al., 2010). In these ecosystems, multiple exchanges of information and people occur through blurred boundaries between the university and the local startup community (Castilla et al., 2000; Potter & Miranda, 2009), where dense formal and informal networks are generated and where knowledge, instead of being trapped in individual organizations, is perceived "in the air" of the community (Brown & Duguid, 2000, p. 22).

Several studies report on the invigorating entrepreneurial symbiosis between local and regional communities and emblematic universities, such as Stanford (Eesley & Miller, 2012;

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Lee, Miller, Gong Hancock, & Rowen, 2000; see also CB Insight, Winter 2012), Rensselaer

Polytechnic Institute (Leslie, 2001), MIT (Roberts, 1991; Roberts & Eesley, 2009; see also CB

Insight, Winter 2012), and the University of Wisconsin at Madison (Kenney, Nelson, & Patton,

2009). These studies suggest different types of involvement of the external local actors in

university engineering curricula. Local entrepreneurs and venture capitalists not only fund

program and student competitions, but they also are frequently invited as speakers in

entrepreneurship courses, judges in competitions, mentors of student projects, part-time

instructors, and members of advisory boards (e.g., Bilén et al., 2005; Creed et al., 2002).

However, little is known about how these type of interactions influence the framing of curricular

ideas that are used by faculty for promoting curricular change in engineering within and across

institutions. Again, these specific mechanisms of influences have been reviewed in the literature

on social and intellectual movements in curricular change in the humanities and social sciences.

Internal Actors in Colleges of Engineering

In one of the few empirical articles exploring the internal diffusion of entrepreneurship in

engineering, Standish-Kuon and Rice (2002), established that the leadership of top

administrators is crucial. They found that the role of the director of the entrepreneurship center or

program was the single most important factor in promoting entrepreneurship education within a

college. Deans, top administrators, and core faculty also played an important role; depending on

the sampled institution, they were seen as major obstacles or major assets for the promotion of

E^3. This study suggests that individuals who champion the idea within campuses constitute a

decisive factor in promoting entrepreneurship. However, the influence of these campus leaders

may have a downside in the long run. From research on curricular change in engineering

education, we know that when changes depend primarily on campus leaders' and top

administrators' commitment to an initiative, the sustainability of the change is compromised, especially when the effort and decisions are not shared by faculty (Merton et al., 2009).

Different Frames of the Curricular Idea

The ASEE 2012 report *Innovation with Impact* reveals that, for the majority of schools, E^3 is still a marginal idea. From a survey of faculty committees, chairs, and deans representing 72 engineering colleges, the report concludes that entrepreneurship education is not as "warmly embraced" (p. 7) as other new learning opportunities related to laboratories and research experiences. In fact, only about 20% of the respondents indicated that teaching entrepreneurship was practiced routinely at their colleges, far behind other innovative programs such as international education (30%) and engineering competitions (45%).

Definitions of E^3 vary, depending on the institutions or the actors involved in the promotion of entrepreneurship education (Mars & Metcalfe, 2009). Concepts such as "engineering entrepreneurship" (Nichols & Armstrong, 2003), "the entrepreneurial engineer" (Goldberg, 2006; Timmons, Weiss, Loucks, Callister, & Timmons, 2014), "technology entrepreneurship" (Beckman et al., 2012; Dorf & Byers, 2008; Roberts, 1991), and "entrepreneurial mindset" (Kriewall & Mekemson, 2010) imply different emphases. For instance, Dorf and Byers (2008) define technology entrepreneurship as "a style of business leadership that involves identifying high-potential, technology-intensive commercial opportunities, gathering resources as talent and capital, and managing rapid growth and significant risk using principled decision-making skills" (p. xv). On the other hand, Kriewall and Mekemson (2010) define the entrepreneurially minded engineer, as the engineer who "places product benefits before design features and leverages technology to fill unmet customer needs" (p. 8). These engineers can work as traditional staff engineers, intrapreneurs—those who take

leadership roles and engage in creative processes within companies—or entrepreneurs. Thus, a curriculum oriented grounded on the concept of entrepreneurial mindset is broader than a curriculum with a focus on technology entrepreneurship. We could also infer that different definitions imply different interdisciplinary emphases, for instance, between engineering and business, law, or other subjects. Byers acknowledges that "there's no one model that works for everybody," and that "different schools dial in different recipes" (Epstein, May 14, 2010). He asks, "Should courses on or experiences of entrepreneurship and innovation be required? Should there be a certificate? It's a really exciting part of the debate and I don't think we've figured it out yet" (Byers quoted in Epstein, May 14, 2010).

Entrepreneurship education is an emergent curricular idea in engineering and its rise seems to derive from the collective action of local and national actors that span beyond university boundaries. Thus, the case of E^3 represents a special opportunity to examine the framing of curricular ideas and the interactions of several actors from multiple social systems as they collectively engage in a curricular change.

Research Questions

The overarching question of this study is: How did contextual factors and the collective actions of actors internal and external to a university affect change in its undergraduate engineering curriculum? Sub-questions that explore the case of E^3 through the theoretical lens of SIMs and collective action frames are:

What strategies—e.g., leadership, access to resources, and access to micromobilization context —did external and internal actors who promoted E^3 use to advocate for E^3 within the university?

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What framing strategies were used by external and internal actors to promote E^3 and how did these strategies change over time?

How do the frames of the E^3 idea created at the local level relate to those at the national level?

Chapter 3: Research Design and Data Collection Methods

This research is an in-depth single case study that draws together data from interviews, observations, archival and published documents to examine, through the lens of SIMs (Frickel & Gross, 2005) and collective action frames (Benford & Snow, 2000), the emergence of E^3 within a university campus. Case study is an effective research strategy when "the focus is on a contemporary phenomenon within real-life context" (Yin, 1994, p. 1) and especially useful when studying educational innovations (Merriam, 2009). A case study method also offers the depth of analysis necessary to identify the causal mechanisms that operate in a certain phenomenon (Gerring, 2004), such as the emergence of E^3 within an engineering school. In a case study, as Miles and Huberman (1994) suggest, "the influences of the local context are not stripped away," and "the possibility for understanding latent, underlying, or nonobvious issues is strong" (p. 10). These reasons explain, in part, why the case study method has been extensively used by social movement researchers, including collective action frame studies (Snow & Trom, 2002).

Population

This investigation is conducted in a selective engineering school at a research university primarily for three reasons. First, at research universities, engineering schools tend to lead initiatives for teaching entrepreneurship to their undergraduate students (see Appendix I). Selecting one of these campuses for in-depth study increases the chances of finding advocates for entrepreneurship education that specifically target engineering education. This facilitates the examination of the challenges to the curricular status quo and framing and reframing of E^3 ideas

that occur as a result of interactions among multiple actors. Second, graduates from elite engineering schools are over represented in the population of technological entrepreneurs in the United States (Wadhwa, Freeman, & Rissing, 2008), evidence of the influence of these schools in the world of technological venture. Finally, research universities are complex organizations where multiple visions and interests coexist (Cohen & March, 1974). In these organizations, curricular changes are political processes that require some level of collective action and negotiation, which increases the relevance of the mechanisms described in this study. This is the reason why this investigation does not focus on prestigious but engineering-specialized institutions, such as Olin College, a paradigmatic case for engineering education innovations, including entrepreneurship (Goldberg & Somerville, 2014).

Case Study Sample

Merriam (2009) defines a case study as "an in-depth description and analysis of a bounded system" (p. 40) where the most defining feature "lies in defining the object of the study" (p. 40). The unit of analysis is an entrepreneurship education program for undergraduate engineering students. The setting is the CoE in the UM, a public research university with very high research activity according to the Carnegie Foundation Basic Classification.[1] Teaching entrepreneurship to engineers is primarily the responsibility of the CoE. The CoE is neither one of the E^3 pioneers nor one of its latest adopters (see Table 1). However, UM has attracted national attention and is acknowledged as an advocate for entrepreneurship education (U.S. Department of Commerce, 2013). Moreover, in the Ann Arbor community, there is a "fast growing high-tech startup culture" that attracts seasoned and new entrepreneurs as well as

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[1] http://classifications.carnegiefoundation.org/descriptions/basic.php

venture capitalists (Halpert, March, 2013, p. 18), which suggests a potential for frequent interactions between the local community and the CoE.

In addition to being bounded by space, a case study is also bounded by time (Gerring, 2004). To define the exact origin of a movement is a daunting task (Klandermans, 1992; Koopmans, 2004). The origins and roots of a movement come from the interpretations of participants and researchers. Moreover, these interpretations may change overtime as actors reflect about the movement drift (Klandermans, 1992; Zald & Garner, 1987). Thus, an arbitrary but reasonable decision has to be made.

The establishment of most of the E^3 programs at engineering schools in the United States did not begin until 2000. At the CoE, it is reasonable to argue the starting point for investigating the emergence of E^3 is the Fall Semester of 1999. The Zell Lurie Institute for Entrepreneurial Studies (ZLI) was established in Ross in 1999. David Munson, Dean of the CoE, instituted a Committee on Entrepreneurial Environment and Programs for Students (CEEPS) in October 2006 and the Center for Entrepreneurship (CFE) was established in 2008 at the CoE. A report prepared by CEEPS (2007) chose the time frame Fall 1999–Winter 2007 for analyzing entrepreneurial courses in the CoE. In 2012, a task force on Campus-Wide Entrepreneurship Education (CWEE), at the university level, recommended that a minor in entrepreneurship be available for all undergraduates. In Fall 2013, Provost Martha Pollack appointed Thomas Zurbuchen, the associate dean for entrepreneurial programs in the CoE, as Senior Counselor of Entrepreneurial Education. The Senior Counselor's main charge is to launch a university-wide academic minor starting in Fall 2014. The case for E^3 is still a work in progress. However, the Provost's decision to launch a university-wide minor in entrepreneurship, the first university-

wide minor in the university history, is a significant milestone. This decision will be considered the concluding event of the case. Thus, the time frame of this study is Fall 1999–Fall 2013.

UM was also selected because of convenience sampling (Merriam, 2009). The researcher is familiar with the institutional culture, since he has been a graduate student at the UM's School of Education for about five years. This facilitates access and understanding of the case context. On the other hand, the researcher is not affiliated with the CoE or any type of entrepreneurial organization at UM, which provides him some distance from the phenomenon. His status as an international student also implies some distance from the American culture of innovation and entrepreneurship. These background characteristics shape, inescapably, the data collection and analysis in qualitative research (Maxwell, 2005). However, the theoretically driven research questions, the standardized data collection procedures, and the systematic devices for analysis of the study reduce the risk of bias and flawed analysis (Miles & Huberman, 1994).

Methods of Data Collection

The case study was conducted through semi-structured interviews, participant observations, and documentation; methods of data collection that are extensively used in empirical studies of collective action frames (Snow, 2004). Data for this study were collected for over a year, from May 2013 until May 2014. In addition to this corpus, in a previous pilot stage, the researcher conducted observations and interviews at the UM, UC Berkeley, Stanford University, and at Open 2013, the NCIIA's annual conference, in Washington DC.

Interviews

Semi-structured interviews are the most important source of information for the construction of this case study (Yin, 1994). According to Blee and Tylor (2002), semi-structured

interviews are a central means in social movement research for allowing scrutiny of movement participants' and leaders' understandings of their contexts; providing a participants' perspectives on movement dynamics (e.g., growth and decline); bringing perceptions of human agency into the analysis; and accessing the ways in which movement messages are received by intended audiences.

Participants in the study were identified either as internal or external actors. Internal actors are those who either work full-time for the institutions or played a key role in the promotion of E^3 when students. External actors are individuals whose primarily work affiliation is not with the university but have been involved in E^3 initiatives at UM. For example, external actors include donors and current and past advisory board members. Interviews with both groups focused on the framing of E^3 through questions about the emergence of E^3, key factors in its emergence, the evolution of the E^3 idea, current strategies for the promotion of E^3, perceptions of the roles of local and national external actors, and ambiguities or contradictions found during the study (see Appendix II for the interview protocol).

Since most interviewees are in positions of power and influence, the interviews were conducted and analyzed taking into account the specialized literature on elite interviewing (Dexter, 1970; Odendahl & Shaw, 2002). For instance, an important challenge was to work with the ability of elite individuals to turn interviews around, redirect or alter questions to make them one's they want to answer (Marshall & Rossman, 2011). The literature and the researcher's own experience confirmed that entrepreneurs are particularly good at communicating strong and crafted ideas and worldviews (Anderson, 2005; Isaacson, 2011; Martens, Jennings, & Jennings, 2007), which made it difficult to elicit answers to questions that do not fit within their discourses.

All participants in the study were informed beforehand that the main focus in the study was on the different ways the E^3 idea has been framed in the promotion of entrepreneurship at UM.

Interview respondents were identified through campus documents first and then via referral sampling. In total, 27 individuals were interviewed for this study. Among them, 20 are considered internal actors and 7 external actors. The sample of internal actors consists of 10 faculty, 3 staff members, and 7 students. Internal actors represent the CoE (11 participants), the College of Literature, Science, and the Arts (4), Ross (3), Medical School (1), and the School of Public Health (1). In terms of faculty ranks, eight are tenured and two are non-tenure-track; all tenured faculty serve or served in leadership positions within UM. Students were either founders or served as leaders of the three major student organization associated with entrepreneurship during the study time frame, MPowered Entrepreneurship (2), OptiMize (3), and the Student Startup Accelerator TechArb (2). Technically speaking, non-undergraduate students were interviewed for this research since all student leaders had graduated by the time of the interviews. The sample of external actors consists of venture capitalists (4), heads of international companies (2), and a lawyer (1). All of them had extensive experiences as entrepreneurs themselves (i.e., they started one or several companies). In terms of locations, three lived in Silicon Valley and two lived there but moved to Michigan more than five years ago. All but two external actors who participated in the study were CoE alumni. Among the external actors interviewed for this study are the top two donors for entrepreneurial education at the CoE.

Most participants were contacted directly by the researcher first via email message (see sample in Appendix III). Several participants helped contact other potential interviewees, usually through an introductory email. Although not all potential participants who were invited to be part

of the study responded to the invitation and agreed to participate, all the actors who were at the core of the case—those that documents and other informants said were key—were interviewed. Scheduling the interviews was one of the main challenges of the study. Entrepreneurs, university leaders, and faculty have busy agendas, and for them time is clearly a precious asset. Since some of the external actors and internal actors moved from UM and now live in other states, geographical location was another challenge for scheduling interviews. In total, twenty three interviews were conducted face-to-face, and four by phone. All the interviews were audio-recorded and transcribed verbatim. The researcher transcribed eight interviews to enhance his familiarity with the data. The remaining transcriptions were done by an assistant. Since it is difficult to disentangle the actors from specific case events, participants were asked if their quotes could be attributed to them. A form of quote approval was conducted upon request. Excerpts that might jeopardize or compromise the reputation of the participants were anonymized or discarded.

Participant Observations

Observation refers to the systematic noting of events, behaviors, and artifacts in a particular setting (Marshall & Rossman, 2011). Participant observation is a type of observation in which the researcher, to some degree, participates in and assumes different roles within case study events (Litchterman, 2002; Yin, 1994). In social movement research, according to Litchterman (2002), "[l]istening to people talking in their own settings, on their own time, participant-observers have the opportunity to glean everyday meaning, tacit assumptions, ordinary customs, practical rules of thumb that organize people's everyday lives" (p. 138). In this study, the main purpose of observations is to capture the current discourse about and the everyday meaning of the E^3 idea promoted by local and internal actors in a particular set of

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interactions. In this sense, the researcher played the role of "observer as participant," in which "participation in the group is definitely secondary to the role of information gatherer" (Merriam, 2009, p. 124).

Data were gathered through field notes taken at the sites of observed events and subsequent memos. The procedures recommended by Emerson, Fretz, and Shaw (1995) for field notes were followed: note first impressions (e.g., details about physical setting and people in the setting), focus on key events or incidents, and maintain open sensitivity to events that seem significant and important for those in the setting. The subsequent memos were notes that reconstructed the observation in a chronological and narrative manner and that expanded what was captured in the field notes with personal observer's own behavior and reactions (Merriam, 2009). Most subsequent memos were written during the observation day.

It is important to note that these observations were part of a theory-driven project (Litchterman, 2002) where curricular studies in higher education and SIMs and collective action frames theories guided the field notes, memos, and further analysis. However, special attention was given to events that did not fit with the theory (Litchterman, 2002). In total seventeen entrepreneurial events were observed. They include observations at student startup fairs, entrepreneurship workshops, competitions, speaker series, information sessions, and other social events related to entrepreneurship education in CoE.

Documentation

Documents are important sources of evidence to corroborate and augment data from other sources—interviews and observations in this case (Yin, 1994). Among the strengths of using documents as a source of evidence, Yin (1994) mentions stability (i.e., can be reviewed repeatedly), unobtrusiveness, exact content, and broad coverage. On the other hand, documents

can produce biased selectivity (if the collection is incomplete) and reporting bias. The best strategy that a researcher can follow for reducing these biases is examining the documents to understand the specific contexts in which the documents were written (Yin, 1994). Documents can also be used for making new inferences, which should only be considered as clues for further investigation (Yin, 1994). Finally, collected documents can be used to identify key actors.

Four types of documents were consulted; all of them produced during the time frame of the study. University reports and academic articles represent the most important group of collected documents (key documents, hereafter). University reports are UM documents that focus on undergraduate engineering education, E^3, or university-wide entrepreneurship education. Documents that were not published by UM faculty, but included the case of entrepreneurship education at the UM were also collected for this study. For instance, the report produced at UC Berkeley, *Engineering Entrepreneurship Education: Best Practices and Next Steps* (Sidhu, Tenderich, & Broderick, 2010), includes several references to the teaching of entrepreneurship at the CoE and is one of the key documents. Academic articles are those about entrepreneurship education in the CoE. These articles were written by CoE faculty and presented at engineering education conferences. In total, twelve key documents were collected, seven reports and five articles. A list of the key documents is provided in Appendix IV.

Newspaper articles are the second type of collected documents as they are an important data source for social movement scholars (Clemens & Hughes, 2002) and are increasingly common in entrepreneurial studies (e.g., Anderson & Warren, 2011; Pollock & Rindova, 2003; Radu & Redien-Collot, 2008). In particular, university student newspapers have been a critical resource for movement studies in higher education (e.g., Barnhardt, 2012; Rojas, 2010; Soule, 1997). Thus, *The Michigan Daily*, the most important UM student-run newspaper since 1890,

was a primary source of articles. A systematic search was conducted in order to collect all the articles related to the case. The words "entrepreneur," "entrepreneurship," and "entrepreneurial" were used in *The Michigan Daily* search engine. The search engine includes the online version of all the newspaper articles published since 2001, so there was no need to delimit the beginning of the time frame of the study, Fall 1999. The last search was conducted on December 26, 2013. The search output contained 246 articles. These articles, were read and those articles related to entrepreneurship education at UM, entrepreneurial students and student organizations, and the relationship between UM and the entrepreneurial community in the state of Michigan were selected for analysis. Other articles were excluded from the research corpus. For instance, references to entrepreneurship in the context of the 2008 and 2012 U.S. presidential campaigns were eliminated. In total, 213 *The Michigan Daily* articles were finally selected. In addition to this corpus, other 64 articles were collected from different newspapers during the study. However, no systematic search, as the one used for the *The Michigan Daily,* was conducted since these newspapers did not have public search engines that cover the research period of this study or did not focus on the UM campus. These other news articles include texts from *The University Record,* the UM official source of news for faculty and staff, and from several national and local printed and online newspapers, such as *The Ann Arbor News* and the *Detroit Free Press*. In total, 277 news articles were collected.

The third document type consists of blog entries written by key actors in the case. Entrepreneurs are known for their intense use of social media, in particular blogging and tweeting (e.g., Fischer & Reuber, 2011). The researcher regularly visited blog and Twitter sites of those identified actors who had one. Only blog entries that directly addressed the case of E^3 were collected. Tweets were not collected, since they do not contain the amount of narrative and

information found in blogs. In the aggregate, the study of tweets might yield interesting insights, but it would require a different analytical approach, such as story-grammar analysis (Johnston, 2002), that is beyond the scope of this study. In total, 79 blog entries were collected, all of them within the time-frame of the study. The majority (75%), were collected from the blogs of Thomas Zurbuchen and Doug Neal, the CoE associate dean for entrepreneurial programs and CFE executive director from 2009 to 2013, respectively.

The final type of documents corresponds to texts that do not fit in the previous three groups. These texts include newsletters, web contents, course syllabi, brochures, and web videos. For instance, the CFE sent weekly newsletters over the semester of Winter 2013 that contained detailed information about the CFE activities, milestones, and achievements. These newsletters include multiple links to the CFE and the CoE websites and to news in online newspapers and other websites. This information was used primarily for learning about entrepreneurial activities and corroborating evidence obtained from other sources. Only available course syllabi from core entrepreneurship courses coordinated by CFE were collected. If key documents or interviewees mention a particular video or document related to the framing of E^3 ideas, they were also collected and informed the case.

Data Analysis

The present study has a theory-driven research design and the data analysis was guided by the theories of SIMs and collective action frames. This theoretical or deductive approach to the analysis helped with data management and data discrimination (Yin, 1994). Thus, theory was revised and confronted with evidence throughout the analysis. As discussed in the data collection section, the data corpus consists of interview transcripts, field notes and memos from

observations, and different types of documents. Generally speaking, this study has two analytical phases. First, the case of E^3 in the CoE is constructed and presented, describing its development through the independent and collective actions of internal and external actors. The case study elaborates the progression of intellectual movements described in the literature review. This means particular attention was given to the initial challenges to the curricular status quo in the early 2000s, the key internal and external actors who first promoted or challenged E^3, micromobilization contexts, access to resources, milestones, and the framing and reframing of the E^3 development in the CoE. In the second phase of analysis, evidence of the framing tasks and strategic framing processes in the E^3 promotion in the CoE was sought. Since the oversimplification of multilayered complexities of framing activities is an important criticism of collective action frames perspectives (Benford, 1997; Morris, 2000), competing E^3 ideas and how actors merged ideas during the process of building coalitions was examined.

These two phases of analysis were conducted through a systematic organization and examination of the data. In terms of data organization, files were carefully labeled, so the data type, date, participants, settings, and authors were always traceable. Since the analysis was an ongoing process, immersion in the data started as soon as the first transcripts and fieldnotes were created and documents collected (Marshall & Rossman, 2011). A summary of study outcomes and data sources is presented in Table 2. First, all data but observations were used for the construction of the case. This entails identification of key events, actors, and anecdotes. Interviews, observations, and key documents were systematically coded through a process that mirrors the two general phases of analyses. Finally, key findings were contrasted and extended with data from blogs and other collected documents in order to enrich the case and check trustworthiness.

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Table 2. Analytical Goals by Type of Data

Type of data	Case construction (Events, people, dates)	Evidence of scientific and intellectual movement propositions[a]	Evidence of collective action frames (task and alignment processes)[a]	Contrasting, confirming, and expanding findings
Interviews	X	X	X	
Observation		X	X	
Documents:				
Key documents	X	X	X	
News articles	X			X
Blog entries	X			X
Other	X			X

[a] Both analytical goals require the coding process described below.

Construction of the Case

The first step was to construct a timeline of events using multiple data sources. The first version of the timeline was constructed with information found in key documents and newspaper articles, as recommended by Yin (1994). New timeline entries were added as the collection of other data progressed. Tiki-toki, a web application, was used to construct the timeline. Each entry was classified as *people* (e.g, hiring, new position), *organization* (e.g., founding, new location), *curriculum* (e.g., new program, new course), *networking site* (e.g., conference, study tours), and *competition/campaign* (student-team competition, awareness campaigns). The web application allowed the researcher to link an entry to web addresses, annotations, and complementary materials. The narrative that articulates and provides meaning to the timeline of events was based on the coding of interviews and key documents (see next section).

Coding Process

Interview transcripts and key documents were coded in two phases. First, the constructs from the theory were used in deductive coding. Through a first reading, segments that comprised a primary idea or topic were assigned to codes using the qualitative software NVIVO 10. The first set of codes were labeled *case facts* (e.g., mention of people or events), *SIMs-resources* (funding, employment, and organizational), *SIM-micromobilization context*, *SIM-leadership*, *SIM-organizational opportunities, framing tasks* (diagnosis, prognosis, and motivation), *framing strategy,* and *master frame*. Then, analyses within each set of codes were conducted and short memos were written. These analyses were used to construct the timeline, the key movement periods, and a first narrative of the case. The second phase consisted of both deductive and inductive re-coding of the framing task and framing strategy codes. The objective was to drill down the case in order to find the predominant themes within each type of collective action frame. For instance, those segments previously codes as *framing strategy* were recoded as *frame amplification*, *frame bridging*, *frame extension*, *frame transformation*, and *others* (for those references to frames that did not fit with existing frame strategies). Within each framing strategy, recurrent themes were identified inductively. For instance, the theme of E^3 *sharing core principles with social entrepreneurship* was found within the *frame bridging* codes. The narrative of the E^3 case was revised to incorporate themes that were not represented in in the first draft of the story narrative. Separate reports on these themes were written to identify the framing strategies used by internal and external actors in the promotion of E^3.

Contrasted and Expanded Findings

Throughout the construction of the case and the analysis of data, multiple points of contradictions or alternative explanatory theories appeared. These incidents were contrasted or

triangulated (Yin, 1994) with data found in blog entries and other documents. In other words, blog and select document data were used to both evaluate the viability of alternative explanations and to support generalizations gleaned from interview and observations.

Limitations

This research design has three major limitations. First, the emergence of E^3 in a single campus was primarily constructed through a retrospective exercise. Interviewed actors told the story as they recalled it and assigned meanings to the different case strategies influenced by the actual context of the case and their relationship with it (Blee & Taylor, 2002). Therefore, the presentation of the case as a grassroots movement and the case findings might be biased by the current interpretations of the case. The case study's narrative might do not necessarily represent how the actors understood the situation at the time they undertook particular actions. Some of the actual strategies then may be overlooked or exaggerated. The diversity of data collection methods used in this research mitigated the potential bias of this retrospective exercise. Second, collective action frame research has been criticized because of its focus on leaders or committed movement actors and the exclusion of bystanders (Benford, 1997). This was also the case for the present study. The study focused almost exclusively on key influential actors. No bystander faculty or student was interviewed, for example. Certainly, their perspectives would have added a valuable dimension to the case. Third, this is a case study of a single university campus. The historical, social, and economic contexts surrounding the UM may not warrant the generalizations of the findings.

Chapter 4: The Emergence of Entrepreneurship Education in the College of Engineering at the University of Michigan

The case of the emergence of entrepreneurship education in the CoE at UM is presented in four periods: the latent (late 1990s - 2006), the launch (2006-2008), the start me up momentum (2008-2011), and the branching out of engineering (2011-2014) periods. These periods are divided by three key events, each representing a pivotal moment in the evolution of E^3. The appointment of Professor David Munson as Dean of the CoE in 2006 marks the beginning of collective action around E^3. The beginning of CFE in 2008 under the leadership of Professor Thomas Zurbuchen represents the consolidation of efforts that has consequences beyond the CoE campus. This new period is characterized by a startup approach that makes E^3 central in the university environment. The University of Michigan's College of Literature, Science, and the Arts (LSA) students' 1,000 Voices campaign in 2011, demanding more resources and visibility to entrepreneurial education, symbolizes a new period in which E^3 reaches a campus-wide stage.[2] This last period finishes with the announcement, in Winter 2014, of a university-wide minor in entrepreneurship, the first of its kind.

Throughout the narrative of the case, special attention will be given to how the case actors understood and used the notion of entrepreneurship education in the CoE. This notion was continuously debated, framed, and reframed in each period. Initially, the notion of entrepreneurship education was peripheral to the attempts to increase the commercialization of

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[2] The short name "E^3" is not used in the case narrative, since it was created in the context of this study. The narrative attempts to stay close to the naming and concepts used by the case actors.

research at the CoE and at UM, in particular among faculty and graduate students. This attention shifted by the time of the launch period, when multiple actors realized that entrepreneurship education at the undergraduate and graduate levels should be the center of the promotion of entrepreneurship in the CoE. The idea of entrepreneurship education was then conceived around the elements of launching and developing technological startups. Rapidly, a broader conceptualization of entrepreneurship as a mindset emerged, which sought to capture the habit of mind of someone who disrupts markets, institutions, and communities in order to bring value and positive change to those social spheres. Several collective action frames coalesced into the notion of entrepreneurial mindset, such as social innovation, intrapreneurship, technological startups, and engaged learning. Towards the end of the case, the entrepreneurship education movement launched a new initiative that will promote the entrepreneurial mindset from UM central administration. This step would allow the CoE to come full circle to refocus on the promotion of the commercialization of research among faculty and graduate students, this time, within a well-resourced pro-entrepreneurial culture in the CoE and at UM. The evolution of these frames as well as the collective action strategies used for their promotion are detailed in each period. To facilitate the reading of the case, readers might see figure in Appendix V for an overview of the periods. Each period is also introduced with a summary of key events. The case starts with a brief review of the historical and institutional context of the CoE, which also includes an overview of the main curricular characteristics of the undergraduate engineering curriculum over the case study period.

The Context: The CoE at UM

The first engineering degree at UM was awarded in 1857, following the steps of Rensselaer Polytechnic, Union College, Harvard University, Dartmouth College, and Yale University. The department of engineering at UM was established in 1895 and enrolled 331 students. At the beginning of the twentieth century, the CoE pioneered the areas of electrical engineering, chemical engineering, marine engineering and naval architecture, and civil engineering. By the end of the 1950s, the CoE was acknowledged as a world leader in the emergent fields of nuclear energy, aerospace engineering, and computing science (Duderstadt, 2003). Throughout its history, the CoE has innovated in engineering education with the creation of new programs, new teaching approaches, and teaching and research facilities (e.g., Celis 2011). The CoE has also incubated educational programs and practices that were later adopted by UM. For instance, the UM modern language programs can trace their origins in the early instruction of German and French given by the CoE (Duderstadt, 2003). Today, the CoE is located on North campus, two miles from UM central campus, and is composed of 12 departments that are consistently ranked among the best in the nation. In the Fall semester 2013, there were 381 tenured and tenure track faculty and 127 research faculty. The CoE enrolls about 6,000 undergraduates and over 3,000 graduate students. The CoE endowment was valued at $423.3 million in 2013 ("CoE," n. d.).

In order to appreciate what had to be changed by the efforts described in this chapter, it is necessary to describe the key features of the CoE's undergraduate engineering curriculum over the case study period. According to Sheppard et al.'s (2009) report, *Educating Engineering,* which includes the CoE as one of the six studied schools, the "dominant curricular model" is a four linear components organized in hierarchal manner: a large base of mathematics and science

first, a series of engineering science courses, a sequence of technical courses in a specific field of engineering, and a final design experience. The main assumption underlying this model is that students need to move from theory to practice following a particular sequence. This is the curricular model that Duderstadt (2008) criticizes because of its "over dependence on the pedagogical methods used in science courses—large lecture courses, rigidly defined problems assignments, highly structured laboratory courses" (p.33). The CoE's report (2009), *Michigan Engineering 2020,* echoing these criticisms states, "[a]fter 50 years of evolution the UM engineering curriculum… is strongly aligned to disciplinary lines, has become focused on engineering science, and is packed full of technical courses with no room for addition and little room to maneuver" (p. 10). The CoE undergraduate curriculum consists of a solid base of mathematics, physics, and chemistry, followed by a sequence of technical courses corresponding to each degree program. Across the CoE programs, there is little room for general elective courses (see Appendix VI). Furthermore, Lattuca, Terenzini, Knight, and Ro's (2014) study of engineering curricula, including UM, concluded that preparing undergraduates who "can think like entrepreneurs" (p. 10) is among the learning outcomes that receives less support from administrators and faculty.[3]

Despite the CoE's dominant curricular model described above, there are "pockets of innovations" (Sheppard et al., 2009, p. xxi). For instance, in the late 1990s, the CoE introduced freshman design courses, which provide hands-on experiences and training in communication skills. Other key CoE efforts that introduced flexibility, multidisciplinary and international experiences into the curriculum will be discussed later in this chapter. In addition to these efforts, there are two other features that set the CoE apart from other schools with similar curricular

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[3] Lattuca et al.'s (2014) study is based on data collected in 2007-2008, period in which the idea of entrepreneurship education was just emerging in the CoE.

models: strong support for student organizations and interdisciplinary collaboration. As well, both of these features characterize UM at large (Peckham, 1994). Kuh, Kinzie, Schuh, Whitt, and Associates (2005) suggest that UM "goes to extraordinary lengths to support its students, both inside and outside the classroom" (p. 49). This commitment is reflected through substantial investment in infrastructure and professional and financial support to multiple student organizations, living learning communities, study abroad programs, and co-curricular activities.[4] An example of the UM support to interdisciplinary collaboration is the $30 million investment to hire 100 new tenure-track faculty in interdisciplinary clusters, announced by President Coleman in 2007. In these clusters, faculty "share research facilities or work together across disciplines" in topics such as, alternative energy and environmental sustainability (Connel, November 16, 2007).

Stage I: The Latent Period (Late 1990s-2006)

Before 2006, there were no collective efforts for promoting entrepreneurship education in the CoE. In fact, there were very few opportunities for undergraduate engineering students to engage in entrepreneurship education at UM. Outside Ross, little was happening in terms of teaching entrepreneurship. However, there was a latent energy that was preparing the ground for entrepreneurship education. Most of the action in the CoE was concentrated in fostering the commercialization of research. CoE alumni, in particular those in Silicon Valley, were the more active actors in seeking ways of engaging with UM around entrepreneurship. Individual faculty

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[4] The Duderstadt Center is an example that illustrates the commitment to student initiatives and multidisciplinary. The Duderstadt Center is an educational building located in North Campus, formerly known as the Media Union, opened in 1996, which serves the entire UM community, 24 hours a day, 7 days a week, with library, work spaces, and state-of-the-art computing and media technologies. The center is intensively used, but not exclusively, by engineering, art, and architecture students (Duderstadt, 2003).

and small groups of students were increasingly aware of the national movement around startups, disruptive businesses, and venture capital opportunities. Moreover, the depressed economy in the State of Michigan created a pressure for the development of new business activities beyond the ones produced by traditional large corporations. In the view of several study participants, the main barrier for entrepreneurship in engineering was that the leadership of the CoE at that time did not have entrepreneurship among its priorities. This predisposition changed when, in July 2006, Professor David Munson, the chair of the Electrical Engineering and Computer Science Department (EECS), became Dean of the CoE.

Making the Commercialization of Research the Fourth University Mission

Even though several selective engineering schools across the United States started to embrace entrepreneurship education in the early 2000s (see Table 1), there was no such efforts in the CoE. Most of the administrative and faculty action regarding entrepreneurship was concentrated on the research front. With the passage of the Bayh-Dole Act of 1980, which allowed universities that conducted research with federal funds to retain ownership of their discoveries, numerous technology transfer offices (commonly called tech transfer or OTT) were established in research universities across the United States. UM opened its first tech transfer office in 1983. These offices initiated a new field of practice (Owen-Smith, 2011) that significantly altered the research mission of universities (Geiger & Sá, 2005; Kennedy, 1997). The UM tech transfer office would grow from one individual in the 1980s to a larger and more robust organization over the next two decades.

As in the rest of the nation, scientific, technologic, and medical fields were more affected by these changes. In the early 2000s, the CoE opened a tech transfer satellite office to facilitate the commercialization aspects of research conducted by engineering faculty. In 2001, in the

UM's Office of Technology Transfer (OTT) Annual Report, the executive director, describes with enthusiasm and optimism, the environment of new opportunities and multiple entrepreneurial connections available across the university and its surrounding community.

> There's an exciting buzz in the air around Ann Arbor these days... In this short time, we have seen a tremendous increase in the availability of venture capital, in entrepreneurship and intellectual property, in attendance at technology and business events, and in the participation of our students, faculty, and researchers in technology transfer. The University has played key roles in much of this activity and is increasingly seen as a vibrant and effective partner connecting our business, government, and community neighbors. (Ken Nisbet, Executive Director, UM's OTT, Annual Report 2001, p. 1)

The "exciting buzz" felt at UM was, however, carried out by a small but enthusiastic group of faculty and administrators who pushed for changing the university in favor of the "modern era of entrepreneurialism," said Steven Goldstein, Professor, Department of Orthopedic Surgery and Department of Mechanical Engineering. Professor[5] Goldstein has a long history of engagement with entrepreneurial activities at UM. He has 25 patents and is the co-founder of two university startups in the field of medical devices. Professor Goldstein noted that in the 1980s, tech transfer activities were handled by only one individual. As the field of technology transfer was growing in the United States, there was a whole infrastructure to be built, which involved a robust set of policies and guidance on issues such as conflict of interest. In the 1990s, a "pivotal time", entrepreneurial activities around research accelerated at UM. Many policies and processes were implemented, an increasing number of patents were licensed, and startup companies were founded. Despite this progress and the enthusiasm of those involved in these changes, in the late 1990s and early 2000s, Professor Goldstein admitted the number of faculty entrepreneurs in the CoE and in the School of Medicine was still modest. This small group

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[5] Throughout the case, individuals' titles (e.g., dean, professor) will be used only for tenure-track faculty members, so the reader could easily distinguish those internal actors with direct influence on the curriculum within the institution from the rest.

accounted for most of the excitement around technology transfer. According to Professor Goldstein, there were cultural barriers to the dissemination of entrepreneurial activities. A key barrier was "conceiving entrepreneurial activity as opposed to classical academic activity."

In this era, a great part of the motivation of the faculty involved in entrepreneurial activities was seeing these new commercial opportunities as a way of making their lab research readily available for use in society. Alec Gallimore, an Aerospace Engineering Professor, who co-founded ElectroDynamic Applications (EDA) in 1999, represents this small group of engineering faculty pioneers who understood and took advantage of these new opportunities. Professor Gallimore saw the activities associated with EDA as a "different avenue of intellectual pursuit." Among the benefits of starting a company, he also mentions the possibilities of advancing research work without compromising the education of graduate students.

However, in contrast with the optimistic view expressed by the OTT in 2001, Professor Gallimore describes a period in which faculty engaged in entrepreneurial activities despite a lack of administrative support. There was a fear not only of faculty being distracted from their research and teaching duties, but also the risk of misusing university resources or committing fraud. In the 1990s, multiple and resounding scandals tainted entrepreneurial activities at prestigious research universities (Kennedy, 1997). This bad press, coupled with the still incipient development of tech transfer offices, made UM risk averse and overly zealous of the procedures in terms of regulating research commercialization. The barriers were such that faculty rank was a key influence on the transference process at UM. The fact that Professor Gallimore and colleagues were tenured faculty with demonstrated loyalty to the university helped them overcome the administrative barriers. However, despite their rank and reputations, they felt that

their entrepreneurial activities were deemed as "criminal" by the UM administrative apparatus regulating technology transfer (see also Blumenstyk, July 19, 2002).

In the early 2000s, along with the small group of faculty who were interested in the commercialization of research at UM, a collective interest was taking shape more than 2,000 miles to the west of Ann Arbor. Steve Carnevale, a CoE alumnus and venture capitalist for more than 20 years, recalls that in 2003 a "loosely formed group" of 20 or 25 CoE alumni began to meet in Silicon Valley. This group sought a way of getting connected with the university and giving back. This desire for connection and giving back comes from a strong feeling, a passion, towards their alma mater. This Silicon Valley group, however, seemed different than other UM alumni chapters. All of them are seasoned investor capitalists, entrepreneurs, and investor bankers. For this alumni group, "social time is built around technology and entrepreneurship," rather than in friendship and remembrance, said Carnevale. It is perhaps not surprising, then, that they wanted to establish a business channel with UM around technology and entrepreneurship. The influence of this alumni group in Silicon Valley would become crucial for the later developments around entrepreneurship education.

In a different corner of Silicon Valley, Marc Weiser, CoE and Ross alumnus (BSE in aerospace engineering and MBA) and venture capitalist now based in Ann Arbor, was about to become a central figure in the collective action around entrepreneurship education in engineering. Weiser recalls conversing in the early 2000s with other UM alumni in the San Francisco Bay Area about UM being behind its peers in its capacity for translating part of its high volume research activities into commercial endeavors (see also Blumenstyk, July 19, 2002). In the Bay Area, Weiser was an active participant in the networks of UM alumni and participated in a series of exchanges between them and university representatives on the West Coast. His

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commitment to increasing the awareness of entrepreneurship at UM brought him to organize, with the support of the OTT and Ross, a large event that brought together about forty venture capitalists, many of them UM alumni from Silicon Valley, and about forty faculty, deans, and university authorities. Among the venture capitalists who participated in the event, at least thirteen held bachelor's degrees in engineering.

The event, held at Ross on September 9, 2005, followed a "speed dating" and roundtable format to foster networking. This event was one of the seminal encounters intended to integrate the entrepreneurial networks of UM alumni and academics. According to Weiser, it symbolized a "real pull" for fostering the commercialization of research at UM. Among the goals of that afternoon were to: "provide researchers with feedback on trends in the high tech and startup communities," "spark ideas of how venture capitalists may involve professors or research labs in some of their portfolio companies," and "establish relationship for recruitment of students" (Marc Weiser, personal communication, July 11, 2014). The event was a success, but it made Weiser and others realize that the main barrier to entrepreneurial activities at UM was a lack of education and understanding between these two groups. According to Weiser, faculty and university leaders were not aware of the logic and practices of entrepreneurial groups and the opportunities that could be fostered with a greater relationship with them.

In the early 2000s, collective action around entrepreneurship, which would affect the later push for entrepreneurship education, was coming from external actors to the university. Marc Weiser and Steve Carnevale recall their frustration with the reception they found around that time, particularly from the CoE leadership. There was not a real audience for entrepreneurship. For instance, the only formal channel of communication between UM and the Silicon Valley alumni group was through fundraising and UM development agents who did not have the tools

for engaging with the interest of these eager venture capitalists and entrepreneurs. In the 1990s and 2000s, the growth of entrepreneurship at UM and the CoE, in particular, was slow and promoted by an enthusiastic but small number of faculty and staff. Certainly, there was not an organizational structure or enough leadership interest for leveraging the energy around alumni venture capitalists and entrepreneurs.

James Holloway, Vice Provost for Global and Engaged Education and Professor of Nuclear Engineering and Radiological Sciences, characterizes entrepreneurship in the 1990s and early 2000s as a rare but emerging area. Professor Holloway connects this interest for entrepreneurship as a way of commercializing research to an initial interest for teaching entrepreneurship to students. However, teaching entrepreneurship, in the early 2000s, was still not on the CoE radar, and considered by most faculty to be a distraction from other curricular demands.

> There was a lot of interest in creating more successful models of technology transfer from the CoE to industry... But it wasn't considered so common. It was sufficiently rare that there was a sense that there needed to be an emphasis placed on it to do tech transfer in a more systematic and purposeful way. And you know I think you can sort of see a trend there, where it started with taking ideas created in CoE and pushing them out to license them, to get companies to actually implement them, to faculty creating companies in increasing numbers, to eventually saying, "Oh, maybe, we ought to teach students about entrepreneurship and how to do this." But you know those were all evolutionary steps. It was certainly not the case when in the early 2000s, when, yes, there were faculty creating companies. There wasn't a big ground swell of people saying, "We should teach students how to do this." I think most faculty would have considered it a distraction from what we should be teaching students. (James Holloway, Vice Provost for Global and Engaged Education, CoE Associate Dean for Undergraduate Education between 2007-2013)

The Disconnected Teaching of Entrepreneurship

On the teaching front, entrepreneurship education was somewhat in evidence at the CoE. There were marginal efforts and scattered individuals who taught classes with a component on entrepreneurism. There were no curricular or co-curricular paths and no collective efforts trying

to push entrepreneurship education forward. Professor of Industrial and Operations Engineering (IOE) Andrew Crawford was considered one of the pioneers of entrepreneurship education in the CoE. Since the 1980s and for more than fifteen years, he taught a class on entrepreneurship for engineers, which had a business plan as well as a personal development component. He had a deep impact on his students, among them, Larry Page, the co-founder of Google (IOE, Fall 2005, p.10). Professor Crawford passed in 2001, and a group of IOE alumni established, in 2005, the Andrew S. Crawford Award for Entrepreneurship Excellence to be granted to the top students in the IOE entrepreneurship class.

In the 1990s, courses such as Professor Crawford's were mostly elective and were taken by a small group of students. Jeffrey Schox, a CoE alumnus, patent attorney and Consulting Professor at the Stanford Law School, recalls a CoE entrepreneurship class that he took in the mid-1990s taught by a local entrepreneur. Schox was an engineering student and the course was small. In Jeffrey's case, he took the class in an almost serendipitous way, "I don't remember how I stumbled upon it; it probably just fit in my schedule." Although the topic was marginal to the engineering curriculum, the class had an influence on Schox's trajectory as an entrepreneur. "I think that the root of who I am as an entrepreneur is based on that one class that I took back in undergrad," Schox said.

Certainly, in the 1990s and early 2000s, there were core product design and product development courses that could have been taught with an entrepreneurial approach (e.g., with focus on customer discovery or venture development). However, professors' and students' mindsets were not headed in that direction. Bryce Pilz, a Clinical Assistant Professor in the Entrepreneurship Clinic at the UM Law School, who was also an engineering student in the mid-1990s at the CoE, reflects back on this period. The mechanical engineering senior design class

had a clear focus on product design and development, created in the context of a big automotive

company. Entrepreneurial notions, such as intellectual property (IP), were not present in that

class. Most students were not thinking of commercial opportunities or launching startups; they

were looking for well-paid jobs in big companies. Students with an entrepreneurial vision were

viewed with skepticism.

> So I was there in the mid-nineties. I can still remember that in my senior design class, Mechanical Engineering 450, which every engineering student takes before they graduate, we worked with Ford on the Ford Taurus windshield wipers. It never crossed my mind who owned the IP we were creating. I'm sure it never crossed the other students in my group's minds… It was just a class. It wasn't you know some future startup. It wasn't you know the act of creating something that could have some life outside of the class. And so I think that was basically the mindset on campus. There were these big lucrative jobs at Intel and General Motors, and a lot of people were going to California. Working at Hewlett Packard was the dream job back then. You just didn't hear people saying, "Oh, I'm starting my own company…" They were the exceptions. If there were, I'll say this. Probably the perception was, "Oh, it is because you didn't get a job at Hewlett Packard." (Bryce Pilz, CoE alumnus, Clinical Assistant Professor in the Entrepreneurship Clinic at the UM's Law School)

The general perception was that starting a new business was not a viable option among

CoE engineering students. It was perceived as an alternative for those who were not able to find

lucrative jobs in major corporations. By the mid-2000s, student perceptions around

entrepreneurship began to shift. Ashwin Lalendran, an engineering student who co-founded

MPowered in 2007, remembers that before MPowered, he was part of an informal network of

students who gathered to talk about successful startups and product developments. These

gatherings often happened in UM dorms very early in the morning, denoting at the same time the

enthusiasm of these students for the topic and how marginal entrepreneurship was in the student

environment. According to Lalendran, "there was no unifying medium through which these

activities could be said, 'Okay, these are entrepreneurial activities'." Entrepreneurship was not a

unifying theme and well-known co-curricular activities were not in place for undergraduate

students. Nevertheless, an entrepreneurial culture in the United States was becoming visible. Videos of Steve Jobs introducing iconic Apple products were highly visited on the web and circulated among students. Other attractive figures were bringing entrepreneurship topics to UM, but always subordinated to other themes. For instance, Lalendran recalls the case of an astronaut who gave a talk in the context of an astronomy themed semester.

> Or even I remember an astronaut came over to central campus. It was some astronomy themed semester or something like that. And there were people interested in space that came out and started talking about space. And then they started talking about what was going on with space, on privatizing space. There were all these conversations happening on multiple corners of the university on the topic of entrepreneurship, but the topic of entrepreneurship was always a secondary; it was tertiary, and there was no organization to it. (Ashwin Lalendran, co-founder of MPowered)

The example of the space exploration talk is illustrative of entrepreneurial trends emanating from technological industries. In the United States, space exploration went from a heavily government-funded activity in the hands of a few contractors to an increasingly private enterprise with disruptive newcomers as protagonists. Emerging companies, such as SpaceX and Blue Origin, have reduced the cost of space exploration and brought opportunities for space tourism (Belfiore, May 13, 2014). These companies were also capturing media attention and the interest of engineers and scientists (Zurbuchen, 2007). CoE professors were taking note of these changes. For instance, the master's program in space engineering was altered to accommodate the curriculum to the new demands of the space industry (Zurbuchen, 2007). Thomas Zurbuchen, Professor of Space Science and Aerospace Engineering, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education, was leading this curricular change. At that time, although entrepreneurship was an unfamiliar concept to Professor Zurbuchen, he felt the need for changing his teaching methods and the program's curricular structures to better prepare his students for new job demands. Professor Zurbuchen

summarizes the change as going from preparing students for solving well defined problems to working with a purpose in a more open and challenging environment.

The changes in the master's program in space engineering introduced a problem-oriented approach with direct ties between industries and classroom teaching (Zurbuchen, 2007). For instance, in the redesigned core class sequence, composed of Spacecraft Technology and Space Systems, student teams design and enable technologies that address system-level problems of companies or government labs. During this transition in the master's program, Professor Zurbuchen received support from Google, the mega company that epitomizes the Internet era and a leading investor in cutting edge technologies, including space technology. Professor Zurbuchen personally met Larry Page, who introduced him to Chris Uhlik, a Ph.D. engineer in charge of Google special programs. Uhlik worked closely with Professor Zurbuchen and his student teams. Some of the student teams ended up presenting their work to Larry Page himself. This access to Google exemplifies the CoE's connection to and close relationship with leading companies in Silicon Valley. Professor Zurbuchen's commitment to curricular innovation and close ties with companies would eventually bring him to be the champion for entrepreneurship education at UM.

Professor Zurbuchen was not alone in his efforts to introduce entrepreneurial approaches to teaching, such as the one described above, into engineering classrooms. For instance, Professor of EECS Mohammed Islam taught a course called Patent Fundamentals for Engineers. There was not much more. A CoE study estimated that only eleven CoE courses contained half or more than half entrepreneurial content before 2007, such as "innovation, product development and marketing, intellectual property licensing and protection, business organization and business decision making" (CoE, 2007, p. 34). The same study indicated that "these courses are not

coordinated in any organized fashion" (CoE, 2007, p. 36) and most courses were oriented to graduate students. Where, then, did undergraduate students interested in entrepreneurship go? Some of them took entrepreneurship-related courses in Ross. However, most of the Ross courses were designed primarily for MBA students and had limited openings for students from other disciplines. Only a handful of undergraduate engineering students managed to enroll in an entrepreneurial course at Ross.

By that time, Ross already had a long history of entrepreneurial education. In 1927, Ross was the first to offer a course on small business management in the United States. The word entrepreneurship would appear in a course title in 1971, Entrepreneurial Management. In 1981, Business Professor, David Brophy taught for first time the course Venture Capital and Private Equity (ZLI, n. d.). In 1999, entrepreneurship education at Ross reached a new level when Samuel Zell, an entrepreneur, and Ann Lurie, a philanthropist, made an initial $10 million gift for the establishment of The Samuel Zell & Robert H. Lurie Institute for Entrepreneurial Studies, better known as ZLI. Among the early ZLI key initiatives are the Dare to Dream Grant program for student initiatives and the entrepreneurship forum, Entrepalooza. Even though there was a strong focus on entrepreneurship education, ZLI activities were primarily confined to the boundaries of Ross and targeted to business graduate students. Professor of Business Administration and Marketing, Thomas Kinnear, who was the ZLI founding Executive Director, points out that ZLI "tried hard for a number of years without success" to work with the CoE in the early 2000s. Professor Kinnear recalls, "the administration of the engineering school [previous to Dean Munson] was not interested… they had other interests. That no way says those interests were not important, but if you are an advocate for entrepreneurship, it was frustrating."

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In the greater university context, the state of Michigan was affected by a long economic recession. In this period and from 2001, the economic performance of Michigan has been below the national average. In fact, when the United States emerged from economic recession in the early 2000s, Michigan was the only state that was not able to recover (Michigan DTMB, 2011). Among the causes, the decline in manufacturing in the United States and share of the global automotive market are commonly mentioned as the most important factors (Michigan DTMB, 2011). In this period, multiple organizations and cities across Michigan were looking for ways of revitalizing the local economy. In 2005, Ann Arbor Spark, a partnership of government, public and private organizations, was established to foster economic activity in the city of Ann Arbor. One of its objectives is to support local entrepreneurs and startups. Business leader, Rick Snyder, who later would become Michigan's governor, and then UM President Mary Sue Coleman were instrumental in the creation of Spark.

Nationally, the CoE was falling behind other engineering schools and universities that were launching entrepreneurship education programs (see Table 1). Some of the experiences in these programs would affect later developments in Michigan in rather serendipitous ways and not necessarily through academics. For instance, in the mid-2000s, Marc Weiser became involved in the design of an entrepreneurship curriculum related to clean energy at UC Davis, with funding from the Kauffman Foundation. According to Weiser, this experience at UC Davis branched out to other regions and several institutions, such as the University of Southern California and UC at Los Angeles. Weiser was invited to take part in this new curriculum because of his entrepreneurial experience. Years later, Weiser would use part of that curriculum to teach one of the CoE core courses for the new program in entrepreneurship for undergraduates. It is fair to say that much of the early CoE entrepreneurial curriculum was

initially developed by seasoned entrepreneurs and practitioners, rather than by traditional engineering faculty. Furthermore, the UC Davis example highlights the importance of organizations that nationally promoted entrepreneurship education, such as the Kauffman Foundation.

Similar is the case of Jeffrey Schox, who in 2004 taught the graduate level class called Patents, Trademarks, and Copyright. The class was a success and grew from forty to eighty students in the second year. The content, however, "was more on the inventing side than it was on the entrepreneurial side." According to Schox, the class had a greater focus on inventions that occur in large corporations, such as Toyota and General Motors, than on startup activities. After teaching this course, Schox moved to the Bay Area to work closely with multiple startups. There, he taught a similar class sponsored by STVP at Stanford, this time with a greater focus on entrepreneurship. As in Weiser's case, the experience that Schox had in the Bay Area as practitioner and as instructor at Stanford would be crucial for later curricular developments in the CoE when Schox returns to teach a class in the CoE.

Stage II: The Launch of a Movement (2006-2008)

What characterizes this period is the emergence of a movement. Several disparate events converged to create a climate receptive to change and people came together to coordinate efforts around entrepreneurship education in the CoE. First, changes in university leadership opened opportunities and removed barriers for entrepreneurial activity among faculty. Vice President Steve Forrest began expand the research and commercialization capacities of UM, and Dean Munson made entrepreneurship education a priority in engineering. Professor Zurbuchen appeared as the CoE entrepreneurial champion. Second, new conversational spaces allowed the

coordination of several individual and group initiatives that were disconnected before. For example, CEEPS, the task force in entrepreneurship education, sought the involvement of external voices to the university and connected the CoE with several UM academic units, the local business community, and the group of CoE alumni in Silicon Valley. The first Bay Area trip, organized by CEEPS, became a seminal event that mobilized the Silicon Valley group of alumni and reinforced the ties between them and the CoE. The CEEPS report also became a mobilizing tool. A first outcome of CEEPS' work was a gift that launched CFE. Third, the students came into action with Professor Zurbuchen's support. Fourth, the concurrent CoE period of flexibility and the broadening of the undergraduate curriculum created fertile ground for the curricular component of the entrepreneurship movement. Finally, the struggling economic situation in the state of Michigan gave a sense of urgency to the movement. It also connected the CoE efforts with the key political and business players in the state.

Dean Munson, the Spark from the Top

Professor David Munson came to UM as the Chair of EECS, the CoE's largest department, after more than two decades as a faculty member at UIUC. Professor Munson was not involved or exposed to entrepreneurship education at UIUC. His entrepreneurial experience came from the commercialization of his own research. In the early 2000s, right before moving to Michigan, he and a close colleague founded a startup in image-processing systems. By that time, UIUC had strong support for faculty who wanted to translate their research into marketable products. During the 1990s, he also witnessed the rapid success of UIUC students and young UIUC alumni in the dot-com era. Hence, Professor Munson came to UM with a positive bias towards commercialization of research. He viewed the commercialization of research as a way to have an impact on society and "improve people's lives." He believed the CoE, with its strong

research reputation, could have followed that path with more intensity and when he was interviewed for the dean position, he brought his entrepreneurial bias forward. Entrepreneurship was one of his key priorities for the CoE and many actors believed it signaled the beginning of the emergence of entrepreneurship education at the CoE. Professor Munson assumed his new post as a Dean in July 1st, 2006.

The gap between faculty orientations toward publishing and commercialization of research is not easy to overcome. Dean Munson realized faculty and students needed to be educated about the process of launching a company. Fortunately for him, only six months earlier, there was another key appointment in the University that would allow Dean Munson to focus on educating students in entrepreneurship. On January 1st, 2006, Stephen Forrest, Professor of Electrical Engineering at Princeton University, assumed the position of Vice President of Research at the UM. Vice President Forrest, who received masters and Ph.D. degrees from UM, came to Michigan with strong academic and entrepreneurial backgrounds. He has over 200 patents and is the co-founder of several technology companies. He is credited with a substantial change in technology transfer at UM, and he helped the CoE leadership educate faculty about the commercialization of research.

> [Steve Forrest] was very focused on the commercialization of university research. And he did a lot of work, OTT reported to Steve when he was in that job. Steve did a lot of work there and I would say that helped us quite a lot in the college of engineering because then there was a segment of the work we didn't have to do. We were free to focus initially more on education and more on students. (David Munson, Dean of the College of Engineering)

As these changes were taking place within the administration, many of the actors who were pushing for more entrepreneurship in the CoE, primarily alumni, were realizing that a push coming from the students would have a greater impact in fostering an entrepreneurial environment at UM. One of Dean Munson's first actions was to appoint a taskforce on

entrepreneurship education. His observation was that there were very few opportunities for students to be exposed to entrepreneurship. The ZLI at Ross was doing a good job in the area, but it did not offer enough opportunities for engineering students. The goal was to reach a large percentage of CoE students. From the taskforce, Dean Munson was expecting ideas and specific recommendations about this issue. Dean Munson asked Professor Zurbuchen to lead the taskforce. At that time, Professor Zurbuchen was not an entrepreneurship champion. In his decision, Dean Munson points out, he weighted Professor Zurbuchen's personality and engagement with innovation in education. The original charge to the taskforce was, "Develop a plan for a coordinated entrepreneurial curriculum offerings and for an infrastructure to support entrepreneurship in the College of Engineering" (CoE, 2007, p. 26).

Professor Thomas Zurbuchen and the Entrepreneurial Taskforce

In the early 2000s, the CoE administrators did not demonstrate an interest in entrepreneurship and the development of entrepreneurial education seems to have been stalled by this indifference. Then, the appointments of both Dean Munson and Vice President Forrest opened the gates for entrepreneurship and entrepreneurial education. Grassroots efforts became part of the story as Professor Zurbuchen understood that promoting entrepreneurship would require a large network of people. This network would eventually include not only members of the city of Ann Arbor but also individuals from across the state and from Silicon Valley.

In 2007, Professor Zurbuchen was a tenured professor with a stellar research career, but he was not involved in commercialization. Furthermore, he was unfamiliar with the concept of entrepreneurship. He was not an obvious choice to lead the entrepreneurial task force. However, this seeming flaw would become one of the factors contributing to the emergence of entrepreneurship education at the CoE. Out of need, Professor Zurbuchen sought out many

people for advice and invited them to take part in discussions. He had an academic background that gave him credibility with both faculty and external constituencies.

> The benefit or the problem was I didn't know what entrepreneurship is. So I was asked to do this, which by the way, in retrospect, turned to be really smart because I was not the guy who has built startup companies… I was a researcher that built space instruments, so I had a credible kind of background… but what happened I asked people for input, truly, because I needed it. It was not kind of strategic move. It is like "look, could you help me to figure out what the right way of doing this is?" (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

Very early on, Professor Zurbuchen convinced Dean Munson to include members of the broader community and students in the task force. This task force was named the Committee on Entrepreneurial Environment and Programs for Students (CEEPS). Created in October 2006, it began its regular work in January 2007. Among the members were six CoE faculty, four UM faculty and staff from different offices and schools, two CoE students, and two CoE alumni. These two external members were Brian Balasia, a local entrepreneur and representative of the UM alumni association, and Marc Weiser, now had become a local venture capitalist. CEEPS also had an external review committee, which gave feedback on the first committee draft, composed by academics and entrepreneurs. Among these external reviewers six were from Michigan and five from Silicon Valley.

At the beginning of the committee work, Professor Zurbuchen faced a key challenge. Committee members were not communicating with each other with the frequency and fluency he was expecting. To improve the interaction among CEEPS members, he tapped into an idea that had been circulated by the group of Silicon Valley alumni. Again, an alumnus would bring an entrepreneurial practice developed at a peer university. Rick Bolanger, a CoE alumnus and venture capitalist in Silicon Valley, saw how Harvard Business School organized student trips to the West Coast to learn first-hand about the Silicon Valley culture. Bolanger, who received an

MBA from Harvard, observed the benefits of these trips. He suggested the idea to Dean Munson when he was head of EECS.

The First Bay Area Trip and the Launch of MPowered Entrepreneurship

Professor Zurbuchen was not yet well known in the CoE entrepreneurial network in Silicon Valley, but by organizing this trip he would rapidly show his entrepreneurial style for moving ideas forward. His approach would impress Steve Carnevale, who has a vivid memory of how the trip came about. Carnevale remembers the visit to the group that Professor Zurbuchen did in December 2006. Carnevale immediately recognized in Professor Zurbuchen the right champion for fostering entrepreneurship at UM.

> Doctor Zurbuchen came out to visit us in December of 2006. We met as a group. I hosted a group meeting… You understand that at the university there tends to be a lot of professors who are very professorial and they operate in—I'll just say—a very un-entrepreneurial way. But Professor Zurbuchen was very different… Together we came up with this idea, "Why don't we get a bunch of Michigan students and bring them out to Silicon Valley and we'll expose them to Silicon Valley?" And he said that's great, "Why don't we do that for spring break?" I said that's fine and why don't we study that, and next year in 2008, for the spring break, we'll get something together. I'm thinking at a university pace. And he said, "No-no, I want to do it this spring break." I said, "Thomas, that is in two months and this isn't a formal idea." He said, "I know but I want this to happen in February." And that's when we all knew they had identified the right guy. (Steve Carnevale, CoE alumnus, Venture Capitalists, CFE advisory board member)

According to Carnevale, Professor Zurbuchen had a different speed and entrepreneurial approach than most UM faculty. The first Bay Area trip would surpass everybody's expectation and would become one of the key milestones of the early times of the CoE entrepreneurship movement. This first Bay Area trip was an opportunity for the Silicon Valley alumni group to demonstrate its networking and organizational capabilities in their territory. The trip was organized in less than a month and was a kind of "a Silicon Valley venture capital boot camp," Carnavale said. The trip included two days of networking and talks given by seasoned Silicon Valley entrepreneurs. Bolander was part of the organizing team of this "mini startup" event. He

describes the entrepreneurial curriculum of one day. The topics were patents, disruptive technologies, legal requirements beyond patents, financing with debt equity, and how to launch a startup. Bolander views this trip as "a seed that germinated a lot more passion and interest" in what UM could become if it fully embraced entrepreneurship. Indeed, this first Bay Area trip created in many members of the Silicon Valley group a greater commitment to entrepreneurship education at the CoE. Many of them would serve as key advisors to the CoE entrepreneurial programs and even as instructors in entrepreneurship courses. The Bay Area trip would become a CoE annual signature event. Moreover, in the following years, similar events would be also organized in Boston, New York City, and Chicago.

For the first Bay Area trip, Professor Zurbuchen persuaded Dean Munson to not only cover expenses for the entire CEEPS committee, but also for an equal number of undergraduate and graduate students, 20 participants in total. That was another key decision. One of the most important consequences of that trip was the initiation of collective action for the promotion of entrepreneurship education at the student level. The trip marks the beginning of MPowered Entrepreneurship (MPowered), a student organization dedicated to fostering the entrepreneurial culture at UM. Two of the undergraduate engineering students who went on that trip, Ashwin Lalendran and Israel Vicars, are the MPowered founders. An anecdote concerning their participation was offered by Professor Zurbuchen, and it bears repeating because it captures the students' eagerness as well as his style of supporting student participation.

> There were two students that I had not included [in the list of participants], and they really wanted to go. One of them, basically, sent me letters. The other one kept coming to my door and said he wanted to come. And so I talked to both of them [and said], "if you show up in the Bay Area, you can participate. I am not going to pay your flight." So both of them showed up, and both of them became the founders of MPowered Entrepreneurship. They saw entrepreneurship there… they came back and said 'we can do that too.' And it was really their initiative, and I helped them. Like for example, I gave them an artist of the university to help design their logo. I helped them get their website.

There is not [another] student organization that is ".umich.edu." (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

Professor Zurbuchen's involvement with MPowered was crucial. According to Dean Munson, "it was really hands-off. It was kind of stir the pot a little bit, get some students excited and then let them go off and do their own thing." From the very beginning, Professor Zurbuchen helped MPowered to distinguish it from other student organizations. The professional support for MPowered's logo and the access to the university's official web address are powerful examples of his involvement. Only a few months after its launch, MPowered was featured in the final CEEPS report. In fact, one of the key CEEPS recommendations is to support the student organization.

Beginning with his first year at UM, Ashwin Lalendran, co-founder of MPowered, was interested in entrepreneurship. He approached Professor Zurbuchen for the first time in January 2007, when 65 students and faculty met with CEEPS in a town-hall meeting to discuss entrepreneurship at CoE—in the following month, the committee would also conduct a student survey to collect their opinions on this matter. Lalendran felt that Professor Zurbuchen's actions were in line with his interests. During the first Bay Area trip, Lalendran realized how far UM was from the entrepreneurial climate at Stanford. He recalls a startup job fair, where he was impressed by the student attendance and by how relatable this experience was to his everyday life. This last point is significant. It was not that UM was behind Stanford in any given academic domain; UM was distant from a social phenomenon.

[At Stanford] there were startup job fairs that were happening specifically for startup companies… were 100 to 200 plus students showing up for these things… I remember there was a small startup I was using for text messaging or instant messaging and they were there. I didn't even know they were from California. It was something that was easy relatable. I was using this product and they were hiring right there in front of me and that

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wasn't the case at the University of Michigan in 2007. (Ashwin Lalendran, co-founder of MPowered)

Rapidly, MPowered and its first President, Lalendran, and Vice-President, Israel Vicars, began to have an influence at UM. For example, they were often quoted in *The Michigan Daily*. In that period of early enthusiasm, however, they also faced some skepticism. Lalendran remembers an article published in *The Michigan Daily* that paraphrased Professor Thomas Kinnear, who by then was director of ZLI.

> The one thing that motivated us early was a *[The] Michigan Daily* article… I think it was August or September of 2007 where there were some people that said—one person in particular that was quoted in the Michigan Daily—when asked, what do you think of this organization or this club this individual said, "These clubs come and go and the real test will be to see if they last two years, five years and ten years from now." [6] We used that internal motivation to say "we will be here"…We were there to stay and we wanted to change the culture. We didn't want to do that individually; we wanted to part of that. (Ashwin Lalendran, co-founder of MPowered)

MPowered members were ambitious. They chose to focus on a cultural change rather than directly engaging with the creation of student driven startups. With the launching of MPowered, a three pronged effort was formed and consisted of the students, Dean Munson, and Professor Zurbuchen. Professor Holloway offered that this triad would be responsible for the initial growth of entrepreneurship at the CoE.

> Three things drove this growth out of entrepreneurship at the CoE of Michigan: Dean Dave Munson, Thomas Zurbuchen, and an initial group of students who ran MPowered, the entrepreneurship organization. It was those three together… So Dave Munson could provide the wherewithal. He could provide the administrative support, the finances, to develop a program, the support to make it happen. Thomas Zurbuchen had the energy to throw his all into this. And the student group created this really interesting student voice that other students would listen to because students listen to students. So I think the alignment of those three was very important to creating the success here. (James

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[6] In the referenced article, Professor Thomas Kinnear was paraphrased as saying that MPowered as "other groups with similar goals have come and gone, and that the group's biggest challenge will be to create a lasting support system" (Quarton, September 19, 2007).

Holloway, Vice Provost for Global and Engaged Education, CoE Associate Dean for Undergraduate Education between 2007-2013)

The CEEPS Report, Social Networks, and the Innovative Funding

CEEPS finished its regular meetings in May 2007 and delivered a final report that contains a thoughtful analysis of the situation of entrepreneurship education and nine detailed recommendations to the CoE. The report highlights the interest of CoE students in taking entrepreneurship courses and the need for an "entrepreneurial ecosystem" (CoE, 2007, p. 1) that supports their interests. Among its recommendations are: an entrepreneurship certificate program for undergraduate and graduate students and the establishment of a center, anchored in the CoE, that coordinates and facilitates multiple entrepreneurial activities. The report was distributed to many CoE constituencies and received positive reactions. This report also contributed to establishing Professor Zurbuchen as the leader of the emerging entrepreneurial movement. Dean Munson recalls, "It was an excellent report and one that we should follow-up. And in fact I basically agreed with...pretty much every recommendation they had. And so, I asked Thomas if he would be willing to lead the effort and of course he said, yes."

The report would also bring, very quickly and unexpectedly, the necessary funding for implementing many of the report recommendations. A few days after the report was released, it fell into the hands of Mr. X (pseudonym), a Midwestern chairman of a multinational manufacturing company, who is also the director of Foundation X (pseudonym). In few weeks, Mr. X committed the first million dollars for entrepreneurship education at the CoE. Foundation X has a long tradition of giving to research universities, primarily in the Midwest. Most of its gifts are anonymous, including its gifts to entrepreneurship education at the CoE. That is why the pseudonym X is used for the Foundation and its director—"X" was suggested by the donor himself. It is worthy of note that Mr. X is not a UM alumnus and had no affiliation with UM at

that time. Mr. X is, however, an engineering graduate from another prestigious Midwestern university. Although the report was attractive and contained specific recommendations, what caught Mr. X's attention was the name of a friend, Marc Weiser, on the list of CEEPS committee members. This personal connection and trust in a committee member was key as the first step towards his donation. Rapidly, Weiser, Professor Zurbuchen, and Mr. X held a series of meetings where the initial character of a CoE entrepreneurial center was shaped.

Through previous gifts to other universities and to other initiatives at UM, Mr. X forged a critical vision of what universities do with gifts. According to him, when gifts are planned, there is a great focus in matching the interests of the donors. However, after the deals are closed and the transactions completed, university staff redirect the original focus and fund their own agendas. That is what Mr. X thinks happened to another initiative heavily funded by Foundation X at UM. Mr. X was interested in funding what the report was proposing and the plan that Weiser and Professor Zurbuchen envisioned. To secure Foundation X funds, they had to create an atypical gift. According to Mr. X, they came up with an "innovative" mechanism for the gift. First, the gift would allocate all the money upfront, so Professor Zurbuchen would have two years for implementing the initiative. Second, there would be assessments of critical milestones along the way that would have to be signed by Mr. X and Professor Zurbuchen. Finally, in the case of no agreement between the two parties, the money would be kept at UM, but Mr. X would be free to reallocate the funds somewhere else within the university. With this mechanism in place, the assumption was that Professor Zurbuchen would have the political power to control the budget by using the threat of reallocating the funds as an argument for maintaining the desired direction.

With this gift, the "grassroots" approach to the promotion of entrepreneurship education

started to gain momentum. According to Mr. X, the gift had to be structured in such a way that

kept the focus on the students. If something were to change the UM culture and make it more

entrepreneurial, he, Weiser and Professor Zurbuchen thought, it would most likely come from

the students. Mr. X trusted that Professor Zurbuchen would keep planning entrepreneurial

activities at the grassroots level.

> The other part that Marc was very insistent on is it needs to be grassroots. It has to be
> from the students. It needs to be student-centered, and from my experience from [another
> initiative at UM] and other groups at other universities, I agree, in saying this can't be
> institutionalized. Once it becomes institutionalized, it is not for the students. It is for the
> staff. It is for the politics. (Mr. X., head of Foundation X and CFE donor)

A collective action started to take shape as individuals coming from different social

groups—Silicon Valley entrepreneurs, local businessmen, UM faculty and students—began to

coalesce. Also, a self-awareness of being part of a grassroots initiative began to grow. More

decisive for a social movement, people started to realize that their actions had to follow some

non-traditional routes, such as the structure of Mr. X's gift. Along with the resource concerns,

the discussion about defining entrepreneurship in an educational environment became important.

This discussion was important because the definition set the metrics for evaluating the future

center. The CEEPS report vaguely mentions an "entrepreneurial spirit" that will "drive the

commercialization of innovation in the State of Michigan, the Nation, and the global economy"

(p. 1). At that time, the most obvious way of thinking about entrepreneurship education was

around the notion of startups (e.g., conceiving, launching, and developing a lean technology

company) and the most obvious metric was the number of student startups in a certain period.

However, Marc Weiser and Mr. X already were opposed to this way of thinking about

entrepreneurship education. The concept of entrepreneur that they would eventually construct emphasized particular habits of mind, an "entrepreneurial mindset."

> Early on Marc and Thomas and I had a lot of different discussions, but one we really had was: What is the definition of entrepreneur?... because there are so many definitions floating out there… You know, we want to create the next Google, we want to see this software startup... We measure success by startup companies? Marc was actually the biggest one speaking not to. Between the three of us we sort of keep iterating this. (Mr. X., head of Foundation X and CFE donor)

It became clear that focusing only on startup-creation would be too narrow for their vision of an entrepreneurial ecosystem. The exact definition of what everybody would understand as entrepreneurship education could wait. After all, this had to be a grassroots initiative, and the definition should emerge from the interaction among many actors. When the funding decision was clear, however, the problem of naming the CoE entrepreneurial center appeared. This process was not trivial and the selected name would have consequences for the broad approach that the entrepreneurship movement would have at UM. Since Mr. X was providing all the funding, the center could have been called the X Center but Mr. X himself thought this was not a good idea.

> This is an early decision...I was providing all the funding, the opportunity was there to say you can name it the [X] Center... And I use anonymity for my grants. Sometimes you need to push your name forward, particularly for matching grants because it adds credibility. At times though, the anonymity allows ownership, so I thought this is very key: Do not put a name on it... This came from Thomas. It came from the school of engineering. It came from the students... It wasn't someone funding it. It wasn't Zell Lurie... It was a conscious decision because I was offered that, and we were trying to come up with a name and I said, "Thomas make up a name, you know, you design this. You develop what is next." Often by having anonymity, you are able to allow the mission to be shaped by people involved in it, and that is what I was looking for the CFE. (Mr. X., head of Foundation X and CFE donor)

The contrast with ZLI in Ross is a telling sign of the emerging principles of the entrepreneurship movement emerging in engineering. The center would finally be named the

Center for Entrepreneurship (CFE). Mr. X thought that the name was so important that a second gift he provided to CFE stipulated the center could not bear any donor's name. The naming of CFE had another important twist. Why isn't the word "engineering" in it? After all, the center resulted from a CoE initiative. This omission was also a conscious decision, one that symbolizes the switch from focusing exclusively on engineering to a much broader educational focus. Dean Munson admits he was convinced of dropping engineering from the title by Professor Zurbuchen. In the following years the center would involve more students from other schools than from engineering.

> As Thomas was launching the effort, we thought a little bit about the name for this [unit] that became the Center for Entrepreneurship. And at the time, I had in mind that this would be at least primarily engineering focused, and obviously run out of engineering. My feeling was that perhaps engineering should be in the title somewhere. But Thomas convinced me that this is really for all the students at the University of Michigan and everybody should feel welcomed. And so we didn't put engineering in the title and that turned out to be a very interesting move really on behalf of the campus because if you fast forward to today, I think half of the students in entrepreneurship programs are from outside of engineering. (David Munson, Dean of the CoE)

Along with the establishment of CFE, an entrepreneurial curriculum had to be constructed. The creation of an entrepreneurship certificate program was the first key recommendation of CEEPS. The proposed certificate required nine credits that would consist of at least one seminar, one core course, one elective, and one practicum or capstone project. Many of the courses that would make the final list had to be created by CoE, since there was not much room for engineering students at Ross. The certificate also had to be approved by the CoE curriculum committee.

The Favorable Curricular Context

The creation of the certificate in entrepreneurship happened at an opportune time within the CoE. Throughout the history of the CoE, the tension between a specialized and narrow

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curriculum versus a broad education returned from time to time (Duderstadt, 2003). As in many engineering schools in the nation, the CoE undergraduate engineering curriculum had little room for new initiatives (Sheppard et al., 2009). However, the CoE was working on creating more flexibility within its undergraduate curriculum. For instance, in 2002, LSA minors were approved for CoE students, with Mathematics, Economics, Physics, Spanish, and Music as the most popular programs (CoE, 2009). Thus, the CoE was in a period of increasing flexibility when Dean Munson came to his deanship with three new interdisciplinary areas in mind: multidisciplinary design, international engineering, and entrepreneurship. These three priorities would become curricular programs in the following years. They would be conceived in a structured and consistent academic plan. These three areas would "address common educational needs: to create flexible, creative, self-actualized change agents" (Conger, Gilchrist, Holloway, Huang-Saad, Sick, & Zurbuchen, 2010, p.1). Later, the notion of "entrepreneurial mindset" would be included as one of the six competencies sought to nurture by the Engineering Plus Philosophy, the CoE strategic plan for adding broader skills to the core competencies of traditional undergraduate education.

The need for new courses in entrepreneurship was readily met because funding was in place and CoE alumni, with years of experience as entrepreneurs, were willing to participate. The first new instructor recruited by Professor Zurbuchen was Jeffrey Schox, CoE alumnus, patent attorney, and Stanford professor. Susan Kornfield, a local intellectual property expert, introduced them. Both also met during the first Bay Area trip. Schox was impressed with what he saw. He was inspired by the students' enthusiasm and mobilized by the energy with which Professor Zurbuchen led the CoE entrepreneurial initiative.

> [Coming back to teach at Michigan] It was a big deal. It certainly wasn't for financial reasons. The class was two weeks long, and was very disruptive to my business. It was

the energy that Thomas brought. I knew and felt that he was creating something very special and I wanted to be a part of that. And when he asked me, I felt that it was something that I must do. It wasn't just a thing that I could do; it was something I must do...I also saw the excitement from the students, going back to Ashwin and Israel of the conviction that they had, and they were very inspiring. They both wanted me to come back to teach. So I was being persuaded from the top from Thomas and also from the students. Again, it was something I simply couldn't say no to. (Jeffrey Schox, CoE alumnus, patent attorney, Consulting Professor at Stanford Law School, CFE advisory board member)

Professor Zurbuchen convinced Schox to come back to Michigan and teach the class that he was teaching at Stanford, similar to the one he had taught years before at the CoE, but now with a greater focus on startups and lessons learned from his Silicon Valley experience. The class—Patents, Copyrights, and Trademarks—was a two-week intensive course taught at the beginning of the semester of Winter 2008. Schox has since become committed to promoting the teaching of entrepreneurship at UM.

In parallel to CEEPS work, Aileen Huang-Saad, a lecturer IV in the CoE Biomedical Engineering Department, was implementing the redesign of a capstone course with a strong entrepreneurial component. Before joining UM, Huang-Saad worked in the private sector on the development and testing of medical devices. The new idea for the graduate course BioMedE599 was to expose students, in a two-semester sequence, to what they would face in the biomedical industry. In these semesters, student teams would go from the ideation of new devices through the commercialization of these products. Unexpectedly, in the first version of the course that started in Fall 2007, student teams raised $43,210 from different sources for the development of their prototypes (Huang-Saad, 2009). Most of the funding came from local grants and from NCIIA. This success surprised Huang-Saad and prompted her to study the literature on entrepreneurship education. Professor Zurbuchen would recruit Huang-Saad as director for academic programs at CFE.

The first year that I taught the class, I largely was teaching more for giving the exposure to students of what industry would be like, which is something that graduate students were more currently missing in that curriculum... Interestingly, in the first year the students became very entrepreneurial, so the students raised a lot of money on their own...I was very intrigued why they became so entrepreneurial, so I started to look at entrepreneurial literature, and it turns out that the framework in which I was teaching the class is one that was shown in other places to cultivate what we called the entrepreneurial mindset. (Aileen Huang-Saad, CFE Associate Director for Academic Programs)

The State in Free Fall: The Recession Hits Home

By 2007, the state of Michigan was in a long period of economic recession. Nevertheless, Ann Arbor felt somewhat better off than the rest of the region. There were some positive business signs. For instance, in September 2006, Google opened an office in the city for its AdWords division. This was good news. Google expected more than 1,000 jobs for this office over the next five years (Bomey, February 1, 2012).[7] This was considered a "seminal moment for the image of the local tech community" (Bomey, February 1, 2012). However, only a few months later (January 2007), Pfizer, a multinational pharmaceutical, announced the closure of its Ann Arbor facility and immediately, 2,100 jobs were lost. This closure was the coup de grace of the state economic depression (Dickson, January 26, 2007). This event added a sense of urgency to the emerging entrepreneurship movement. Entrepreneurship was conceived as a way out of the desperate situation in Michigan.

Among the actors who were becoming visible spokespersons was Rick Snyder, a UM alumnus and venture capitalist. In 2011, Rick Snyder would become the 48th Governor of Michigan. He was a member of the initial group that received the CEEPS report. The report appears to have come at the right moment, when influential people were open to listening and

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[7] This Google office only added 300 jobs in that period (Bomey, February 1, 2012).

giving support. To Professor Zurbuchen, the closure of the Pfizer facility meant a shift in people's attitudes and the potential of a big change.

> Nobody thought it [would] touch Ann Arbor, and what happened. Pfizer from one day to the other closed the research facility out here, and it was absolutely clear that it hit us too… Right here, right in the neighborhood of the university. And that just seemed impossible. So yeah, in the community there were people that came in and started talking about entrepreneurship as the way out (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

Professor Zurbuchen believed the biggest change would come from empowered people. According to him, "part of what drives them is the excitement of doing new [things], but part of what drives them is also fear." He reasoned that with the economic downturn, students and their families would become more concerned about their future. The desire to control their fates, which comes from fear, would prompt more entrepreneurial activity.

Stage III: The Start Me Up Momentum (2008-2011)

This period saw the emergence of entrepreneurship education as a movement emerging from within the CoE. One of the key factors behind this phenomenon was the CFE "startup mode", a relentless style that mobilized students, faculty, and actors external to the university. This mode also produced innovative strategies. In terms of curricular programs, CoE broke conventions in supporting curricular and co-curricular programs open to all UM students in order to create a greater momentum and add multidisciplinarity, which was conceived as a key characteristic of entrepreneurship, according to Professor Zurbuchen and other actors. CFE also established a symbiotic relationship with student organizations, in particular, with MPowered. Together, CFE and MPowered launched the 1,000 Pitches competition and made it a cultural change agent on campus. As already noted, the CFE startup mode also prompted some fundraising strategies that crashed with traditional advancement practices. A key milestone was

the approval of the nine credit certificate in entrepreneurship for CoE students. During this period the definition of entrepreneurship became broader, and the phrase "entrepreneurial mindset" came to represent the learning objective of CFE programs. Furthermore, individuals and organizations began to construct an entrepreneurial ecosystem around UM in a grassroots fashion. At the same time, UM administrators' commitment to entrepreneurship education continued to grow.

Start Me Up CFE

CFE was established in January 2008. The intention was to run it as a startup rather than as a traditional academic unit. In many regards, CFE demonstrated its commitment to look and behave as a startup and to be the epicenter of what they saw as a grassroots initiative in the CoE and at UM. With operational funds already secured for at least two years, a critical first task for Professor Zurbuchen was to recruit the right people for the center. In 2008, the CFE added three people, Susan Hill, a full time administrative assistant, and two half-time members. The first hiring was Huang-Saad to be in charge of the academic and curricular programs. Then, Amy Kinkle assumed the role of engaging with the entrepreneurial community. Conveniently, she split her time with the UM Business Engagement Center, which was established in 2007 jointly by the Office of the Vice President of Research and the Office of University Development. Both Huang-Saad and Kinkle followed Professor Zurbuchen's style of working very closely with students. In 2009, CFE hired its first Executive Director, Doug Neal who, by that time, was a successful serial entrepreneur from California. According to him, the rapid growth of entrepreneurial programs that CFE experienced was due to the team's enthusiasm and sense of purpose. They were part of a "revolution", not a traditional academic unit.

> The people involved at the Center for Entrepreneurship look at what they were doing not
> as a job, not as some place they got paid, but it was their mission and they felt passionate

that they had to be successful in doing this. There [was] an opportunity [to have] an impact on many people's lives if we were successful. So we were all driven, very passionately, to make this a revolution as opposed to just an academic center. (Doug Neal, venture capitalist, CFE Executive Director between 2009 and 2013)

CFE staff readily acknowledged that there was interest and a campus buzz around entrepreneurship. Nevertheless, it was not that they built CFE and people came. They had to work hard, reaching out and mobilizing the UM population, especially students. Accordingly, CFE was launched in a startup mode. One of the promotional materials was a laptop sticker, in-fashion among entrepreneurs, with the phrase "START ME UP" written in blue letters in a maize circle. A good scene that epitomizes this CFE startup mode is the one written by Doug Neal in an early blog entry as CFE executive director, titled "Running on Empty." He writes, "in startup mode, however, the reason I shut off the pump before the tank is filled is TIME! It kills me to waste time when there are a thousand things that need to get done and believe me; in startup mode you are never ever done" (Neal, September 13, 2009). As Neal himself acknowledges in his blog entry, not filling the tank is not efficient for time sake (i.e., eventually one loses more time going several times to the gas station). But a startup mode is not completely rational. It is an impetus that challenges tradition. Clearly, this mode brought CFE to act not within the framework of academic convention and it suited a grassroots approach.

"Begging for forgiveness instead of asking for permission" was one of the mantras of this startup mode. Events and activities were designed and prepared in short periods of time, and this pace prompted some unsuccessful events or breaking some university rules, such as no-alcohol on campus events. CFE had room for experimentation and making mistakes. The center had an important initial budget and, more importantly, UM authorities were becoming more pro-entrepreneurship. Amy Klinke describes this period as a "perfect storm" that allowed the CFE team to experiment and put in place numerous activities and events with students and alumni.

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Failure is a critical component of every startup. "Fail early and fail often" is another startup mantra. It was one of the CFE early principles and some of the failures were expensive. Amy Klinke recalls an early failure, an event organized around a football game, a big and symbolic event for the UM community. The event brought entrepreneurs and venture capitalists to campus to become familiar with the technology coming out of the CoE. As is common in many research universities, the most important discoveries and inventions are at a basic science level, far from immediate practicality and commercialization. The event was unsuccessful. Entrepreneurs and venture capitalists were not engaged at this level of research. However, from this experience, CFE learned that student and local startups with venture-ready technology were essential. According to Klinke, "we spent a lot of money on it to bring people in and a lot of work and it totally failed. And that was okay."

Consistent with the startup mode of operation, CFE established an advisory board where most of the members were venture capitalists and entrepreneurs. Eventually, this operational style would clash with the academic nature of the institution. For instance, when CFE was about to hire its first director in 2009, the advisory board wanted to make the final decision. Professor Holloway was among those who thought that was an improper procedure. If UM is the hiring institution, then the final hiring decision belonged to UM. The advisory board was not supposed to act as a governing board. The confusion created at this point caused CoE authorities to be more careful about the role of this eager board. It is important to note that there was not a conflict in the actual hiring of its first director. The conflict was about the procedure.

Among the advisory board members who were external to the university, the tension between the startup and the academic way of doing things was also present. CFE had secure funding for only two years. Mr. X offered to cover the operational expenses for five more years

if the gift was not treated as an endowment. UM refused the offer. It was an issue of control. The board was divided on this matter. Venture capitalists were on Mr. X's side. With no endowment, CFE and the advisory board would have more control over the budget and the operations, which is a common practice among entrepreneurial ventures. Faculty and no venture capitalist members were on the endowment side. According to Mr. X, a board member who was a businessman from the corporate world and was close to the financial sector, advocated for the endowment. Portraying startups and venture capitalists as being in opposition to large corporations, in particular those from the pre-internet era and from the financial sector, was a common strategy among some of the entrepreneurs involved in this initiative. UM believed it was unlikely to find a significant endowment during the economic downturn of 2009 and so finally, Mr. X and UM agreed on two years of funding.

A Curricular Program that Develops an Entrepreneurial Mindset

CFE continued in this same startup mode as it began promoting entrepreneurship education at UM. CFE attracted people who fit with the startup mode and followed its practices. They believed that acting as if CFE were a startup was a key factor in excelling as an academic unit. How was that startup mode translated into curricular structures and course content? At first, the *startup basics*, so to speak, were almost directly translated into the curriculum, for example, methods for evaluating the commercial opportunities of emerging technologies. However, the justification for an entrepreneurship curriculum started to shift. This was a subtle but a critical distinction for the movement. Dean Munson's original idea was to stimulate engineering students and faculty towards starting profitable companies and commercializing research. He came to think, however, that an entrepreneurial approach was desirable for almost everybody and entrepreneurial learning would be important in almost any human endeavor.

I think the deeper we got into this; the more we realized that entrepreneurship isn't just about startup companies. So at this point, our thinking is taking a turn… While we're launching the programs, I'm thinking about for profit startup companies, but the further we got into it, the more we were talking about the entrepreneurial mindset. So from that point it wasn't just about startup companies… I think it is that broader notion that's carried over to this desire and intention to do something at the campus level (David Munson, Dean of the College of Engineering)

The focus of CFE curricular programs became developing students' "entrepreneurial mindset". When entrepreneurial mindset had to be defined, a quote from Ma and Tan (2006) was often used: "Entrepreneurship is a particular type of mindset, a unique way of looking at the world… At the heart of entrepreneurship lies the *desire to achieve*, the *passion to create*, the yearning for freedom, the drive for independence, and the embodiment of entrepreneurial vision and dreams through tireless hard work, calculated risk-taking, continuous innovation, and undying perseverance." (Ma and Tan quoted in Conger et al., 2010, p. 3, emphases from the reference)

The Curriculum and Its Disciplinary Boundaries: Everybody is Welcomed

Originally, Dean Munson's idea was to have the first entrepreneurial efforts focus on undergraduate and graduate engineering students in engineering. When the question of whether the program in entrepreneurship and CFE activities in general should be restricted to engineers or open to all UM students arose, there was no immediate agreement. Professor Zurbuchen advocated for opening the program to everybody. The incentive for keeping the program and its classes for engineers only was clear. The main argument against opening courses was a matter of resources. The CoE would receive funding according to the number of CoE students in the classroom. In other words, an open program would use CoE resources for non-engineering students. Professor Zurbuchen believed that argument was flawed. He had the Ross experience in mind—when engineering students could not take entrepreneurial courses in Ross because of

restrictions on the enrollment of non-business students. He did not want to follow that model and he countered with, "entrepreneurship is intrinsically interdisciplinary." Therefore, an effective entrepreneurial educational experience for engineering students required multiple disciplines in the classroom. He did not want to compromise this principle for the sake of financial accounting. Professor Zurbuchen also rejected the prospect of creating a selective program centered on promising entrepreneurial students: "Many people encourage me to make the entrepreneurship program a highly elite thing, so you make it small with a few people. I'm like 'that never did anything for any other school.' It costs you a lot of money and it doesn't really affect the university as a whole."

Ultimately, when the courses and programs were launched, they were open to all enrolled students at UM. It is important to note that the first CFE courses were taught on North Campus, approximately 2 miles away from Central Campus, where most of the undergraduate programs are located. To bring non-engineering students to North Campus is always an achievement. For Professor Zurbuchen and the movement, the openness of the program ultimately became a key to success as the program popularity grew faster within the non-engineering student population. Thus, the decision to welcome all students in CFE programs "turned really into a campus-wide movement even though we were just a school." Even those who expressed concern about allocating CoE resources for non-engineering students were surprised by the outcome. Professor Holloway was among them. He acknowledges that Professor Zurbuchen was right and believes the idea was a "brilliant move," part of CFE's success.

The Core Entrepreneurship Courses

At the beginning of CFE, the traditional curricular questions were rapidly answered. What should be taught? Different aspects of launching a startup, such as the ideation process,

customer discovery, venture development, and intellectual property issues. To whom should we teach this content? To everybody, not just engineering students. What is the appropriate sequence? Since the program required a small amount of credits and was open to everybody, there were almost no requirements and sequence was not relevant. Who should teach these courses? For Dean Munson, it was clear that entrepreneurship instructors should be found outside the university, among those with great experiences in starting businesses. Although Dean Munson was a startup co-founder, he did not consider himself experienced enough to teach these courses. The strategy was "bring in people who do this every day as opposed to people who do research on how to do it" (Zurbuchen quoted in Lafay, November 26, 2007). To recruit these people, it was necessary to build a large network, far beyond the university, and Professor Zurbuchen worked tirelessly to build that network. Multiple entrepreneurs, some of them with no teaching experience, came to UM to teach a course, be inspirational speakers, or mentors.

In Winter 2008, three courses were launched from CFE. These courses were taught even before the certificate was approved. Jeff Schox taught a two-week, one credit course—Patents, Trademarks, and Copyright (see last section of the previous stage). Marc Weiser taught a Venture Business Development class based on the curriculum developed years earlier at UC Davis. This was a course that went from the evaluation of a business idea to how to develop it. Weiser was not expecting students to start actual business from that class, but to give students a framework that they could use later in their careers. The third class was a semester long seminar called entrepreneurship hour which brought weekly speakers to tell their experiences and inspire students. Professor Zurbuchen, with the help of Weiser and others, was responsible for this speaking series. This seminar was organized in response to the lack of exposure students had to

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entrepreneurs. They wanted students to "engage with entrepreneurs in a regular basis," said Weiser.

The seminar meant much more than a simple talk. It was a place for experimentation and networking, where entrepreneur enthusiasts and those who were curious would see each other in a large auditorium. The seminar brought high profile entrepreneurs, including those who started their enterprise in and outside Michigan. Bringing speakers to talk every week is a labor intense endeavor. It was even harder for CFE since they targeted well-known and seasoned entrepreneurs from across the state and the nation. CFE wanted to have an impact from the beginning and that required names that would grab the attention of the UM community. These names were often big successful alumni or big donors. Access to the entrepreneurial networks was key and Marc Weiser helped with the first round of speakers. Among those who came to campus for the first time were influential Michigan actors such as Dick DeVos, a Grand Rapids entrepreneur, and 2006 candidate for governor of Michigan.

> I was involved in that class because I was bringing my friends to speak... One of our primary foci was this notion of impact, and [CFE] actually incorporate it into the curriculum, but that speaker series, we tried really hard to have big branding speakers. That's, you know, big donors, or big successful alumni... I will give one example. We brought a guy called Dick DeVos, multi-billionaire, his father started Amway [a multiproduct company]... It was the first time he ever came and did anything at the University of Michigan. We had [the UM Vice President for Development]. We had the dean. We had the associate provost. I mean all these people showed up... It wasn't because we asked them [the speakers] to come and do something at the UM, we asked them to come to talk to students. What a great calling card! (Marc Weiser, CoE alumnus, venture capitalist, CFE advisory board member).

According to Weiser, the idea of talking to students is very appealing for most entrepreneurs. Weiser has never received a negative answer after inviting a guest. Even, he has had to reject some self-offerings. During the initial offering, Professor Zurbuchen noticed that the speakers from Michigan had the greatest impact on the students, even compared to guests

who were founders of popular companies, such as Pandora, a music streaming service. According to Professor Zurbuchen, the Michigan entrepreneurs were obviously closer to home and to the experience of the students. Moreover, their stories were more inspirational in the context of a state that was struggling and searching for new economic models.

As expected (see last section, the launch period) the certificate in entrepreneurship was approved. Even though the CoE curriculum is constrained, the nine credit program did not pose a threat to any CoE departments or to other faculty interests. Among the three curricular initiatives launched by the Dean (international education, multidisciplinary design, and entrepreneurship) entrepreneurship was the only one that did not establish a minor. This helped in obtaining CoE support, or at least in not attracting detractors. It also made it more appealing for students. The certificate was more likely to fit into their schedules and required a small commitment of time.

MPowered, Its Startup Mode and Signature Events

In addition to the nine credit hour certificate, the CFE supported the development of co-curricular activities. MPowered, the student organization, spread the entrepreneurship buzz and ran many of the co-curricular activities around campus. In many respects, MPowered mirrored the startup mode of CFE. Interestingly, MPowered leaders, although entrepreneurship enthusiasts, were not interested in launching startups themselves, while in college. Their focus was on creating a cultural shift and helping others materialize their ideas. MPowered used entrepreneurial practices to promote organizational change.

Although MPowered started with CoE students, it was open to students from all disciplines. Lauren Leland, a business major, who would become the third MPowered president, joined the student organization in 2008, when it was still a small group. Leland's background fit with MPowered aspirations. Leland was a student leader and member of Greek life. In her first

year, Leland participated in a UM leadership program and became more interested in social

entrepreneurship. In that context, she met MPowered leaders and joined them.

> I first became involved after my freshman year. I attended a leadership development program called, Leadershape. And the program encouraged you to think about what was important to you and what you wanted to pursue. I became very interested in social entrepreneurship. Entrepreneurship in general but specifically: how you can use the ideas of entrepreneurship to make a positive impact in the world. And there were current members of the MPowered executive team at the conference as well. And so they approached me and let me know what they had been doing in MPowered. It was only about a year old at the time. And that spring term, I joined the team and have been involved since… I knew a little bit about it and I was interested in companies like Ashoka and Kiva and things like that.[8] (Lauren Leland, MPowered president 2009-2010)

Leland would not launch a social venture, she would help MPowered create opportunities

for others. In 2010, MPowered would reach 60 members. Leland acknowledges that the early

MPowered leadership functioned in startup mode. This meant a certain level of sacrifice, for

instance, many working hours and declining academic grades. For them, the higher learning

came from the experience of leading a growing organization. According to Leland, "leadership

and organizational design" played a central role in MPowered. The organization is still a very

active student organization that reaches all UM schools and other campuses across the United

States. Many of MPowered's former leaders remain in touch with each other and with the current

leadership.

Another key characteristic of MPowered was that it grew alongside CFE in a symbiotic

relationship. From the beginning, there were mutual cooperation and weekly meetings. The

MPowered president would even sit in the CFE advisory board. CFE would provide resources

and access to funding for MPowered activities. MPowered would be in charge of spreading the

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[8] Ashoka, founded in 1980, is an organization that supports social entrepreneurs, providing startup financing, professional services, and connections to a global network of business and social organizations (see www.ashoka.org). Kiva, founded in 2005, is an organization that provides funding to microfinance institutions around the world (see www.kiva.org).

word, making entrepreneurship visible across schools. For CFE members, MPowered was central to the general grassroots effort. Two of the first flagship MPowered activities, the startup career fair and 1,000 Pitches, are good examples of the support received from CFE. A Stanford startup career fair was an activity that impressed Ashwin Lalendran, MPowered co-founder, in one of his visits to Silicon Valley. The goal was to bring many startups that were either hiring or offering internships. The first startup fair at the CoE was done in cooperation with Digerati, a design and software company located in Detroit and founded by Brian Balasia, a CoE alumnus. Balasia was one of the external members of CEEPS. Although the fair was important for being the first of its kind, the results were modest. The fair was small, rather resembled a resource fair, and was mostly restricted to engineering students. By the second version, in 2009, CFE stepped in. Amy Klinke worked on the small and startup company side. MPowered focused on bringing students to the fair. The number of companies and student participants rapidly grew. One early innovation was to allow student startups to participate for free. Small businesses and startups had to pay a fee for having a booth in the fair. The fair had a high impact for the student startups. They were able to recruit fellow students and get a form of social legitimization within the greater startup community.

According to Amy Klinke, students were not as interested in meeting the community as the community was in meeting students. The startup career fair was a great way of plugging students into the community. A problem was that small business and startup companies did not have the resources to hire students with a competitive salary. This was particularly true for computer scientists, who are in high demand. However, Amy suggests that the grassroots approach generated such enthusiasm that some students felt compelled and interested in working in a startup company, even if that was not the most economically attractive destination for them.

In 2008, the UM entrepreneurship education advocates needed a highly visible event. An event that would makes CFE and MPowered recognizable organizations around campus. The first suggestion that came to MPowered and Professor Zurbuchen was to organize a business plan competition. That is what other entrepreneurial programs used to do, including Ross. According to Professor Zurbuchen, however, that would create a disciplinary barrier and would not resolve the matter of visibility. Business plan competitions attract mostly business students. Moreover, they would hardly qualify as a massive event. CFE and MPowered were looking for a "cultural change agent," said Zurbuchen.

> The basic challenge I had was nobody knew that we had open doors, and I worried about that. Okay, so how do we figure out where the people are with ideas? And said, "let's make it as simple as possible for them to identify themselves." I really wanted two things to come. I wanted to find the people that had good ideas that wanted to work on that, and the other thing I wanted to do is frankly create a sense of "this is what we are about," of course, I didn't guess that it is going to be so successful. We just called 1,000 pitches... There had to be something with the word thousand on it because otherwise nobody would never know what we were doing... We are a big university, 40,000 in the university, if you do something where a 100 students come, nobody knows anybody that does it. If you do something that has a 1,000 on it, everybody will know somebody that participates in it. And so basically, it becomes a narrative. (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

Lauren Leland was part of the team that came out with the 1,000 pitches idea. She was the first student to lead the event. Her rapid path to organizing this event reveals several important entrepreneurship movement characteristics. Leland was interested in social entrepreneurship, but she understood that CFE and MPowered needed "boots on the ground" and "viralization" in order to be known around campus. Thus, she merged her idea for a social entrepreneurship competition into 1,000 pitches. Social entrepreneurship was included in the "dream category" of the competition. Some of the other categories were high-tech, Michigan matters, and local business. For the students participating in the competition, the operation was simple. Students had to make a short video pitching their ideas and submit it to the competition.

A group of judges would select the best pitches within each category. The first challenge was to get people to submit their ideas. Leland and the MPowered team had to work hard, spreading the word and pushing for submissions. Leland used her networks in Greek life. Sororities and Fraternities helped. One of the marketing strategies was to emphasize the disciplinary openness of the event. In short, 1,000 Pitches was not restricted to business or engineering majors. There were also no concerns about quality. Not many students knew what an entrepreneurial pitch was. Leland recalls "the bagel store" idea as an example of the unattractiveness of some of the pitches. However, that idea was needed in this first version. An idea, no matter what kind, was the "first step" to entrepreneurship. In the first version, in the final minutes, the competition reached 1,030 pitches. The first 1,000 pitches competition was a success and became one of the signature events of the entrepreneurship movement at UM. Thomas Zurbuchen hailed the event as "the World's biggest collegiate entrepreneurship competition" (Zurbuchen, December 10, 2008). The large scale events and big numbers would become a constant in the narrative built by the entrepreneurship education leaders at UM.

To some extent, many of the activities organized by CFE or MPowered were adopted or adapted from activities run first at other institutions. The competition 1,000 Pitches was an exception and in coming years, another university would adopt it. Within the UM campus, the competition became a well-known event that would easily surpass the 1,000 threshold. In, 2009, in its second iteration, the 1,000 Pitches competition would reach 2,165 pitches. In 2010, a new record would be set with 3,031 pitches. UM President Mary Sue Coleman, speaking at closure of the 2010 competition, would say, "What you're doing (through this) innovative, wonderful competition is showing our region, our state and our nation that the entrepreneurial spirit is thriving at Michigan," (Adler, March 3, 2011).

CFE and MPowered started to be known across the University. Figure 1 illustrates the annual number of The Michigan Daily articles about entrepreneurship. In 2007, articles about entrepreneurship grew exponentially, following many of the events generated by the UM entrepreneurial movement. The entrepreneurship student leaders also became recognized. Every year, The Michigan Daily selects several students as the students of the year. In 2009, Ashwin Lalendran was selected as one of the students of the year and a feature article was written about him. In 2010, it would be Lauren Leland who was featured.

Figure 1. Number of Articles per Year about Entrepreneurship in The Michigan Daily (N=212)
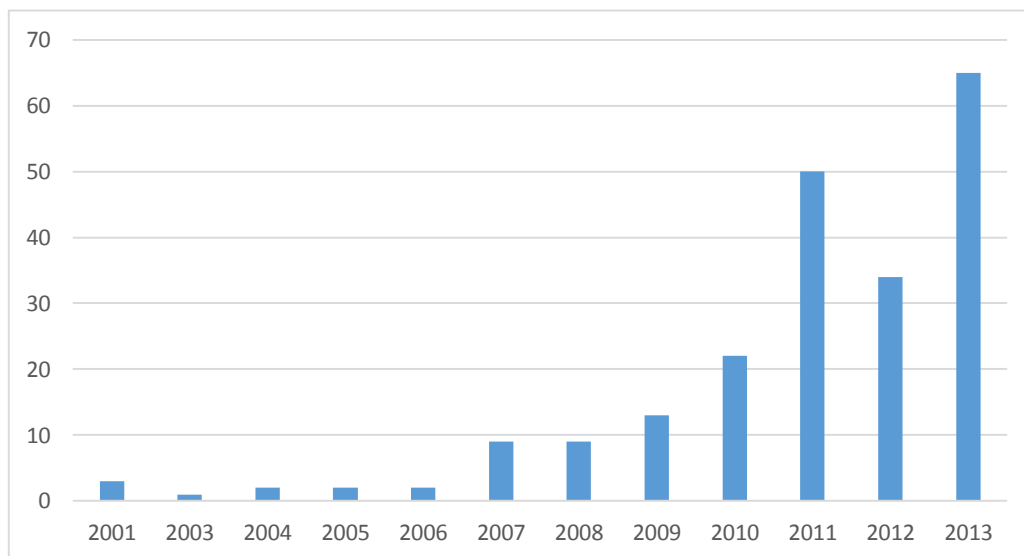
TechArb & the RPM Summer

While MPowered was dedicated to changing the campus culture, there were other students who focused on the success of their startups. After the first round of CFE courses in Winter 2008, a group of student teams wanted to immediately put their ideas into practice. To help them maintain that momentum, Marc Weiser, through his co-founded venture capital firm RPM Venture, ran a ten-week summer program called RPM_{10}. This program was conceived as a

real-world internship for the student teams (Huang-Saad, Bornhorst, Zurbuchen, Grover, & Weiser, 2010). Each team received $20,000 to cover their startup launching costs. In addition to the founding, they received office space and mentoring, primarily from RPM Venture advisors (Huang-Saad et al., 2010). Three teams were funded. Among the team members was the CoE senior Jason Bornhorst. He along with other two engineering students founded the networking website CampusRoost.com during the RPM_{10} program. Their startup intended to keep social connections among neighbors on the web. The launch focused first on the Ann Arbor community. To promote their site, in the dawn of the first day of class, they spread 200 white plastic chairs with the legend "Your neighbors could be sitting here," across UM, a guerrilla marketing technique (Gregg-Geist, September 9, 2008). Even though the campaign drew many visitors, the website did not succeed. Nevertheless, Bornhorst and friends would continue having an impact in the community.

After that summer, a group of RPM_{10} participants, Bornhorst included, along with other friends realized that a greater interaction among student startups would be beneficial for all. They sought office space and an organizational structure that would nourish their businesses and the startups of those to come. They approached RPM Venture and CFE for support. With them, in the summer of 2009, they launched the student-run accelerator TechArb, located in the basement of a building in downtown Ann Arbor. The office space was lent for three months, thanks to a local real estate firm connected to Marc Weiser. To furnish the space, the students established the "BYOC" policy—bring your own chair—a policy that would capture for years to come, the spirit of the student startups at UM (Huang-Saad et al., 2010). The next version of the RPM_{10} program, was run at TechArb and it became a UM institutionalized initiative. Each summer, TechArb would host more than 10 student startups.

To establish a student startup accelerator was part of the CFE plan, but the students made it happen sooner. CFE would eventually be closely involved in TechArb and would cover part of its funding needs, this time in a joint effort with ZLI. TechArb became another community site that would attract Ann Arbor entrepreneurs, primarily as mentors. More important, now, there was a space in downtown that directly connected students with the community. When TechArb started, Jason Bornhorst, along with CoE students Kunal Jham and Mayank Gark, founded Mobil33t, a startup that developed iPhone applications. One of their applications called DoGood achieved great success. DoGood suggested daily good deed to its users. The application idea emerged from the mobile computing class of CoE Professor Elliot Soloway. The application was featured in *The New York Times* (Huang-Saad et al., 2010) and was downloaded more than 70,000 times. In less than a year, Mobil33t, DoGood was acquired for a significant amount by a media firm (Bomey, April 15, 2010).

<center>*Let's Share our Ideas*</center>

It became clear at UM that sharing ideas was an important condition for a successful entrepreneurial ecosystem. However, it seemed to those involved in the early phases of the entrepreneurship movement that Michigan people were not willing to openly share their business ideas. This attitude was in total contrast to what was being observed in Silicon Valley. The CEEPS report devotes several pages to this issue, suggesting that intellectual property (IP) policies might be a key barrier. With frequent interactions and numerous students with business ideas, the issue of IP became more pressing. It helped that in 2009, the UM amended its IP policies in order to "remove any ambiguity regarding student inventions" (Pilz, 2012, p. 24). Basically, UM would not claim ownership of any student invention created unless he or she was paid by the institution (Pilz, 2012). The amendment was needed because when UM developed its

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policies for technology transfer, concerns about student inventions were not within the OTT scope. According to Pilz, UM adopted one of the most student-friendly policies in the country. These policies cover not only student startups but also student inventions developed in capstone projects. This university position helped create a more open environment where people feel comfortable sharing their ideas.

Facilitating mentoring interactions among venture capitalists and students with ideas and startups raised concerns. According to Dean Munson, having venture capitalists who "are hoping to find good investments for their firms" is reasonable and expectable. Nevertheless, the CoE has policies in place that protect its students if needed. It is important to note that for many of the venture capitalists supporting entrepreneurship at UM, making a profitable investment out of their engagement was not a priority. For example, Marc Weiser asserts that the engagement of RPM Venture in the summer programs mentioned above did not generate any return for the firm, nor was it expecting one. The purpose was to support the entrepreneurial grassroots at UM and in the Ann Arbor community.

An Entrepreneurial Ecosystem under Construction

During this period, multiple entrepreneurial initiatives emerged both at UM and in the Ann Arbor community. These initiatives were conceived with different goals and targets in mind. The novelty of this period is the bridges that began to be built among these efforts. CFE was at the center of the ecosystem and helped to connect numerous entrepreneurial initiatives within the same framework. At UM, several schools started to follow the path of Ross and CFE. Decentralization has always been characteristic of UM, and for entrepreneurship education that was the case. "Let a thousand flowers bloom" is a phrase that many actors used to describe what happened with the emergence of entrepreneurship at UM. For instance, the School of Medicine,

which according to Professor Goldstein lagged behind the CoE in commitment towards entrepreneurship, started the Medical Innovation Center (MIC). The purpose of MIC was to help bring medical ideas into the market, in particular, new medical devices. In this area, the School of Medicine had a close collaboration with CoE faculty, researchers, and students (Bomey, August 20, 2011). Another school with natural inclinations towards entrepreneurship is the UM's School of Information (SI). Ann Verhey-Henke, Associate Director of Innovation and Social Entrepreneurship at the UM's School of Public Health (SPH), was the director of research administration in SI during this period. SI was interested in promoting entrepreneurship among its faculty and students and Verhey-Henke recalls that she was the staff liaison with CFE. Although there were no joint programs between CFE and SI, each was aware of what the other was doing.

Not all the entrepreneurial initiatives emerged from particular academic units. There were some campus-wide initiatives. In 2010, TEDxUofM hosted its first annual event. TEDxUofM was inspired by the TED (technology, entertainment, and design) conferences, which started in 1984 in Silicon Valley. Since its beginning, TED has been closely associated with West Coast entrepreneurs. TED coined the phrase "ideas worth spreading" and has become a web and cultural phenomenon. TED conferences consist of straight forward presentations given by well-known intellectuals and public figures. TEDx are independent organizations that follow the same TED presentation and conference principles. There are hundreds of TEDx organizations around the world. The first TEDx was run at the University of Southern California in 2009 (Rosenbloom, September 24, 2010). TEDxUofM is organized primarily by students with support from across the UM community. In 2011, the TEDxUofM event attracted about 1,700

participants (Dewitt, March 27, 2012). This UM conference would become another site where entrepreneurial-minded people meet and share ideas.

University-wide entrepreneurship competitions would also become a key component of the entrepreneurial ecosystem. In 2010, DTE Energy and UM broadened the scope of a previous competition to launch the DTE Clean Energy Prize with $100,000 in prize money. The goal was to help bring student technological ideas into profitable ventures. The competition included student teams from several Michigan universities (Chiu, March 29, 2011). Similarly, in 2010 the Accelerate Michigan Innovation Competition, with a $25,000 grand prize, was launched by the University Research Corridor and Michigan business leaders. Student teams from across Michigan had to pitch their ideas in different rounds (Snider & Williams, September 21, 2010).

While all of this was happening on campus, Ann Arbor was becoming a vibrant entrepreneurial community. A group of successful technology entrepreneurs, among them, Dug Song, a serial entrepreneur, is often credited with the emergence of this community (Bomey, July 24, 2009). In 2009, Song was one of the founders of the Ann Arbor New Tech Meetup group, which welcomed everybody interested in Ann Arbor high-tech startups. The group continues to meet every few weeks and engages in an array of events such as networking, short demos and presentations, and happy hours. During its first year, this Meetup group attracted more than 100 attendees every month (Bomey, July 24, 2009). During this time, Dug Song also became one of the founders of Tech Brewery, a large office space where startups can rent desks for short periods of time. Tech Brewery also hosts events for the Ann Arbor tech community (Gardner, March 4, 2010). This new environment in Ann Arbor started to be compared to cities with strong technological startup communities such as Boulder, CO, and Austin, TX (Halpert, March, 2013).

CFE was central to the UM connections within the local startup community. CFE understood very early on that an entrepreneurship program could not be built in a vacuum. A vibrant community was needed. Amy Klinke's role was to be the community face in CFE. Although Klinke was not known in that community, she very quickly became the UM face in several events where technology entrepreneurs regularly met. Through her, people in that community found ways of connecting to UM at different levels. Klinke recalls the energy of those tech groups, in particular around areas such as hardware, wind energy, and biotechnology. Klinke's rapid access to this community can be explained in part by her skills developed in her previous work in the local non-profit and political world, but also by the non-hierarchical and straightforward communication style of the startup communities. In short, you just have to show up and talk to strangers to get connected to those groups.

> I started going to every event possible. And I would speak at events. I quickly joined all the entrepreneurial groups in Ann Arbor… They would know, "Amy is at U of M; I can ask her how to get plugged in?"... I wasn't known. I was known in the nonprofit community. And I was known in the political community but I hadn't reached out to that community… I just went and said, "Hey, I'm Amy Klinke; I'm doing this." (Amy Klinke, CFE Assistant Director for Small Business Initiatives)

In these interactions, Amy Klinke also realized the importance of learning from the experiences of cities with well-known entrepreneurial environment. She recalls visits to Boulder, CO, San Diego, CA, and San Francisco, CA. These trips reinforced in her and in CFE the importance of creating an exciting community around entrepreneurship and in producing changes at UM and its ecosystem.

CFE connections to the startup and entrepreneurial world were not restricted to Ann Arbor or Southeast Michigan. During this period, a significant and powerful Silicon Valley community connected to UM was consolidated, in particular, throughout the annual Bay Area trips. For instance, Amy Klinke, who coordinated these trips, remembers that on one of them,

Dick Costolo, the CEO of Twitter and UM alumnus, reconnected with his alma mater. Many Silicon Valley companies were interested in hiring CoE students and through those hiring channels, Klinke obtained many of the company tours for the Bay Area trips. According to Klinke, it was easy to enroll Silicon Valley people for this event. She describes those who helped mobilize the UM network in Silicon Valley as "human routers." The numbers of students who participated in the trip grew significantly during these years, from the 11 in 2007 to almost 50 in 2010.

UM also pushed for more entrepreneurship in the state of Michigan from the top level. Vice President Forrest is frequently praised for his engagement with the community. Vice President Forrest worked closely with Ann Arbor officials and business leaders to create an entrepreneurial ecosystem in the city. It was his conviction and the sentiment of many UM leaders that for UM to thrive in the development of technological businesses, it needed a stronger interaction with the community and the state. Following the commitment of President Mary Sue Coleman, Vice President Forrest served as a member of the Ann Arbor SPARK executive board.

Despite the increasing entrepreneurial activity and enthusiasm generated around the emergent startup community in Ann Arbor, not everybody involved in the movement for entrepreneurship at the CoE is optimistic or impressed. In particular, local CFE advisory board members think that Ann Arbor and the region in general need more entrepreneurial critical mass in order to become a new hub for technology startups. What it is missing is a big referent, a company that injects more capital and entrepreneurial inspiration to the region, such as Dell in Austin, TX. Michael Dell founded Dell, a multinational computer technology company, in 1984 when he was a first year student at the University of Texas at Austin.

The Social Network, the Movie

During this period, entrepreneurship continued on the rise in the popular culture. In October 2010, the movie *The Social Network* was released and became a success at the box office and a cultural phenomenon (IMDb, n. d.). The movie tells the story of how Mark Zuckerberg founded Facebook when he was an undergraduate student at Harvard University. According to several actors, the movie reinforced the entrepreneurial movement at UM by making the idea of starting a company while in college more popular among undergraduate students. Indeed, in Winter 2011, more than 200 students signed a petition nominating Mark Zuckerberg as the 2012 commencement speaker (Wassman, September 21, 2011). By 2011 entrepreneurship education was already mainstream not only in engineering, but also across the university.

Stage IV: Branching out from Engineering (2011- 2014)

In this period, the entrepreneurial movement spread across the campus at every level. Among students, entrepreneurship became a mainstream theme. UM leadership also took up entrepreneurship, promoting it among faculty, the region, and the nation. The multiplicity of advocates for entrepreneurship education and entrepreneurship in general had several consequences. First, CFE became a central hub for UM. Second, struggles started to arise around the definition of entrepreneurship. Third, UM decided to create a coordinating entity led by Professor Zurbuchen and announced a university-wide minor in entrepreneurship. This decision would allow CFE to refocus on engineering.

LSA Opens the Doors to Entrepreneurship, the 1,000 Voices Campaign

By 2011 the number of LSA students surpassed the number of CoE students taking CFE courses in entrepreneurship, a surprising result. Furthermore, more than 40 percent of student members of MPowered were LSA students. While CoE students could receive a certificate in entrepreneurship for a nine credit curricular program, LSA students did not have that incentive. Moreover, LSA students did not have entrepreneurship classes in their academic home. LSA administrators were not willing to take part in the entrepreneurship education initiatives of other schools. To pressure LSA authorities to support entrepreneurship education, MPowered, organized the 1,000 Voices campaign. In March 2011, MPowered launched the website 1kv.org to collect the signatures. Their petitions to LSA were summarized in three bullet points:

- To support and empower entrepreneurial activities
- To offer a program that allows students to develop entrepreneurial skills and mindset
- To offer more classes in entrepreneurship (MPowered, n. d.)

Ankit Mehta, MPowered president at the time, viewed the campaign as a definitive moment for UM. "1,000 Voices is more than just a petition, it's a movement. This is a once in a lifetime opportunity. In the 194 years of our University, no opportunity like this has ever come out," Ankit said (Lee, March 16, 2011). Within a few days, they reached their goal. In total, 1,365 students signed the petition (MPowered, n. d.). LSA is the largest UM's college. It enrolls about 17,000 students. Nevertheless, the number of students signing the petition was significant and meant a conflict around a topic that was seen positively by UM central administration.

Professor of History Terrence McDonald was the LSA Dean between 2002 and 2013. Professor McDonald remembers the campaign and the first time that the issue was officially

discussed in the LSA curriculum committee. LSA finally recognized the CFE certificate in entrepreneurship for its students. However, the discussion raised questions about the academic rigor of the program. To some extent, this was the first formal questioning of what CFE was teaching. According to Professor McDonald, there was not a clear definition of the subject matter. What is entrepreneurship? For LSA faculty, the idea of awarding academic credit for coursework in entrepreneurship was unresolved.

> The first time it came up officially was when the LSA curriculum committee was asked to consider whether or not LSA students could get a certificate in entrepreneurship… The curriculum committee decided that students in LSA shouldn't be prevented from getting it. But the discussion was complicated. What is it? Is it a curriculum? Is it really the type of thing we would normally give academic credit for? So the question of the academic standing of the program was in the air when the certificate proposal came forward. (Terrence McDonald, Director of the Bentley Historical Library, LSA Dean between 2002 and 2013)

The most problematic aspect of CFE's entrepreneurship program, according to Professor McDonald, was the lack of distance from the subject matter. Practitioners, not scholars who could critically examine what entrepreneurship is or how it works, taught entrepreneurship. The greatest skepticism in LSA came from the absence of disciplinary perspectives. For instance, no economics course was required for the CFE certificate. If there were an economic course, the numbers of students declaring the program would likely plunge, suggests Professor McDonald. The low barrier of entry to the program was a key strategy for attracting students. Professor McDonald also points out that although many students declared the program, a low percentage of them actually completed it.

Professor Zurbuchen remembers heated debates with Professor McDonald. Professor Zurbuchen attributes critiques about the lack of disciplinary perspective to the entrenchment of traditional departments, the university status quo. To understand entrepreneurship, one must abandon strict disciplinary perspectives. The profound piece in this discussion, according to

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Professor Zurbuchen, is that entrepreneurship is also action. It cannot be understood only by thinking.

> The best entrepreneurs are little Renaissance people. But there is one element that is really, really, important for every entrepreneur and that is you have to try some things. You cannot design the iPad with just thinking. That is a really profound piece. I mean, so in that sense, you know, entrepreneurship really is a force that really challenge the status quo within a university. Some of our top entrepreneurs, some of them have quit… My personal feeling is for a university like ours to be relevant and be the best university that it can be, it embraces this kind of movement without rejecting what we [the university] have done. (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

With the LSA approval of the certificate in entrepreneurship, CFE received a burst in the number of program declarations. At seen in Figure 2 the number of declaration goes from 105 for the 2010-2011 academic year, to 215 for the 2011-2012 academic year. The number of students completing the program is much lower, less than a third. There is no cost associated with declaring, withdrawing, or not completing the program.

Figure 2. Number of Students Declaring the Certificate in Entrepreneurship by Year
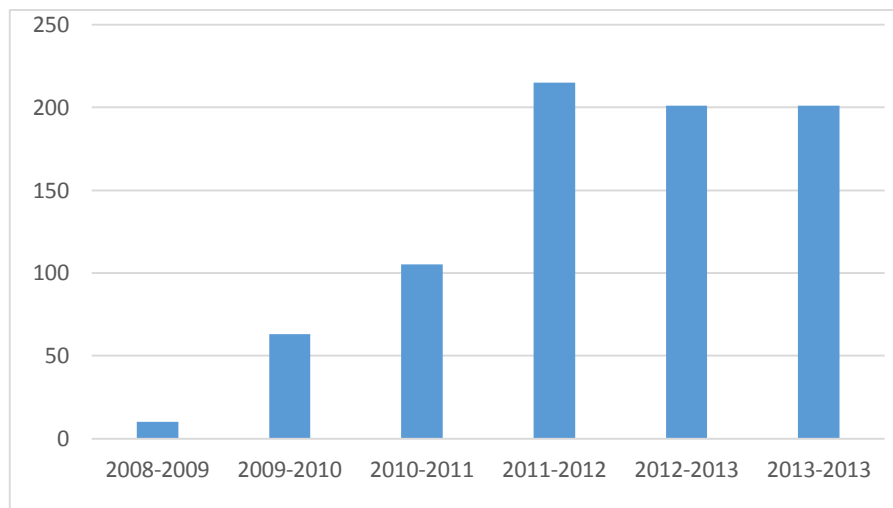
MPowered Reaches a New Level of Organizational Capacities

MPowered continued to grow and reached new levels of organizational capacities. Its activities attracted large numbers of students from across the nation and received the support of many UM academic units and private sponsors. MPowered's signature event, 1,000 Pitches, broke new records every year. In this period, 1,000 Pitches grew from 3,303 video pitches collected in 2011 to 5,342 collected in 2013. In 2013, the competition was adopted by a student organization at Pennsylvania State University, Innoblue. This growth meant greater independence from CFE. Some of their activities were no longer run with the closest support or direct intervention of CFE. Amy Klinke recalls that MPowered practically took over all the organizational responsibilities of the 2013 Startup Career Fair. One of the changes they introduced in the fair was an almost exclusive focus on startups, instead of including more established local small companies.

The days of the Startup Career Fair were noisy and crowded in North Campus, where the norm is long corridors with scattered and mostly quiet engineering students. The 2013 Startup Career Fair, organized in January, attracted over 80 startups, ranging from well-established technology companies, such as Barracuda Network, to newly formed student startups. Most of them offered full time positions and summer internships. MPowered's fair differed from traditional university career fairs. Most students, as well as startup members, dress casual and almost no ties are seen in the crowd. Most startup teams wear polo t-shirts with their startup name or logo. If a startup conducts interviews, these are brief and with interviewer and interviewee standing up. Many startups use colorful booths with attractive messages. Although the fair is open for everybody, most startups look for students with knowledge and skills on

specific coding languages. Even pieces of code or software language names are written in some of the booths' signals.

MPowered defended the startup style of the fair, describing the startup experience in contrast to what students could experience in large and well-known companies. In 2013, the fair's website said about startup working experiences, "you'll be encouraged to work with agility and speed—there's no time for bureaucracy and dawdling as you may find at other companies." In 2014, "do it at a startup" was the phrase of the fair, which MPowered organizers wore in their t-shirts. In the Startup Career Fair, it is interesting to see how startups that are well known in the social media or the entrepreneurial world get great attention from students. In the 2014 version, long lines could be observed in front of the booths of Buzz Feed, a social news and entertainment website, and at a16z, the short name for Andreessen Horowitz, one of the best-known and largest venture capital firms in the United States. Interestingly, these two organizations have their headquarters on the East and West coasts, respectively. On the other hand, many local startups explicitly pointed to the fact they were established in Michigan on their banners.

In this period, MPowered also launched numerous new activities and events. Among the most ambitious events was MHacks. Hackathons are events where computer programmers create solutions to a wide range of problems in a limited period of time. These programming sessions grew in popularity during the 1990s, in the dot-com era. In the CoE, EECS Professor Elliot Soloway has organized small hackathons for CoE students since 2008 (EECS, February 8, 2011). In 48 hours, student teams have to create applications for mobile phones. In November 2011, CFE sponsored a 36-hour hackathon organized by TechArb and the UM North Quad Residence, in which 45 students participated (Goldsmith, November 13, 2011). In this competition, teams built startup projects based on web applications. In 2012, a group of CoE undergraduate students

after traveling to PennApps, a hackathon organized at the University of Pennsylvania, founded Michigan Hackers. In 2013, Michigan Hackers teamed up with MPowered to organize the first MHacks, a 36-hour hackathon. In February 2013, the first MHacks received about 500 students from across the country who packed Palmer Commons at UM central campus. The event was considered the largest student-run hackathon at that time (Chowdhry, February 6, 2013). Both organizations planned to organize a large hackathon every semester. Next semester, in September 2013, MHacks was hosted at the Big House, the UM football stadium, and attracted about 1,200 students from over 100 colleges and universities (Sivakumar, September 22, 2013). The setting and the energy coming from student teams were inspiring. To some extent, the event resembled a college athletic competition, some of the teams had their college flags or t-shirts, and there was an abundance of energy drinks. Most of the action, however, was happening in front of computer screens. In the winter of 2014, MHacks was hosted in downtown Detroit, in restored buildings, an equally inspiring setting. More than 1,000 students attended (Burns, January 18, 2014).

Mpowered reached a high capacity for organizing complex events, receiving financial support, and attracting students. Other student organizations developed around entrepreneurship could not claim the same. For instance, in the semester of Fall 2013, a group of undergraduate business students organized a three day conference called Innovate, which aspired to be the "largest student-run entrepreneurship conference." They were wide off the mark. Despite having attractive speakers, only about 20 students showed up to most of the sessions.

Entrepreneurship at the Core of the Student Government

With the traction gained for the entrepreneurial movement among students since 2007, it was almost natural that entrepreneurship would become a central theme for university student

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politics. In 2012, Manish Parikh, business student and independent candidate, won the election for the Central Student Government (CSG) presidency, making entrepreneurship his major platform point (Bologna, March 18, 2013). CSG is the main student government organization at UM. As soon as Parikh took over the presidency, many activities promoting entrepreneurship were launched. One of the first CSG actions was to create the Entrepreneurial Commission within CSG. The commission members were the leaders from 15 organizations, such as MPowered, Michigan Hackers, and TEDxUofM. MPowered President Scott Christopher chaired the commission (Bologna, October 24, 2012). CSG president Parikh also collaborated with MPowered's 1,000 Pitches competition. CSG would support with resources, connection, and infrastructure to the best student pitches that could be implemented at UM (Block, November 8, 2012). CSG designated March as the "Month of Entrepreneurship," during which a series of events highlighted the diversity of student organizations and initiatives around entrepreneurship. According to MPowered President Scott Christopher, one of the goals of this month is to "remove the stigma that entrepreneurship is only for business and engineering students" (Sivakuman, March 19, 2013). In the CSG election for the coming academic year, the business and LSA student Michael Proppe was also elected with the promise of continuing the CGS promotion of entrepreneurship (Bologna, February 25, 2013). During these two years, CSG and several student organizations pushed UM towards a more decided action to reach all students with entrepreneurial opportunities. Professor Zurbuchen collaborated with both CGS governments.

Interestingly enough, there was no vocal opposition from any student organization about the emphasis on entrepreneurship. Among the more than 200 *The Michigan Daily* articles collected and reviewed for this case, no frontal opposition was found. A handful of articles,

however, started to ask what kind of pressures this entrepreneurial environment puts on those students who are not interested in entrepreneurship (e.g., The Michigan Daily, September 18, 2013).

OptiMize, the Students Who Replaced Entrepreneurship by Innovation

Along with entrepreneurial education, multiple social ventures have been launched by students. For instance, CentriCycle, founded by CoE student Carolyn Yarina, has become a well-known initiative on campus that develops portable medical centrifuges for diagnosis in rural villages in poor countries. From the beginning of CFE, a significant number of engineering students felt attracted to the idea of solving world problems through social entrepreneurship. CFE, and the entrepreneurship movement in general, have used such a broad framework for entrepreneurship that the "social" component has been subsumed, or not emphasized on a large scale. Hence, according to Huang-Saad, business-oriented or social-oriented engineering students are not mutually exclusive groups. Within CFE's broad vision of entrepreneurship education, a group of non-engineering students appears to have assumed the leadership of social entrepreneurship at UM.

In Fall 2012, LSA students Michael Maiorano, Jeff Sorensen, and Tim Pituch, founded OptiMize. The seed for OptiMize came from Maiorano's leadership experience with social ventures. In his first year, Maiorano joined the UM student organization Student for Educational Equality (SEE), which gives free tutoring to high school students in Ypsilanti and Detroit. Over the next three years, Maiorano was in charge of SEE fundraising and then became its president. In 2012, SEE was honored by the White House initiative Campus Champions of Change Challenge. In the White House, after meeting student leaders from all the country, Maiorano realized the "shared impact" of running social organizations as ventures that apply business

principles. Back on campus, Maiorano developed the idea of sharing his experiences and insights with other students. When finishing his degree he wrote a manifesto titled "Optimize social innovation" and shared it with other student leaders. Sorensen, was among them. With Sorensen, they explored the ways of reaching other organizations on campus. Pituch, who has had experiences with service learning trips to Central America, eagerly joined them. Their first idea was to create a competition with a learning component. They met first LSA Professor Philip Deloria, LSA Associate Dean of Undergraduate Education. He showed some interest. When they met Professor Zurbuchen, they fell victim to his startup mode spell. With a half-baked idea they were thinking of launching the competition in about a year. Professor Zurbuchen encouraged them to start within a few months and gave them financial support for the launch. They started the OptiMize program competition in Winter 2013. At this point, all of the co-founders had graduated; only Sorensen and Pituch continued with the initiative.

Sorensen and Pituch framed OptiMize as "social innovation." They consciously decided to not use the word entrepreneurship in their competition title or in the written material on their website. Entrepreneurship brought negative association to some students that could potentially become part of OptiMize. Pituch recalls that they actually tested this perception at the Shapiro Library, the main UM undergraduate library. They asked people to fill in the blank between social and challenge (i.e., social ____ challenge) with the words entrepreneurship, change, or innovation. They concluded that innovation was the most attractive concept. Sorensen and Pituch became active members of the broader UM entrepreneurial movement and close to Professor Zurbuchen and to other pro-entrepreneurship faculty. However, they acknowledged that the concept entrepreneurship came with a business connotation that was not well received by everybody. Instead of explaining that entrepreneurship could be a useful way to think about non-

profit organizations, they just dropped the term, so their message could be communicated in a straightforward way.

> We found that entrepreneurship, the word, brings up its own, I guess, connotations that we don't really want to associate ourselves directly with. A lot of people when you say entrepreneurship they think starting a business. And that's not what OptiMize is about at all… For the longest time we bought into the fact that social entrepreneurship could be starting a nonprofit. And I still believe that it is but not everyone does. There is nuance there that doesn't get across unless you describe it and you talk at more length about it. We didn't want to have to deal with that kind of nuance. (Tim Pituch, OptiMize co-founder)

Student teams that compete in OptiMize participate in workshops and receive feedback from mentors. The workshops use many of the content and materials used by CFE, such as the business model canvas. Tim describes how they modified many of the business or entrepreneurship jargon in order to make their message more appealing to a different audience. For instance, they replaced the concept of "customer" with "people." From the first to the second year, OptiMize grew from 62 participants to more than 90 in 2014. In their first year, OptiMize raised $85,000 to support the work of the participating teams. LSA, in particular Professor Deloria, gave them support and even gave Sorensen and Pituch the opportunity to work with faculty in new mini courses on topics related to social innovation. Here, an interesting parallel emerge between MPowered and OptiMize. OptiMize leaders as well as in the case of MPowered did not pursue their own ventures, instead they chose to cultivate the right environment for others to do it. Both are meta organizations. Nevertheless, there is a key difference, MPowered has remained as a student-run organization. OptiMize stills depends on his co-founders. Pituch is now a UM graduate student, and Sorensen is working full time for OptiMize and LSA. Both organizations maintain close ties with Professor Zurbuchen and CFE.

The Ecosystem Continues Growing and the Flowers Blooming

During this period, several new academic units dedicated to entrepreneurship continued appearing in the landscape of UM. Announced in Fall 2011 and launched in 2012, the UM School of Law, launched the Zell Entrepreneurship and Law (ZEAL) Program with a twofold goal, boosting the school curriculum in entrepreneurial topics and opening a clinic that serves all students in the university. With numerous student startups being founded, the clinic came to fill a growing need on campus. Students needed legal advice since issues of intellectual property and other rights have become unavoidable for many technology startups. On the other hand, legal fees for these services are unreachable for many students. Thus, the clinic serves student entrepreneurs at the same time that it offers law students a learning space related to startup ventures.

In 2013, the SPH started an office of innovation and social entrepreneurship that would focus on SPH students and faculty. The office runs a five month competition with a learning component called Innovation in Action: Solution to Public Health Challenges. During this competition, students learn aspects regarding the process of launching a startup. The competition is open to all UM students, but all student teams have to be led by a SPH graduate student. This competition has received close support, especially on the content and teaching side from CFE. Ann Verhey-Henke, the office associate director, also works with faculty on commercialization aspects of their research.

Also in 2013, the SI launched its Entrepreneurship Program with the mission of strengthening the school entrepreneurial curriculum and co-curriculum, organizing trips to entrepreneurial hubs and articulating the network of partners and mentors. It follows the CFE model. By the end of 2013, at least five UM schools—Ross, CoE, School of Law, SPH, and SI—

had established programs, with full time faculty or staff committed to entrepreneurship education at the undergraduate or graduate level. LSA has also initiated courses and programs that include entrepreneurial components. For instance, the LSA one-credit course Critical Issues in Education, co-designed with OptiMize, "push students to devise practical, real world-solutions" (The Michigan Daily, November 13, 2013). All of this happened only within 6 years with the exception of ZLI at Ross.

These entrepreneurial activities were noticed by UM authorities. Despite the large number of new entrepreneurship education opportunities, the high student demand for entrepreneurial courses created the impression that UM could align its entrepreneurial initiatives and offer a higher quality entrepreneurship education for all students. In May 2012, a university-wide task force on campus wide entrepreneurship education (CWEE) was established. The task force members were LSA Professor Philip Deloria, CFE Associate Director for Academic Programs Aileen Huang-Saad, CoE Professor Thomas Zurbuchen, and Ross Professors William Lovejoy and Lynn Wooten. CWEE reported to Provost Phil Hanlon, Ross Dean Alison Davis-Blake, and CoE Dean David Munson. A CWEE report was released on November 2012 with a detailed assessment of the state of entrepreneurship education to date. The reports states that more than 2,200 students have taken at least one of the 29 courses in the CFE Program in Entrepreneurship. About 20 student organization had a focus on entrepreneurship. The report's main recommendation was a campus-wide minor in entrepreneurship. The report also assessed the meaning that entrepreneurship had for students and faculty. CWEE summarizes that students define entrepreneurship as "starting or owning a business, based on creativity and innovation as a means of gaining personal independence" (p. 35). On the other hand for faculty, entrepreneurship is "the action of creating a new venture by implementation of an innovative idea that generates

social value" (p.35). Student's definition of entrepreneurship was assessed as closer to

marketplace than the faculty definition. Combining both views, the CWEE report suggests a

lengthy definition:

> Entrepreneurship is serving an external constituency in a novel way. The skills required
> are understanding that constituency, generating a novel idea to serve it, and then having a
> variety of specific skills and the dedication and perseverance to implement the idea. Since
> no single person is likely to have all of the necessary skills and talents to do this, and
> interactions with the constituency are necessary, team work and interpersonal skills are
> required. (UM, 2012, p. 35)

Now, It is the Time for Faculty Entrepreneurship

In this period, faculty also became the target of myriad initiatives and incentives for

moving research to the market. Among the most intense and ambitious programs implemented

during this period is the Innovation Corps program (I-Corps), funded by the NSF. In 2012, NSF

selected UM along with the Georgia Institute of Technology, and Stanford, as an I-Corps node.

UM would receive a $1.5 million grant for a three year implementation. The program would be

run by CFE. I-Corps consists in an intense hands-on training of research teams (up to three

members) on startup building processes, such as customer discovery. The training nodes would

be open to researchers from across the country. Thus, CFE became a national hub for the training

of several cohorts of research teams. Numerous UM faculty would participate in this program. In

the 2012 first version of UM I-Corps, 27 teams participated. Among the instructors were the

CFE staff, Doug Neal, Aileen Huang-Saad, and Jonathan Fay, and the CFE advisory board

members Marc Weiser and Rick Bolander.

The I-Corps program was conceived by the author Steve Blank, who has been one of the

most important influences in the development of the curricular content in CFE. Steve Blank is

one of the best-known Silicon Valley gurus. Doug Neal calls him "a true Entrepreneurial Jedi

Master" (Neal, March 29, 2011). Steve Blank, with an engineering background, became a serial

entreprenuer and a best-selling author. Blank's first book hit was *The Four Steps to Epiphany*, published in 2005, in which he develops his customer discovery methodology. He taught his first entrepreneurship courses in the Haas Business School at UC Berkeley and in the School of Engineering at Stanford. His talks rapidly became a web phenomenon. In fact, one of the first in hearing about Blank in CFE was Doug Neal. In 2009, Doug was so impressed with one of the Blank's talk videos in YouTube that he reached out to Blank for advice. Since then, Blank has been in permanent contact with CFE and visited Ann Arbor several times. In 2012, Steve Blank published *The Startup Owner's Manual*, which became the must-have book among entrepreneurs. In the acknowledgements section of that book, Blank thanks Dean Munson and Professor Zurbuchen for inviting him to teach at UM (Blank & Dorf, 2012, p. 551).

Steve Blank's step-by-step startup guide was a convenient and simple schema for teaching entrepreneurship to researchers as well as to students. Most importantly, it attracts engineers with the simplification of many business concepts. Blank clearly dismisses traditional business knowledge in the startup context. Blank and Dorf (2012) argue, "today after half a century of practice, we know unequivocally that the traditional MBA curriculum for running large companies like IBM, GM and Boeing *does not* work in startups. In fact, it's toxic." (pp. xviii-xiv, their emphasis). Along Blank's methodology, another book that became a staple for teaching entrepreneurship at UM is Osterwalder and Pigneur's book *Business Model Generation* (2010). This book presents the business model canvas, which visually summarizes in a long sheet of paper divided into nine boxes, a startup strategy. To some extent it is a simplified and visually attractive version of a traditional business plan. Long sheets of paper printed with the canvas model are common in faculty and staff offices, entrepreneurial spaces, and classrooms in several UM schools.

Not only did courses target faculty and researchers, there was a series of policy and incentives that would highlight entrepreneurship as another academic duty. Tenure decisions are one of the most influential processes in faculty careers and in shaping the values of institutions (McPherson & Schapiro, 1999; Tierney & Bensimon, 1996). Often during the process of tenure decisions, universities require tenure-track faculty to submit a dossier with their contributions in research, teaching, and service. In 2012, the CoE formally included entrepreneurship as one of the key evaluative components of the casebook. Since then, the number of patents, startup activities, and mentoring to student startups has counted in the tenure-decision process. Here is how Professor Zurbuchen describes the new process in his blog:

> For example, instead of just counting research and publications, the casebook asked for specific inputs to "contributions to technology transfer and entrepreneurship." Similarly, under service contributions, the casebook specifically asks for "consulting and startup activities." And, under teaching, the casebooks ask for mentorship of student teams, which includes student companies and entrepreneurial student organizations. Yet, there is one part of the promotion process, which perhaps was the most impactful: for each promotion a series of letters are requested from the best researchers all around the world. Here is the specific question each one of them as asked: "How would you evaluate the candidate's broader impact in entrepreneurship or business through startup, consulting, technology transfer or other relevant activities?" (Zurbuchen, October 8, 2012)

New funding opportunities also became a way of promoting entrepreneurship among faculty. In October 2011, President Mary Sue Coleman announced the Michigan Investment in New Technology initiative (MINT). This was a bold decision and a clear statement of President Coleman's trust and commitment to UM faculty entrepreneurship. Under MINT, UM would invest $25 million over the decade in startups coming from UM labs. Any faculty at any time could apply for up to $500,000 in funding (Williams, October 5, 2011). Crossbar, Inc., a computer memory company, co-founded by CoE EECS professor Wei Lu, became the first startup to receive the MINT funds (Burke, March 27, 2012). Also in 2011, President Coleman announced the Third Century Initiative, a $50 million university teaching initiative to foster

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engaged learning and hands-on projects across the university (Woodhouse, October 5, 2011). The concept of "entrepreneurial mindset" would become one of the four learning outcomes prioritized by this initiative. In 2012, a group of three CoE professors Mark Burns, Thomas Zurbuchen, and Alec Gallimore, originated MCubed, a novel way of funding research. Basically, if three faculty from different disciplines have a research idea, they can apply for $60,000 to hire a postdoc researcher, or graduate or undergraduate students to work on the idea. First-come, first served. (Moore, May 9, 2012). MCubed fits with the entrepreneurial vision of an out of the box and interdisciplinary approach to research. Professor Gallimore clarifies that entrepreneurship is "an obvious by-product of it, but we didn't design MCubed for entrepreneurship; we designed it for innovation in research and scholarship."

Entrepreneurship in the Voice of the Leaders and in the Victor for Michigan Campaign

President Mary Sue Coleman showed interest in entrepreneurship since the beginning of her time in office. She understood very early on the needs for creating a more entrepreneurial environment around the University (Ann Arbor SPARK, January 18, 2012). In the same direction were her efforts with the Michigan University Research Corridor, where she made the case of the economic impact of university research in the state of Michigan. The appointment of Vice President Steve Forrest was critical for revitalizing technology transfer. In December 2008, the UM regents approved the purchase of the former Pfizer building and agreed in creating, in that site, the new North Campus Research Complex, a center dedicated to research commercialization.

Even though commercialization of research was an early commitment, entrepreneurship education became a predominant theme in President Coleman's leadership agenda during the final period of her presidency. To some extent, UM leaders followed the groundswell movement

coming from students, faculty, alumni, and local entrepreneurs. During this period, President Coleman often made public remarks about entrepreneurship education. For instance, in February 2010, while making the case for university funding to state senators, she highlighted, "it is our job as a university to teach, encourage, and reward innovation and creativity. That ranges from engineering and business to the arts and humanities… Across the University we have over 100 courses that explore entrepreneurialism" (Swanson, March 1, 2010). In April 2011, President Coleman and MPowered organized a fireside chat to talk about entrepreneurship education. At that occasion, President Coleman praised MPowered, "I was very intrigued by your ideas, and invocation, and your thinking of ways to get students involved… I really believe that you have done something really important on this campus" (Snider, April 20, 2011). In 2011, President Coleman co-chaired the National Advisory Council on Innovation and Entrepreneurship (NACIE). This council focused on "the issue of the commercialization of federally-funded research" (U. S. Department of Commerce, 2013, p. 5). President Coleman, using the example of MPowered, promoted entrepreneurial student organizations among NACIE members (Snider, April 20, 2011). In 2013, NACIE released a report that promotes university-based entrepreneurship, in which UM is featured as a case study (U. S. Department of Commerce, 2013).

Fundraising was another area where leadership was crucial for entrepreneurship advocates. For instance, UM leaders have been key hosts in dinners across the country organized by CFE and the CoE Office of Advancement. With the presence of top leaders, more constituents attend. David Thompson, CFE Director of Development, recalls a 2013 dinner where President Coleman and Governor Rick Snyder confirmed their presence. For maximizing the impact of the event, CFE created a well-crafted and emotive video titled *On the Next Level: Entrepreneurship*

at the University of Michigan. The video celebrates CFE achievements. The message is: The UM entrepreneurial spirit is rooted in the UM tradition of excellence and innovation and the industrial foundations of the region, and this "spirit that has always been there is now unleashed" (CFE, 2013). The event was a success. The video's "next level," a common phrase among entrepreneurs, is a concept that would be used in many CFE activities during this time. It represents the promise of a substantial improvement of what exists now.

During this period in which entrepreneurship grew across the university, CFE continued making progress in fundraising, without obtaining yet a mega endowment. For instance, Donald Graham, CoE alumnus and Chairman of the Graham Group, an engineering company, committed substantial gifts to CFE, and in 2012, Robert Beyster, a philanthropist, pledged $1 million to CFE. Specific CFE programs have also been endowed. For example, in 2012, Weather Underground, a successful local startup, gave a $500,000 to endow the annual Bay Area trip, now renamed Weather Underground Start-Up Trek. The CFE's startup mode is still active, and its search for resources resembles a startup aggressive search for funding.

However, this CFE's startup impetus has often clashed with the practices of CoE advancement. As seen in the stage II and III, the rapid startup style for fundraising contrasts with the long-term view of traditional advancement. The issues of fundraising for entrepreneurship became more complicated when several academic units claimed a share of the potential gifts. What complicates the picture is that entrepreneurs do not necessarily have a commitment to certain disciplines and heavily value multidisciplinarity. Moreover, when there are university centers, such as CFE, that have open door policies for all university students, a fair logic for seeking and receiving gifts is hard to make. In other words, it is not clear what school(s) or college(s) should ask for or receive gifts from those who support entrepreneurship education.

A visible symbol of UM commitment to entrepreneurship and coordination capacity of advancement offices across the University is the Victors for Michigan campaign. This campaign was officially launched in November 2013, but "softly launched" in 2011. The campaign seeks to raise $4 billion and focuses on three priorities. Priority # 2, engaged learning, states "transform the Michigan education by extending academic excellence from the classroom into real-world experiences that develop students' global purview and a creative, entrepreneurial mindset" (UM, n. d.).

The Struggle for the Definition

With the multiple actors pushing for entrepreneurship education across campus, another issue that gained more relevance was the working definition of entrepreneurship. This issue was also highlighted in the questions raised by LSA faculty and then by the CWEE report. CFE coined early on the concept of "entrepreneurial mindset," which was useful for not restricting entrepreneurship to startup-creation. However, it was an extremely broad definition that did not clarify the focus of the entrepreneurial movement. Mr. X, who agreed early on with idea of "entrepreneurial mindset," expresses his frustration with the lack of a more assertive definition.

> That is part of my frustration with CFE and we never get across with that notion. So while Thomas, Marc, and I had this conversation early on. We were never able to get that articulated in a sort of a formal you know "this is what entrepreneurship is." So everyone still grab it and define it the way they want it, and I really consider that, a bit of a failure… It is too easy to get off track. (Mr. X., head of Foundation X and CFE donor)

Another important concern for Mr. X, as well as for other key actors, is entrepreneurship education with an exclusive focus on startups. For instance, according to Donald Graham, founder of a multinational manufacturing company, CFE donor, and close advisor to Professor Zurbuchen, the area of greatest impact for CFE would be to promote entrepreneurs within large American corporations, also called intrapreneurs. This has been a difficult area to implement by

CFE. As seen in this case, many activities promoting entrepreneurship among students make the contrast to big multinationals. Influential advisors and donors, such as Mr. X and Donald Graham, are deeply skeptical of the potential of software startups and their focus on service industries. However, they accept the idea of the student startup as a pedagogical tool for creating a proactive, critical thinking, and business sensitive professional.

> Although in my view starting a company is an entrepreneurial act without doubt, entrepreneurialism is much broader. It involves a sense of urgency. It involves an understanding of all of the requirements of getting a product or service to market, and it is entrepreneurial thinking what is, for a lot of reasons, lacking in corporations… If [at UM] we can help people have entrepreneurial thinking to contribute to teams in large corporations, we would make a lot more impact than will happen through the startups, but the startups are popular... So I think it is very important we satisfy demand with little service businesses, internet oriented startups, have incubators, have all the things to compete, but I also think it is going to have greater impact on economy, on job growth, on wealth of our nation if we enhance the manufacturing sector by providing them people that would make them more entrepreneurial. (Donald Graham, founder of Graham Engineering Company and CFE donor)

As already discussed earlier in this section, students have also struggled with the framing of entrepreneurship. The struggle was also present in January 2014 in a mass meeting for discussing the university-wide entrepreneurship program organized by CSG and Professor Zurbuchen. Students in that meeting, mostly student leaders, worried about how to communicate entrepreneurship, in particular, to those students who have not been engaged yet. Many agreed that it is a mistake to strongly associate entrepreneurship with the idea of "the next Facebook" or with technology based ventures. Some students expressed that entrepreneurship should be carefully defined in order to be more inclusive of the diversity of the UM student body. Professor Zurbuchen seemed aware of these concerns. He started the session acknowledging that the association of entrepreneurship to startups as "two guys in a basement" is narrow view, even a view that is gender-biased. Professor Zurbuchen offered instead to conceive entrepreneurship as a methodology of doing things to address the most important world's challenges. This

methodology would have three basic steps, finding problems and opportunities, figuring out a solution, and taking action.

Professor Zurbuchen, who has undoubtedly been the champion for entrepreneurship since 2007, is not intellectually committed to the word "entrepreneurship." He takes a more pragmatic approach to the definition problem. Spending more time in discussing and defining entrepreneurship than in action would have been a mistake, Professor Zurbuchen suggests. He expects that by setting a campus wide program the definition will be set by de facto rather than by an intellectual definition.

> I have worried often whether the word entrepreneurship is even the right one because to a certain extent the definitional problems come from there. You open any newspaper today and you'll find entrepreneurship in more than one location, and in different contexts. So basically to a certain extent it is the word that's a problem... We had massive disagreements early on because basically the Business School thought entrepreneurship is just starting businesses; that is not the case anymore. It is over…Are we together yet? No, we're not entirely but the range has decreased so we're moving in the right direction. My point is the moment we set up the program, we will by de facto define it. Here are the disciplines you need to know to be an entrepreneur. That's what we're struggling with right now. (Thomas Zurbuchen, CoE Associate Dean for Entrepreneurship, and UM Senior Counselor of Entrepreneurship Education)

Indeed, the word entrepreneurship became too problematic for a campus-wide initiative. As it would be discussed in the last part of this section, when the new initiative was launched, the chosen name was Innovate Blue. Entrepreneurship was dropped from the title. Part of Innovative Blue's vision states, "we support both individual creativity and multi-disciplinary teams in tackling the world's most pressing challenges and opportunities, taking full advantage of an academic and experiential space that promotes safe risk-taking and advances entrepreneurial innovation" (Innovate Blue, n.d.).

Circulating Back to Engineering

CFE has been a catalyst for almost all the events described in this stage. Its energetic and entrepreneurial staff members mobilized multiple initiatives across campus and were good at announcing their success. In many news and public events, CFE staff offered impressive participation numbers and entrepreneurial initiatives. Despite the proclaimed success, there was a relentless motivation for continuing to attract students to their programs and creating new educational opportunities. The following two initiatives exemplify this spirit. On December 3, 2012, CFE inaugurated a second office in the Shapiro Undergraduate Library, on central campus. The office which is more similar to a flexible meeting space, opened on the first floor of the library, one of the floors with the largest student traffic in UM. The funds were provided by Provost Martha Pollack (Freed, November 29, 2012). The space was open to all students. Open chats with Professor Zurbuchen or advising and mentoring meetings are often held at the space. All CFE staff continued working in the main office in North Campus, but many of them make several trips per week to the office at Shapiro and to the downtown offices of TechArb. With the addition of this space on central campus, CFE also became, now geographically, the central node for entrepreneurship. The second initiative is the launch of the master's of entrepreneurship. The master's degree was approved by the UM regents in July 2011. The master's of entrepreneurship was launched as a joint venture between CoE and Ross and received its first cohort in Fall 2012. Its co-directors are Aileen Huang-Saad, from CoE, and Williams Lovejoy, from Ross. The master's main selling point is that it is hosted by two leading business and engineering schools in the nation.

During this period of consolidation, CFE has also been publicly recognized. In December, 2012, Marc Weiser, CFE advisory board member, received the 2012 CoE Alumni

Distinguished Service Award. The CoE recognized his multiple contributions in the emergence of CFE and other multiple entrepreneurial initiatives. In June 2013, Aileen Huang-Saad was appointed as Associate Professor of Engineering Practice for her "efforts to enhance the connection between the [CoE] and the world of engineering and entrepreneurial practice" (Goldstein, July 1, 2013). Huang-Saad played a central role in translating practices and ideas of the entrepreneurial world into the constrained domain of the engineering curriculum. The title of Associate Professor of Engineering Practice is a non-tenure clinical appointment and was approved by Provost Hanlon. Huang-Saad was the fifth person to receive this title. Among the other four are a former U.S. Secretary of the Navy and a former General Motors vice president for research and development.

This was also a period of change for CFE. In May 2013, Doug Neal, CFE executive director, left CFE to assume a full time position in his new co-founded Ann Arbor venture capital fund, Michigan eLab. Among Neal's partners is Rick Bolander, CFE advisory board member. Neal and Michigan eLab would continue a close relationship with CoE and CFE. Tom Frank, an entrepreneurial executive with experience in the advertising and entertainment industries, would become the new executive director. Another critical event was the appointment of Professor Zurbuchen as university Senior Counselor for Entrepreneurial Education, an appointment assigned by Provost Martha Pollack. The goal of this two year appointment is to conceive a campus-wide entrepreneurship program and the coordinate the large number of entrepreneurial initiatives around campus. Regarding his new role, Professor Zurbuchen said, "A lot of this, we won't have to build. We just need to bundle. Entrepreneurial activities have grown tremendously here over the past decade. This isn't a top-down effort. This energy is coming

mostly from the bottom up, and that's how revolutions happen" (Moore, November 4, 2013). In March 2014, Professor Zurbuchen launched Innovate Blue.

To some extent Innovate Blue is a spin-off of CFE. Now, Innovate Blue will have the mission of promoting entrepreneurship across UM at the undergraduate level. Until this point, CFE, from engineering, coordinated and supported many of the entrepreneurial initiatives around campus. For Innovate Blue, it seems difficult to rapidly replace CFE in that role. According to Amy Klinke, this coordinating entity was necessary for avoiding duplication and improving the overall entrepreneurial system, a role that today has by been played CFE. However, Klinke foresees important threats. Professor Zurbuchen's appointment is temporary as well as his new office. That lack of institutionalization adds confusion to the system. On the other hand, she understands that "fuzziness" is what makes an entrepreneurial program entrepreneurial

> Right now, I think everybody comes to the CFE, as their first place, and that's fine. They probably should go to Innovate Blue, this new thing. I think it is really confusing so I'd like it to get crystallized and a little more formalized. It is hard because you want to be formalized but you want to have enough gray area that we're not too institutionalized at the university. Like you have to have a balance. The fuzzy fry pan of starting the company because there's not really a right way to do it. I think the fuzziness makes it really important to keep us out of, like to stop slowing us down (Amy Klinke, CFE Assistant Director for Small Business Initiatives)

In this period, the CoE's focus on entrepreneurship education drifted away from engineering but eventually returned to engineering and the original intent to emphasize technological startups among faculty and graduate students. To some extent, throughout these four periods, the case has walked a full circle, as suggested by Dean Munson. With Professor Zurbuchen, an engineer in the UM central administration, and Innovate Blue focusing on undergraduate education, CFE would be liberated from part of its responsibilities regarding undergraduate entrepreneurship education. Now commercialization of research could be embraced with more emphasis. Moreover, now that the case comes to a full circle, the institution

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and the surrounding community have changed. The CoE and UM are pro-entrepreneurial

environments, with multiplicity of resources available for student, faculty, and external actors

interested in starting new ventures or in the commercialization of ideas. Now, seems the time for

the next level.

> What I expect to see happening, in fact, a lot of that underground focus moving from the current CFE to the campus-wide program. And already that is allowing the Center for Entrepreneurship to put more focus on our graduate students and faculty in commercialization of the basic research that we do in the College of Engineering. In a sense we're coming full circle; we're now coming back to some of my original motivation for even pushing entrepreneurship as thrust within the college because the kinds of programs that CFE has been working on recently are programs that very much would have benefited me… And now I think we have way more help available for that than existed previously. (David Munson, Dean of the College of Engineering)

Chapter 5: The Case of E^3 as an Intellectual Movement

The case study asks how contextual factors and the collective actions of actors internal and external to a university affected change in its undergraduate engineering curriculum. Entrepreneurism is not an ABET learning outcome but instead is a type of expertise that groups of students, faculty, administrators, alumni, donors, and other external constituencies believe ought to be included within the CoE engineering curriculum. Thus, the case represents a unique opportunity to understand how curricular ideas are framed and debated and how the collective action of diverse groups of actors inside and outside a university contributes to sustainable change within a college of engineering that are not mandated by a professional association. This and the subsequent chapter use the theories of SIMs and collective action frames, respectively, as conceptual tools to analyze the interactions among key actors and the dynamic and complex process of curricular change.

The case revealed multiple instances of collective action that can indeed be characterized as an intellectual movement. At the most general level, for collective action to be characterized as an intellectual or social movement, the actions must occur outside established institutional channels and challenge the status quo (Snow et al., 2004). In the case of E^3, multiple instances of collective action occurred among students, alumni and business leaders, and a smaller group of faculty and staff. On several occasions, this collective action took no institutionalized routes for achieving its goals. For instance, faculty and alumni interacted with students over weekends and evenings to strategize about innovative programs, curricular activities, or events that would attract more students and faculty to entrepreneurship. In addition, the collective effort slightly

challenged the traditional canon in engineering education and the liberal arts curriculum at the university level. This chapter discusses these and other strategies that external and internal actors used to advocate for E^3 within the CoE, and from there to the whole university, one of the sub-question of this study. These strategies, as well as the characterization of the collective action around E^3 as an intellectual movement, are presented and analyzed through the lens of SIMs (Frickel & Gross, 2005).

Scientific and intellectual movements are most often led by high-status senior scientists and intellectuals and tend to be smaller in size, less revolutionary, and more risk averse than social movements. In keeping with this characterization, E^3 in the CoE was initiated and led by tenured and senior faculty members. Dean Munson made entrepreneurship one of his top priorities from the beginning of his deanship. Professor Thomas Zurbuchen, a nationally recognized astrophysics researcher, became the champion for entrepreneurship education in the CoE and at UM. The core group of actors—in particular the group of faculty who promoted entrepreneurship education in the CoE—was small. However, the number of participants at the student (e.g., MPowered events) and the alumni levels (e.g., Bay Area trips) were relatively large. The main case actors framed the effort to introduce entrepreneurship education as "revolutionary," but the close temporal distance from the case makes it hard to evaluate how revolutionary the activity will be in the college and university contexts. Certainly, during the periods covered by the case study, the curricular changes, in terms of course credits, made in engineering were modest at best. For instance, the program in entrepreneurship was only a nine credit curriculum and no required entrepreneurship course was introduced in undergraduate programs. The E^3 endeavor had a greater impact on the co-curricular domain and on the campus' attitudes towards entrepreneurship. Finally, advocating for E^3 did not represent a significant risk

for its participants, nor were E[3] leaders marginal actors within the academic or social world. For instance, the movement champion, Professor Zurbuchen, who repeatedly used the revolutionary image, acknowledges that the E[3] cause was far from the risk and revolutionary levels of the civil rights movements in higher education. Nevertheless, Professor Zurbuchen did take a certain intellectual risk when he moved his professional focus from research to the promotion of entrepreneurship. For some students, the commitment to the movement, they thought, resulted in lower grades, but most of the student leaders were celebrated and admired by their peers. In summary, these points suggest it is appropriate to treat the E[3] effort in the CoE an intellectual movement. The discussion turns now to a more nuanced analysis of the strategies used by external and internal actors in the E[3] movement. To organize the discussion, the four propositions of the SIMs perspective were adapted (see Chapter 2). At the end of the chapter, the tension of interpreting the E[3] movement as a grassroots initiative or as a movement orchestrated from the top will be analyzed.

Leadership Strategies

The first proposition asserts that SIMs are initiated when high status intellectuals or scientists complain about the central intellectual tendencies of the day. In the case of E[3], *the movement emerged when high status and tenured faculty harbored a new vision for engineering education without rejecting the traditional curriculum.* An important difference from the SIMs theory is that both Dean Munson and Professor Zurbuchen did not publically criticize the core educational practices of engineering education or previous CoE administrations; they offered a new perspective without rejecting the existing ones. Even though their vision contained novel components that opposed traditional engineering education, these differences were subtly presented. For Dean Munson, commercialization of research was a primary concern, even before

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his interest in entrepreneurship education. Dean Munson's views regarding the commercialization of research as an alternative way of producing social impact resembles, what Szelényi and Bresonis (2014) have called, an accelerated form of creating public good. In Dean Munson's view, commercialized research need not become the main focus of engineering faculty, but the CoE must facilitate it when possible. This offers no fundamental criticism of the current state of CoE research.

Professor Zurbuchen, on the other hand, presents a more critical view of academic work than Dean Munson. Professor Zurbuchen criticizes the disciplinary structures of universities, usually depicted as silos. He believes that university research silos replicate themselves in narrow curricula, where faculty have extreme control over the content. This critical perspective, however, did not explicitly appear in his discourse as he promoted entrepreneurship education. In other words, he did not use his leadership platform to criticize the institution or the research and teaching systems. Ultimately, the main message seems to be that entrepreneurship education should be added as a new methodological tool or as a complement to established university curricula. In other words, Professor Zurbuchen promoted curricular change through accretion rather than through a substantial alteration of existing curricular structures (Lattuca & Stark, 2009). In sum, although the E^3 movement leaders portrayed entrepreneurship education as a revolutionary curricular force that would transform institutional attitudes and students' experience, E^3 was presented as harmless to the central tenets and canons of current engineering education.

In terms of key actions, Dean Munson included establishing a task force led by Professor Zurbuchen, assigning resources for the first entrepreneurship initiatives, appointing Professor Zurbuchen as an associate dean for entrepreneurship, and introducing entrepreneurship as a

factor to be considered in the grant of tenure and promotions. Professor Zurbuchen championed entrepreneurship education in the CoE and across UM. His leadership style facilitated the emergence of the E^3 movement by empowering multiple actors, especially students. He became a close ally and advisor for several student organizations. He also invited multiple alumni and donors to invest in the movement and share their perspectives and knowledge. On many occasions, Professor Zurbuchen challenged institutional norms; for example, he opened the CFE programs to all UM students and pushed for alternative advancement strategies.

<p style="text-align:center">Access to Key Resources</p>

The second proposition derived from SIMs theory is *structural conditions gave the E^3 movement access to key resources that fostered its emergence and success*. The emergence of E^3 in the CoE had to be coordinated and produced. In this sense, the case fits within the definition of the SIMs theory. According to Frinkel and Gross (2005), intellectual movements are partially the creation of "savvy political strategists" (p. 213) who assess the opportunities available in their context. The E^3 leaders were able to obtain rapid access to significant resources and to take advantage of several structural conditions at the institutional level. Dean Munson realized very early on the potential of the CoE alumni network, in particular, those alumni advocating for more entrepreneurship opportunities at UM. "There was an energy ready to be tapped," Dean Munson said. Pro-entrepreneurship alumni were suddenly aligned with the CoE's strategic priorities. Professor Zurbuchen also took advantage of those networks, before he was fully familiar with the concept of entrepreneurship. He had mobilized industry resources and talent when he reformed the master's in space engineering program (Zurbuchen, 2007).

When Professor Zurbuchen took the leadership of the E^3 movement, a significant gift allowed an ambitious plan for promoting entrepreneurship at the grassroots level. Interestingly,

this gift did not come from a CoE alumnus, but was made possible through the social network of

Marc Weiser, a CoE graduate, venture capitalist, and key E^3 advocate. This initial gift enabled

the establishment of CFE and the personnel and institutional structures that would attract more

gifts and resources to the movement. Certainly, entrepreneurship education was an appealing

theme for donors, but soliciting their gifts required intense work and negotiation.

The negotiations with the CoE advancement unit were intense. The startup mode of

operating infused by Professor Zurbuchen and maintained by CFE's staff was key for capturing

more resources. CFE effectively obtained federal and state resources, as in the case of the I-Corp

program. In addition to CFE, the resources acquired by key actors and allocated by the Dean

supported expensive courses, co-curricular activities, student startups, and student organizations.

Equally significant is the fact that, because these actions were financed with mostly fresh

resources, no CoE department or academic unit viewed these activities as a financial threat thus

avoiding the potential for conflict in that regard. These fresh resources make the accretion

approach to curricular change sustainable, as long as the E^3 resources are not exhausted.

Structural conditions at UM, the city of Ann Arbor, and in the state of Michigan also

allowed the rapid emergence of E^3. The movement leaders effectively assessed these conditions.

For instance, the presidency of Mary Sue Coleman and the appointment of Steve Forrest as Vice

President for Research, created a strong push for the commercialization of research and a close

engagement with business leaders in Ann Arbor and the state. Dean Munson, realizing this

institutional focus, decided to mobilize CoE resources towards entrepreneurship education. This

decision emphasized the educational potential of entrepreneurship. At the curricular level, certain

key structural conditions allowed the creation of the program in entrepreneurship with very little

resistance. The CoE moved from 2000 on towards a more flexible engineering curriculum with

more space for elective courses. This space enabled the creation of three new programs, entrepreneurship among them, hosted at the college level. Thus, there was no need of engaging in intense negotiation with the CoE departments about the addition of these new programs.

When the CoE started its entrepreneurial initiatives, several resources existed at the national level, including educational networks around the topic. The most significant network in terms of number of members and resources was NCIIA. However, despite the availability of these experiences and resources, the CoE movement drew only marginally from them. None of the CoE movement leaders mentioned any of these networks as a relevant influence in shaping developments in the CoE. Neither were they used as a means of academic legitimization. The contacts with these networks were rather sporadic. CFE Associate Director for Academic Programs, Aileen Huang-Saad participated periodically in NCIIA and in the Entrepreneurship Division at ASEE. There were a few papers presenting part of the Michigan curriculum in these conferences, and certainly some ideas were exchanged; NCIIA funded some UM student startups and courses. CFE executive director Doug Neal also participated in the Global Venture Lab Network, a small network of engineering schools hosted at Berkeley. This network produced a report that shared good practices around entrepreneurship education. In sum, the CoE participated in these networks, but these networks appeared to not be key influences in the E^3 movement.

Another vital resource for SIMs is intellectual prestige, a key driver for individuals in academic contexts (Frickel & Gross, 2005). The prospect of additional prestige, or keeping the prestige already achieved, is part of what mobilizes movement participants. This is usually viewed as the acknowledgment of academic peers and the consolidation of the movement as a new prestigious field. In the case of the E^3 movement, however, intellectual prestige was not its

key leaders' main motivation. Furthermore, intellectual prestige was put somewhat at risk. The E^3 movement in the CoE was not framed as an academic endeavor. There were no significant intellectual materials being published nor was there an evaluation or assessment of the programs. This is an important point: the movement validation was not intellectual and its leaders did not seek an intellectual position in the entrepreneurship education world. For instance, no book or theoretical paper was produced by Professor Zurbuchen or other key CoE faculty. Nevertheless, in the social context, even including mass media, entrepreneurship was celebrated. Faculty, staff, and students were praised for their entrepreneurial efforts. They received wide media coverage and were applauded by powerful politicians and business leaders. For instance, several case study participants reported being motivated by the frequent interaction with high-status CFE advisory board members. In short, *social* prestige was a much more important source of motivation for movement leaders than *intellectual* prestige.

Access to Micromobilization Contexts

A third proposition is that *various micromobilization contexts allowed the movement's rapid rise and growth*. The recruitment of new members is a crucial task for intellectual and social movements. The movement literature calls those sites where movement participants interact frequently with potential new members micromobilization contexts (McAdam et al., 1988). In the case of SIMs, micromobilization contexts range from informal research groups, to conferences and classrooms, to complex and expensive structures, such as research labs and departments. Multiple micromobilization sites were fundamental in the emergence of E^3. Their role cannot be overstated. From the very beginning, the movement leaders came to the conclusion that organizational change would come from a grassroots approach and that this approach would succeed if many actors interact.

To some extent, the importance that the E^3 movement leaders gave to micromobilization sites is not surprising. The master frame in entrepreneurship asserts that entrepreneurship happens through sustained interactions among entrepreneurs, investors, and highly skilled workers. Entrepreneurial ecosystems are almost by definition complex networks of sites through which individuals and ideas move fluidly. Creating an entrepreneurial ecosystem was even suggested as the key strategy by the CEEPS report, at the beginning of the movement. Entrepreneurs, or at least a portion of them, are expert mobilization site builders.

While multiple examples of micromobilization contexts characterize the E^3 case, four were particularly important. They represent different organizational levels, from the more simple and episodic to the most complex and permanent contexts. The 2005 event with university authorities, faculty, and venture capitalists organized by Marc Weiser presents a good example of the meet-and-mingle events that would become a routine practice at UM. The setting of these events is designed to maximize interaction—for example, having tall rounded tables and speed-date types of introductions or short entrepreneurial pitches. The 2005 event was particularly important because it allowed UM members were starting to be more exposed to venture capitalists and their style. At the same time, venture capitalists were able to meet and interact with faculty members willing to engage in entrepreneurial talk.

The Bay Area trips formed another key micromobilization context for enervating the network of UM alumni in Silicon Valley and connecting them to the E^3 movement. Many actors, such as attorney Jeffrey Schox, became intensely committed to entrepreneurship education at UM. Silicon Valley's "human routers" used these trips as an opportunity for engaging more actors. For instance, the CEO of Twitter and UM alumni, Dick Costolo, hosted a company tour on one of the trips and subsequently became more involved with his alma mater. Costolo was the

speaker for the UM commencement ceremony of Spring 2013. These trips not only mobilized entrepreneurs on the West Coast, but also mobilized and inspired UM students, staff, and faculty.

The CFE constituted a third example of a micromobilization context that marshaled individuals at multiple levels. CFE employed highly experienced and motivated staff, recruited influential individuals for its advisory board, coordinated a great number of startup mentors, supported other initiatives and units on campus, and most important, engaged increasing numbers of students. A permanent concern for the CFE office is how to attract and welcome more students. All students, regardless of their discipline or level of entrepreneurial inclination, were invited to talk to CFE staff or CFE mentors. The CFE courses were also key recruitment agents. CFE even implemented strategies such as asking students to bring a friend to the program in entrepreneurship in order to participate in a raffle for a diner with a successful entrepreneur. After getting in touch with CFE, several students who became interested in entrepreneurship grew into active participants in the entrepreneurship movement.

The city of Ann Arbor, a fourth example of a micromobilization context, started to emerge as an entrepreneurial site during the time period of this case. In Ann Arbor's downtown, it is easy to find within a few blocks from each other Ann Arbor SPARK, TechArb, Google, several new tech companies, and hacker and co-work spaces. Successful local entrepreneurs, such as Dug Song, frequently organize meetings open to anyone interested in startups. However, for some of the external actors involved in the CoE movement, Ann Arbor is still far behind other entrepreneurial ecosystems, such as Boulder, CO, or Austin, TX, not to mentions the cities of Silicon Valley.

The case study also saw macromobilization events that represent a departure from the SIMs model because of their massive participation. To some extent, these events resemble social

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movement-like actions. The most distinctive massive event was the 1,000 Pitches competition. Even though the competition is a co-curricular initiative, the movement leaders gave it a "cultural agent" dimension. The competition had a social movement feeling and used social movement tactics (Barnhardt, 2014). For instance, during the days of competition, MPowered members installed original booths (e.g., a baseball pitching station) on the campus "diag"—a busy avenue that is the go-to place for student movements and initiatives—encouraging students to pitch their ideas. The competition is also massive, which gives it the aura of a successful campaign. Moreover, the 1,000 Voices movement campaign derived directly from the 1,000 Pitches competition and had a specific target in the LSA College. The guerrilla marketing campaigns of campus startups, such as CampusRoost's 200 chairs spread across UM, also added a social movement aspect to the E^3 movement.

Framing Curricular Ideas that Resonate with Internal and External Actors

Finally, SIMs theory hypothesizes that *movement participants framed the curricular ideas in a way that resonated with both internal and external actors to the university*. The idea of teaching entrepreneurship to engineers was important and affected a large number of constituencies. Movement leaders had the challenge of keeping this interest alive and securing resources. The framing of curricular ideas that resonated with all constituencies was critical to mobilize more individuals and gain wide support. This framing was also important for offsetting or neutralizing opposition to E^3. The next chapter discusses in-depth the framing tasks and strategies used by the E^3 movement. In brief, movement leaders identified problems already well-known in engineering education (e.g., lack of real-world experiences, being left behind the times) and then offered entrepreneurship education as an effective solution. By approaching and labeling the E^3 collective efforts with terms like "grassroots," and even "revolution," movement

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participants created a sense of an exciting community, one in which students and external actors felt called upon to participated. This approach was reinforced by the startup mode of operation adopted by key movement organizations, such as CFE and MPowered.

The startup mode, a relentless style that mobilized students, faculty, and actors external to the university, worked as an attractive motivational frame for E^3 movement participants and prospective ones. One important challenge for the E^3 movement was to construct frames that aligned the views and priorities of multiple constituencies as the movement progressed. Movement leaders amplified the importance of E^3 arguing that entrepreneurship education was a strong interest among students and that entrepreneurship education was an effective response to the challenges of the global economy. Movement leaders also built bridges with the local startup movement in the city of Ann Arbor, and with students interested in social ventures. Finally, the movement expanded its initial focus on startup-creation with the concept of "entrepreneurial mindset." This concept linked distant groups, such as academics concerned with the educational value of E^3, and donors and alumni who saw E^3 as filling an educational need among new industrial cadres.

A Grassroots Initiative or a Movement Orchestrated from the Top?

Consistently with recent evidence of successful curricular changes in engineering education (Graham, 2012), there was strong support for the E^3 movement among individuals in high level administrative positions in the UM. In particular, Professor Zurbuchen was a central figure in the network of E^3 proponents who closely nurtured and engaged in multiple initiatives with student organizations, faculty, alumni, and donors. When individuals such as Zurbuchen seek to mobilize the bases of an organization (e.g., middle managers, professionals, front-line workers) in order to produce organizational change, scholars describe collective action as an

"orchestrated social movement" (Strang & Jung, 2005). This type of orchestration is partially observed through the case study. However, for reasons I explain in the following paragraphs, many actors I interviewed perceived the E^3 movement was a grassroots initiative, not a movement orchestrated from the top. Furthermore, they did not see themselves as part of a pure intellectual movement concerned with the development of a new area of academic inquiry.

Grassroots is a term often associated with non-hierarchical collective actions that operate at the local level and with a seemingly spontaneous growth (McCarthy, 1987). In the context of higher education Kezar, Gallan, and Lester (2011) define grassroots leadership as those who work to create change, operate from the bottom of the organizational bureaucracy, lack formal authority, and create change outside institutional channels. In the case of the E^3 movement, Dean Munson and Professor Zurbuchen (those with formal authority) as well as groups of alumni and students (those with no formal authority) sought to mobilize alumni and students and CoE administrators. The simultaneous push for E^3 by external and internal actors' gave to the CoE movement the feeling of a non-hierarchical initiative. Moreover, several key organizations were created independent of CFE or Professor Zurbuchen and actions occurred that were not in keeping with CFE or Professor Zurbuchen's initial intentions. For instance, TechArb, the student-run accelerator, was planned and led by CoE students and supported by a local venture capital firm. In other instances, student organization triumphed over CFE preferences. Such was the case when MPowered decided to limit its startup fair to tech startups, excluding local small businesses. Similarly, even though CFE sponsored the first hackathon in 2011, the hackathon event was redefined when Michigan Hackers, a student group inspired by a hackathon at the University of Pennsylvania, organized the first MHacks in 2013. Furthermore, when the E^3 movement branched out from engineering, the network of actors was so large that it was not

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possible for CFE or any other unit to organize and control the movement. This sentiment was reflected in the concerns about coordinating the E^3 movement expressed by several individuals interviewed in this case study. Finally, as shown in the micromobilization section, the movement operated with a focus on Ann Arbor and the state and with strong ties to Michigan business leaders. This includes the Silicon Valley group and its interest in UM and the state.

Zald (1987) notes that the distinction between grassroots and more elaborated forms of organizations is increasingly blurred in contemporary society. E^3 movement actors perceived themselves as part of a grassroots initiative and the E^3 movement displayed many characteristics of a grassroots initiative. Whether the E^3 movement qualifies theoretically as an actual grassroots initiative is not relevant for purposes of this study. What matters is that the actors perceived that they were part of a movement and this identification with the initiative appears to be a key element which motivated their participation.

Summary

SIMs theory was developed to understand the emergence of new scientific and intellectual fields. Indeed, the emergence of entrepreneurship as a research area has been conceptualized as a case of SIMs elsewhere (Aldrich, 2012). Even though the emergence of new fields has implications for curricular change in higher education, the SIMs theory is not intended to explain changes at the institutional level or in curricular contexts. As the case study suggests, E^3 advocates were not concerned with promoting entrepreneurship as a research field. Their focus was on entrepreneurship education. Nevertheless, curricular changes are, after all, an intellectual endeavor. The SIMs theoretical propositions effectively help to explain the evolution of E^3 on the UM campus. The high status leaders of the movement, in particular Dean Munson

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and Professor Zurbuchen, promoted a new vision for engineering education without rejecting the traditional curriculum. This perspective prompted an approach to curricular change based on a strategy of accretion rather than on the replacement of existing curricular structures. In order to add on to the curriculum, E^3 leaders had to obtain access to key resources that allowed its emergence and success. Among the main resources were monetary gifts from donors and active engagement with the city of Ann Arbor and the state of Michigan political and business leaders. Various micromobilization contexts, such as the Bay Area trips and CFE, facilitated the movement's rapid rise and growth. Massive events, such as the 1,000 Pitches competition added a social movement aura to E^3. The movement participants also framed the curricular ideas in a way that aligned with the goals of actors both internal and external to the university. This last strategy is discussed in depth in the following chapter.

Chapter 6: Collective Action Framing Tasks and Framing Strategies in the Movement for Entrepreneurship Education in Engineering

This chapter addresses the final two research sub-questions: "What framing strategies were used by the external and internal actors to promote E^3 and how did these strategies change over time?" and "How do the frames of the E^3 idea created at the local level relate to those at the national level?" The collective action frame theory (Benford & Snow, 2000) is used to examine the case and address these questions. First, the relationship between the movement and the master frame of entrepreneurship in society is analyzed, since it emerged as a salient theme throughout the interviews with the case study actors. Second, the main diagnostic, prognostic, and motivation frames developed by movement leaders and participants are presented. Third, the movement's key framing alignment strategies are discussed: frame amplification, frame bridging, and frame extension. In particular, the frame extension process of broadening the concept of entrepreneurship education from startup-creation to the idea of entrepreneurial mindset is discussed in greater detail. This framing strategy was the most important in explaining the success of the E^3 movement in rapidly mobilizing people and other resources. Finally, the critical changes in the E^3 movement frames are summarized.

Entrepreneurship, a Master Frame of Our Times

Most of the E^3 key actors noted how a general social celebration of entrepreneurship buoyed efforts in the CoE and at UM. For instance, a commonly shared theme is that the Millennials, those born around the 1990s (Deresiewicz, November 12, 2011), come to college

with an entrepreneurial spirit that differs from that of previous cohorts. Many E^3 movement leaders would agree with Deresiewicz's (November 12, 2011) synthesis of this generational ethos, "Today's ideal social form is not the commune or the movement or even the individual creator as such; it's the small business. Every artistic or moral aspiration—music, food, good works, what have you—is expressed in those terms." In social movement terms, the master frame of entrepreneurship operates thus as a cultural symbol that several collective frames share, from social entrepreneurship to web application startups to high tech ventures. Entrepreneurship as a master frame is expressed through a wide range of ideas applied in multiple contexts. Snow and Benford (1992) call these *elaborated master frames,* which "allow for extensive ideational amplification and extension" (p. 140). Consequently with this definition, many E^3 actors attributed to the master frame of entrepreneurship several of the ideas discussed and promoted at the CoE.

The master frame of entrepreneurship is also strongly present in popular culture. For instance, several E^3 actors also pointed to the movie *The Social Network* as a cultural event that influenced current cohorts of college students. The example of the Harvard undergraduate students who created Facebook and transformed the way people communicate influence what students believe is possible during their college years. According to those involved in advancing E^3, many new students at UM arrive on campus with entrepreneurial experiences or expect to have them while in college. Nevertheless, interviewees acknowledged that students did not automatically appear at entrepreneurship education events. A collective effort was necessary to translate the societal excitement about entrepreneurship into an academic and the mainstream topic in the CoE first and then across UM. Part of these creative efforts involved framing the

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curricular ideas in a way that resonated not only with students but also with other internal actors, as well as with external actors to the university.

Framing Tasks

Diagnostic frames: Defining What is Wrong with Traditional Engineering Education

In the context of the E^3 movement at UM, diagnostic frames are the action-oriented beliefs, metaphors, and symbols that activists used to explain the need for entrepreneurship education, the problem with the engineering curriculum, and who deserved blame or responsibility for this problem. The most commonly used diagnostic frame was that the *CoE curriculum lacked real world experiences*. As Jason Bornhorst, a CoE student leader and founder of TechArb, says, UM "has always been really-really theoretical. And you actually go into a startup or young company or innovative company and none of that day-to-day resembles anything you do in class, unfortunately." As an example, Bornhorst points out that most CoE courses teach programming using the C++ language, a general or theoretical programming tool, while other peer institutions focus on languages commonly used for operational system such as iOS, characteristic of most Apple products. Similarly, most E^3 actors described engineering education as oriented to solving well-defined problems that differ from the ambiguous problems faced in the workplace, particularly in entrepreneurial contexts. When E^3 activists used this frame, they used a diagnostic frame familiar to the engineering education world (Sheppard et al., 2009). Typically, the research system and the research orientation of faculty receive blame for the lack of real-world experiences in engineering education. To be fair, interviewees who mentioned this issue also acknowledged that the CoE's rigorous theoretical approach to teaching

developed valuable analytical skills in engineering students. What they wanted is a balanced educational approach.

A second shared diagnostic was that *the CoE was being left behind the times,* a theme directly connected to the master frame. Peer institutions were well ahead of Michigan when the movement started at the CoE. Stanford and MIT were the most notable examples. Certainly, this frame tapped into the competitive nature of research universities and their propensity for demonstrating compliance with the standards of their peers (Arnold, 2004; DiMaggio & Powell, 1983). This said, the idea of an industry working under a new paradigm was also part of the diagnostic. For instance, Steve Carnevale, a CoE alumnus and venture capitalist, suggests that UM needed "catching up" with Silicon Valley's approaches to innovation and economic success. Similar diagnoses were made regarding the entrepreneurial skills needed in new high tech companies, from aerospace engineering to biomedical engineering.

A third recurrent diagnostic was the *CoE's collective conformism with the automotive industry's* high demand for engineers. Students perceived positions in large companies—such as the "big three" of General Motors, Ford, and Chrysler—as well paid and safe. What E^3 movement activists suggested is that students were coming to the CoE aware of a comfortable career path waiting for them after graduation. This perception would have inclined students towards a narrow specialization. Some participants, such as Professor Thomas Kinnear, ZLI founding Executive Director, suggested that the strong tie between UM and the big automotive companies was one of the fundamental reasons for the UM's delay in embracing entrepreneurship education. When the big three sank into a crisis circa 2007, those promising jobs became less attractive and safe than they once had been. Michigan students came into close contact with the economic recession as their families and neighbors were impacted by the crises.

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It was suggested that everybody knew someone laid off from one of the big companies in the state. Since a majority of CoE undergraduates were Michigan residents, this situation produced a new generation of students who were more sensitive about and engaged with their careers. This is perhaps why Professor Zurbuchen noticed that CoE students identified more with the stories of Michigan entrepreneurs, individuals who were closer to their experience and showed an alternative path for Michigan engineers.

Prognostic Frames: Entrepreneurship Education as a Solution

Movement leaders not only develop diagnostic frames, they must also present solutions to problems, or prognostic frames. At the most highest level, entrepreneurship education was the E^3 movement's solution to the problem of equipping students for the new realities of the workplace—making them competitive in the job market. However, entrepreneurship education can be conceived in multiple ways (Katz, 2003; Kuratko, 2005; Mars, 2007). In the case of E^3, the movement actors elaborated three main prognostic frames and each one shaped the academic plan around entrepreneurship in the CoE. One of the earliest ideas was that *students had to be exposed to entrepreneurship in order to increase their interest in it.* Interestingly, this solution was not framed as teaching entrepreneurship to all CoE students. The solution was presented in probabilistic terms. The chances of becoming exposed to entrepreneurship had to be high. Thus, the debate did not center on obtaining curricular credits, a historically hard task in the CoE and in engineering education in general. Instead the initial idea was to increase the likelihood of attracting large numbers of students by building an entrepreneurial ecosystem consisting of a strong co-curricular venue, engagement with the local entrepreneurial community, and a nine-credit certificate.

It is important to note that the CoE had a cadre of graduates who became successful entrepreneurs but had studied at a CoE without entrepreneurship programs. Most movement participants pointed out that by virtue of the talent attracted by the CoE and the size of its student body, chances were that a proportion of the CoE alumni would always become successful entrepreneurs. The new entrepreneurship education program should increase that proportion and create greater impact. Ultimately, this idea was translated into recruiting numerous practitioner entrepreneurs as instructors and mentors, organizing an intensive talk-series, and supporting student initiatives with the potential of large-scale participation and high visibility.

A second component of the movement solution was to take *a multidisciplinary approach to teaching entrepreneurship*. This component had key implications for the entrepreneurial academic plan and in the CoE movement's growth. All the E^3 actors interviewed in this study agreed that entrepreneurship is a multidisciplinary endeavor. Therefore, teaching entrepreneurship to engineers had to include several disciplines. Opening the CFE courses to all UM undergraduates was an early statement that CFE was taking a broad and inclusive approach. Even the exclusion of the word "engineering" from the center's name was intended to symbolize this openness. Movement leaders framed the movement in contrast to Ross's approach, which focused on graduate and business students. This framing diffused across the university. For instance, the SPH required multidisciplinary teams in their entrepreneurship competition. Furthermore, ZLI at Ross became a strategic ally with CFE in key initiatives such as the master's degree in entrepreneurship and the student startup accelerator TechArb. The idea that entrepreneurship education leverages UM's multiple top-ranked schools was vital and consistent with other efforts in the CoE undergraduate degree programs to include multidisciplinary perspectives, such as the Multidisciplinary Design Program. The one caveat of this prognostic

frame was that technology entrepreneurship requires, almost by default, a role for engineers in most startups. In fact, some of the discussions the researcher observed in conferences and seminars among non-engineering students concerned how to attract engineering students to their projects. To some extent, the engineers who led the E^3 movement were confident that no matter how they promoted entrepreneurship, an engineer would be at the core of any technological venture.

A third common prognostic frame was that *entrepreneurship education is a learning-by-doing experience.* E^3 movement faculty, entrepreneurs, venture capitalists and students agree that entrepreneurship education implies action. Typically, this action involves prototyping, implementing student initiatives within the university, and interactions with customers and investors. In particular, external actors emphasized the interactions with customers as the cornerstone experiences for students. For instance, the certificate program in entrepreneurship includes a required practicum class in which students interact with customers to test and commercialize their ideas or projects. The constant pitching of ideas before juries, investors, mentors, and peers, was also framed as another cornerstone of the learning experience. What sets apart this pitching practice is the effort and time that students and mentors invest in polishing pitches through frequent presentations and feedback.

Motivational Frames: Start Me Up CoE

Movement leaders must present a rationale that motivates others to engage in collective action, address diagnosed issues, and implement solutions. It is worth noting that social movement research describes what motivates an individual to join movements as a complex and multifaceted phenomenon (Diani, 2004; Klandermans, 2004). This study was not designed to understand the motivations of participants. However, it was possible to identify three shared

frames that key actors used to explain why they joined the E^3 movement. First, there was the notion of *being part of the community excitement.* This frame was inextricably linked to the master frame. The current culture and economy calls for entrepreneurs. The movement took great advantage of that calling. CFE members and MPowered leaders mentioned that in the early days they wanted to build excitement. Community excitement attracts people. Many participants recalled they joined the movement because they felt they had to be part of a community that was doing something important, something that would make a difference in the CoE, UM, and in the region. Mass events transmitted this motivational frame, as with the 1,000 Pitches competition, and through other activities across campus where the idea of being part of a "revolutionary movement" was constantly reinforced.

Second, Professor Zurbuchen highlighted the idea that *CFE and other UM entrepreneurial units must look and behave as a startup* (Zurbuchen, 2010). In the case context, this meant that CFE not only promoted entrepreneurship but also was an entrepreneurial organization itself. Chapter 4 describes this frame as the startup mode. MPowered also made this frame part of its organizational culture. This frame was important because it communicated the idea that working in startups was not the only way of practicing entrepreneurship. Students, staff, or faculty associated with CFE and MPowered saw themselves as part of startups. This framing helped build a motivated organizational base that promoted entrepreneurship education. If most of the engaged movement students had been busy building their startups, the E^3 movement might not have grown as it did. This motivational frame also helped develop congruency between the E^3 movement's articulated beliefs, claims and actions, which is a fundamental factor in augmenting the degree of resonance of movement frames (Benford & Snow, 2000).

The third motivational frame communicated that *entrepreneurship at the CoE and UM was a source of inspiration.* "Imagine how things could be different," "improve people's lives," and "changing the world" were phrases movement participants typically used to talk about entrepreneurship and its potential social impact. On the one hand, this was an idealistic call for engineering students: it was not about making profits; it was about changing the way people live. Certainly, the master frame and the instances of college students building companies such as Facebook reinforced this message. On the other hand, external actors believed in UM students' potential. Seeing how students grow and start their own businesses inspired those actors. Nevertheless, many participants also believed that what is missing for UM to achieve the next entrepreneurial level is a local highly successful startup, such as Twitter or Google, the type of company that would bring greater inspirations for students and locals as well as capital for making more entrepreneurial dreams a reality.

Framing Strategic Processes of Alignment

Framing strategic processes are used to align movement leaders with key resource providers (e.g., donors, students, UM authorities, local media, and federal agencies). The difference between framing tasks and framing strategic processes is that the tasks define the movement issues while the processes are mechanisms that connect the issues with other groups' interests and problems. This may involve connecting or merging the movement with other collective action initiatives. Framing strategic processes also facilitate dynamic interactions between movement participants, resource providers, authorities, bystanders, and antagonists. The E^3 case study shows that the strategic processes of amplification, bridging, and extension were constantly used by the E^3 movement leaders and participants. In particular, the strategic process

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of extension was fundamental for increasing the support and power of the movement in the CoE and at UM. In the aggregate, these strategic processes show the complexities of promoting curricular change at a university such as UM.

Frame Amplification: Students' Demand and Global Economy

Frame amplification occurs when movement leaders stress the urgency of a particular issue. In the E^3 case, this was a common framing process. Two core amplification frames were identified. The most salient frame was the idea that *students demand entrepreneurship education*. In fact, before 2007 there were more engineering students interested in entrepreneurship than spaces available for them in entrepreneurial courses in the CoE and in Ross. Movement actors highlighted this demand and leveraged it through several mechanisms. For instance, the first CEEPS action was to survey the students and to circulate the findings. When the first CFE courses were taught and student activities launched, every student was counted; even those with modest participation were added to the list. For instance, the 1,000 Pitches competitions added, in just a few months, thousands of students to the movement lists. The one-credit Friday speaker series seminar also added over a hundred students per semester. Students enrolled in courses or organizations with some degree of entrepreneurial content were also taken into account. As a result, the number of students participating in entrepreneurial education increased rapidly. Those numbers were constantly repeated in news articles, blogs, reports, and campus events. In 2010, movement leaders spoke of over 5,000 students involved in entrepreneurship education at UM. The certificate program in entrepreneurship enrolled hundreds of students every semester, but no more than a third completed the required nine credits. Not surprisingly, this number was not found in published articles or talks and discussions that the researcher observed. According to those interviewed in this study, CFE's capacity to "advertise" those numbers was part of the

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rapid success of E^3. The question here is not whether the demand was as significant as the movement leaders claimed but, rather, how the idea of student participation was used effectively to advocate for more support for entrepreneurship education.

The second commonly used amplification frame was the idea that *entrepreneurship education is a response to the challenges of the global economy*. Initially, this frame connected easily to engineering education. Across the United States, the idea that the national economy and security are at risk due mainly to the rise of engineering in other countries—in particular, the number of engineers in countries such as China or India—was widely shared. E^3 movement leaders amplified the importance of entrepreneurship education by suggesting that in order to compete in this new order, engineering students had to develop a new set of skills attuned to the new century. Entrepreneurial skills are commonly mentioned in this set. For example, Duderstadt's 2005 report, A Roadmap to Michigan's Future, highlighted entrepreneurship as one of the new areas that the CoE should embrace. In the CoE context, this idea was underscored by the collapse of the automotive industry. The perception that there are no secure jobs anymore became a prominent theme among E^3 movement participants. Entrepreneurship was presented as the answer for students seeking more control over their future careers.

Frame Bridging: It is Local and Social

The process of linking two structurally unconnected sets of action-oriented beliefs is called *frame bridging*. Since the master frame of entrepreneurship is socially well-diffused, it is hard to conceptually distinguish where an entrepreneurial set of beliefs begins or ends. The criterion used to identify a bridging frame was whether it connects two different groups of individuals with different leaders and purposes, even though they might share some structural

elements (e.g., belong to the same institution). The E^3 movement successfully linked its efforts to several other initiatives at local and national levels.

The idea of *entrepreneurship as a local movement* was an important framing bridge. The E^3 movement members increasingly stressed the importance of acting locally and creating an entrepreneurial ecosystem with a local shape. This thought connected the E^3 efforts with entrepreneurs and organizations in Ann Arbor and across Michigan. For instance, Amy Kinkle very early on linked CFE with the tech startup movement initiated by Dug Song and others in Ann Arbor, facilitating student integration with the local community. Detroit entrepreneurs Brian Balasia and Dan Gilbert supported MPowered startup fair and MHacks, respectively. Grand Rapids entrepreneur Rick DeVos supported some student startups through his Start Garden venture. These entrepreneurs have cultivated a community around tech startups in their cities, with frequent contact with the E^3 movement.

Attention to the local was reinforced with CFE's emphasis on inviting successful Michigan entrepreneurs to be speakers and mentors who made positive contrasts between Michigan and Silicon Valley. Speakers highlighted the great talent provided by Michigan's universities as a valuable asset, available at a significantly lower cost than in Silicon Valley. In other instances, the manufacturing and innovation legacy of the state was stressed. On some occasions, Professor Zurbuchen suggested that Michigan could become an entrepreneurial hub without the Silicon Valley's unapologetic lack of gender and minority diversity. This local frame made the movement attractive to donors and key supporters around the state. Interestingly, this frame did not seem to erode the permanent support received from the Silicon Valley community, perhaps because many of the Silicon Valley's E^3 actors continue to hold UM and the state of Michigan in high regard.

A second important bridging frame was the belief that *entrepreneurship education shares core principles with social entrepreneurship.* Interestingly, social entrepreneurship never became a strong concept at UM. The phrase coined instead was social innovation. Part of the reasons was that very early on, the E^3 movement clearly articulated that its idea of entrepreneurship was not restricted to for-profit ventures. Movement leaders knew that for many engineering students, social or world problems were more attractive than marketplace opportunities. The core idea was that the same entrepreneurial principles applied to both for profit and non-profit ventures. This framing held together students, faculty and staff interested in startups and those interested in socially oriented initiatives. In fact, many competitions, such as 1,000 Pitches, included socially oriented categories, or social projects. This frame may also have emerged because of practical conditions. According to Amy Kinkle, a social worker with years of experience working with the homeless, a specific program could have been built by CFE around social entrepreneurship, but the organizational capacities were not adequate for the effort. The organizational space for social entrepreneurship was taken by OptiMize under the name of "social innovation." However, when OptiMize emerged, the framing bridges with CFE and MPowered were so well developed that collaboration with those organizations naturally emerged and any sign of confrontation was rapidly offset.

Frame Extension: The Idea of an Entrepreneurial Mindset

Frame extension occurs when collective action groups promote ideas that "may not be rooted in existing sentiments or adherent pools" (Snow et al., 1986, p. 472), thereby expanding the boundaries of primary frames. Collective action groups engage in frame extension in order to attract potential members and other resources. The E^3 movement emerged from a group of actors concerned with the commercialization of research at UM. Thus, the original frames of

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entrepreneurship education at the CoE were close to business fundamentals and startup-creation. These original frames were extended with the notion of entrepreneurial mindset. The idea of entrepreneurial mindset had been used and conceptualized in several places (Kriewall & Mekemson, 2010) before it became part of the E^3 movement. However, the notion as used by the E^3 movement took shape in the interactions among movement actors. In particular, the early conversations among Professor Zurbuchen, Marc Weiser, and Mr. X, were central to its articulation. When the movement first framed entrepreneurship education as developing a particular mindset in students, it immediately gained traction and attracted new groups, but also preserved the engagement of early committed groups. Four are identified and represented in Figure 3: CoE and UM faculty and staff, entrepreneurial students, corporate leaders, and entrepreneurs and venture capitalists. The first two groups became E^3 advocates as the E^3 movement expanded its frames with the notion of entrepreneurial mindset; the other groups, originally engaged with the E^3 idea, remained commitment to the movement and accepted the entrepreneurial mindset idea. It is important to highlight that the frame extension was constructed through the interaction of all these groups. The notion of entrepreneurial mindset was not crafted by a small group within the CoE and then sold to different groups. In fact, these groups appear to hold different interpretations of the idea of entrepreneurial mindset (Miethe, 2009) (see Figure 3).

Figure 3. The Entrepreneurial Mindset as an Extension Frame of the E^3 Movement.
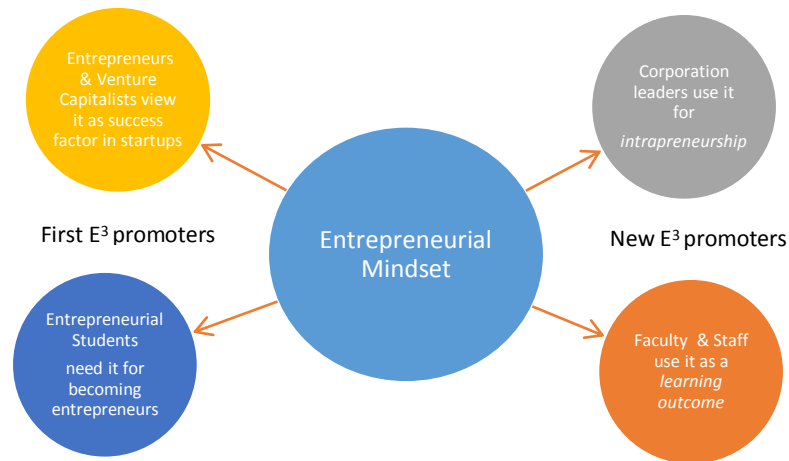
As suggested in Figure 3, there was not a precise definition of entrepreneurial mindset that held together the four groups. Each group defined or described entrepreneurial mindset according to their interests. When the E^3 movement defined fostering entrepreneurial mindset as a priority, it moved its focus from the for-profit orientation of entrepreneurship. The idea of entrepreneurial mindset gave the movement a clear student-centered learning purpose. In the CoE, entrepreneurship education was not about creating businesses. It was about pursuing a learning outcome that could be applied to multiple situations and contexts. The development of businesses or startups was only a byproduct of this approach to entrepreneurship education. Thus, this framing resonated with faculty and staff who were close to the undergraduate curriculum, one of the four groups included in Figure 3. It also resonated with the educational agenda of CoE leaders and UM administrators who sought to enrich the student experience beyond the classroom, a common aspiration for colleges and universities (Kuh et al., 2005). Two examples demonstrates this alignment. First, the notion of entrepreneurial mindset was included

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as one of the six competencies of the Engineering Plus Philosophy, the CoE strategic plan for adding broader skills to the core competencies of traditional undergraduate education. Second, UM's Third Century Initiative placed the concept of entrepreneurial mindset among its four core student learning outcomes. This initiative also defined entrepreneurial mindset as a competency in which "students must know how to observe the opportunities and capacities of human communities, understand where new or existing ideas or systems could bring value within those communities, and be able to act effectively in order to drive sustained and positive change to provide that value" (Third Century Initiative, n. d.). Strikingly, this definition of entrepreneurial mindset contains almost no business or startup jargon, such as customer, market, service, or product.

Heads of large corporation, represented by another circle in Figure 3, played a key role in constructing the frame of entrepreneurial mindset and became central supporters of the E^3 movement. Among these supporters were Mr. X, chairman of a multinational manufacturing company, and Donald Graham, founder of the Graham Engineering Company. Their experiences as heads of multinational manufacturing companies made them realize the importance of engineers, and professionals in general, who are willing to take risks, handle business concepts that are out of their comfort zone, and work in multidisciplinary and multicultural contexts. These characteristics are the ones represented by the notion of entrepreneurial mindset. These company heads were not primarily interested in the creation of new ventures. They were more interested in nurturing a new engineering cadre, one that can keep revitalizing large and bureaucratic companies. A member of this professional cadre, who applies entrepreneurial principles within a single organization, is often called an intrapreneur (Kriewall & Mekemson, 2010), a concept that appeared in some of the E^3 discussions.

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The collective action around E³ emerged first from a group of tech entrepreneurs and venture capitalists who were interested in the commercialization of research and venture opportunities around UM. This group is represented by a third circle in Figure *3*. For tech entrepreneurs and venture capitalists, the creation of faculty and student startups was central. In fact, many of them, such as Marc Weiser, Rick Bolander, and Jeffrey Schox, became teachers and curriculum designers at the CoE. The knowledge that they brought to the college concerned venture creation. They expected the movement to generate an entrepreneurial ecosystem and a greater number of promising regional startups. Nevertheless, they also found the notion of entrepreneurial mindset alluring. In their vision of an entrepreneur, more important than specific knowledge was a certain set of beliefs, attitudes, and behaviors (such as resilience or positive thinking). Consistently, no Silicon Valley participant thought that the primary immediate outcome of the E³ movement was the creation of successful student startups. The main educational outcome was to nurture students' entrepreneurial mindset. Indeed, many participants from Silicon Valley view student startups as a medium for bringing learning experiences about entrepreneurship into students' early professional development. This belief means that the sooner a student fails, the more capable she or he will be of launching a successful venture in the future. Furthermore, they think that if a student does not become an entrepreneur, chances are she or he will interact with entrepreneurs in almost any professional path they pursue after graduation.

Students are the fourth group shown in Figure 3. By framing entrepreneurial mindset as the learning outcome of the E³ movement, its collective action became broader in terms of members' disciplines, experiences, and levels of commitment. Since the notion of developing a mindset is abstract and somewhat detached from the actual doing, startup-ready students, those with little exposure to entrepreneurship, and those not at all interested in launching a company

could engage with the movement. Furthermore, even within the significant group of students for whom the principal attraction was startup creation, the learning process was fundamental. For instance, according to Kunal Jham, a serial entrepreneur who co-founded TechArb, the best way for UM to nurture entrepreneurship is through solving open problems in traditional engineering courses. According to Kunal, developing the capacity to solve un-structured or ill-defined problems is more important than startup experiences. Many students and student organization such as MPowered shared this perspective. The main focus was on learning key concepts and developing the right mindset, not in creating startups during college.

When collective action groups use frame extension, they risk creating tensions or divisions within their membership (Snow et al., 1986). The E^3 movement also experienced tensions between groups. To illustrate, a certain degree of antagonism existed between the actors from the manufacturing world and the advocates for student startups. Mr. X, for instance, did not believe that student tech startups would fulfill the promises of entrepreneurship education. He said, "I sucked up and accepted it [laughs]. But you can't make that a metric. If that [the focus on startups] is what you are going to start rewarding and want to see, then you lose the value." In the CFE board of directors, Mr. X repeatedly confronted the pro-startup group from Silicon Valley. These confrontations never reached a point of rupture and both sides reported learning from each other. Mr. X ended up valuing the startup approached followed by CFE and acknowledging that a startup experience was an effective experience for nurturing an entrepreneurial mindset among students.

Similar exchanges occurred among students. For instance, within and between student organizations a tension existed between framing entrepreneurship as pure startup promotion (close to what TechArb does) and as a cultural change with a broader focus on institutional

change (close to what MPowered does). MPowered navigated this tension using the idea of mindset and framing the organization as a startup: "We were selling entrepreneurship. We were selling this mindset, this way of thinking, this culture and this art. Right from day one, it was entirely looked upon as our startup" (Ashwin Lelendran, co-founder MPowered). In sum, the idea of entrepreneurial mindset kept the movement purpose at a higher level, which allowed discussions and antagonisms without either rupture or compromise of the movement momentum.

Nevertheless, there were indications that the idea of entrepreneurial mindset suffered some erosion due to two forces. First, when actors became more interested in evaluating CFE work and defining the focus for the years to come, the idea of entrepreneurial mindset seemed too broad to assess programs and to guide further steps. Many participants expressed concerns about the lack of a tight definition. The second source of erosion derived from LSA faculty who questioned the idea of entrepreneurial mindset as an academic definition. "What exactly is an entrepreneurial mindset?" they asked. Thus, the frame extension was weakened when the movement required sharper boundaries, when the push for institutionalization increased.

Key Changes in the E³ Movement Frames

Several E^3 movement leaders, such as Dean Munson and Marc Weiser, initiated collective actions with a clear interest in the commercialization of research. These leaders framed research commercialization as a new means to impact society; some even called it the university's "fourth mission". They saw great market potential in the extensive UM research activity and their attention shifted towards entrepreneurship education when they recognized an opportunity to make a cultural shift in the CoE. The *frame shift from commercializing research to promoting entrepreneurship education* crucially marks the beginning of the E^3 case. When this change occurred, the idea of engineering entrepreneurship became salient. Dean Munson and the

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CEEPS committee centered entrepreneurship education in engineering. However, the emphasis on *engineering entrepreneurship morphed rapidly into the idea of an entrepreneurial mindset*. As discussed in the preceding section, this process of frame extension required negotiation and debate. Professor Zurbuchen was a key proponent of an open and inclusive approach to entrepreneurship education and the notion of an entrepreneurial mindset that was equally important for engineering and other undergraduates. Finally, the changes captured towards the end of the case study seem to have two potential ramifications. On the one hand, the campus-wide initiative called Innovate Blue seems to de-emphasize the notion of entrepreneurship by stressing the concept of innovation. On the other hand, CFE seems to have re-focused on engineering and the idea of commercialization of research and entrepreneurship education at the graduate and faculty levels. In the words of Dean Munson, this last framing is the "coming full circle" of the initial idea of entrepreneurship in the CoE.

Summary

The collective action frame theory helps to explain the E^3 movement in the CoE and across UM. While the E^3 movement drew a great part of its genesis and success from the ubiquitous master frame of entrepreneurship in society, collective action nurtured it. Movement leaders and actors elaborated core frames that resonated with multiple constituencies. In addition to these core framings, the E^3 movement engaged in framing processes of amplification, bridging, and extension that produced alignment among multiple constituency groups. Movement leaders amplified its cause by stressing that entrepreneurship education was a response to student demands and to the challenges of the global economy. Frame bridges were built with the local startup movement and social entrepreneurship advocates. Frame extension

occurred when E^3 movement actors added the notion of entrepreneurial mindset to the vision of entrepreneurship education centered in startup-creation. These framing processes resulted in greater UM and community support and in resource acquisition with minimal antagonism. During the time period of the case, it was observed that the overarching movement frame was transformed from the idea of commercializing research to a focus on entrepreneurship education in engineering, and was subsequently transformed into the broad notion of entrepreneurial mindset across UM.

Chapter 7: Conclusion

Over the last three decades multiple actors have struggled relentlessly to promote change in engineering education. Scholars, decision makers, and change advocates have learned that successful and sustainable transformations in engineering education must combine a top-down and bottom-up approach. Previous change efforts have also shown that external actors to the university can prove highly influential in promoting engineering school initiatives. However, empirical research on bottom-up approaches and the role of external actors in curricular change is scarce. Thus, this study sought to understand how contextual factors and collective action among internal and external actors affects undergraduate engineering education. In order to address this overarching question and its three research sub-questions, this investigation employed the existing rich literature on social movements and change in higher education, which focuses on the humanities and the social sciences. In particular, this study of E^3 in the CoE used the theories of SIMs and collective action frames as conceptual lens.

Entrepreneurship has been one of many curricular ideas promoted among engineering schools over the last three decades. The emergence of E^3, still ongoing, involves several of the processes of curricular change found in the social movement literature: local contexts and external actors are fundamental to the appearance of the first E^3 initiatives; the shape of the first E^3 programs was influenced by the disciplines that took the lead in its promotion (in most cases engineering or business); national networks were formed to share resources and promote E^3 across colleges and universities; and E^3 advocates adopted a movement rhetoric that characterized themselves as part of a "revolution" or a "social movement."

The research method employed was a case study of E^3 on a single campus, the CoE at UM. The focus on a single campus over an extended period of time permits an in-depth analysis of the multilayered interactions among internal and external actors in a particular context. For over two years, the researcher conducted interviews with internal and external actors, collected documents, and observed E^3 related events. The data analysis was primarily deductive, following propositions derived from the conceptual framework of the study.

Overall, the case study illustrates how intense collective action among multiple actors—administrators, faculty, staff, student leaders, venture capitalists, entrepreneurs, and local business and political leaders—contributed to the emergence of E^3 in the CoE at UM. Moreover, this collective action can be characterized as an intellectual movement but with characteristics of a grassroots effort. The general theory of SIMs helps to describe the bottom-up or grassroots approach to change the E^3 movement exemplifies. The strategies used by external and internal actors who promoted E^3 are discussed in relation to four SIMs' theoretical prepositions: SIMs are more likely to emerge and succeed when leaders harbor complaints against the status quo; movement participants have access to key resources; sites exist where new ideas can be discussed and new members recruited; and movement participants frame movement ideas in ways that resonate with key constituencies.

The E^3 movement emerged first when high-status and tenured faculty promoted a new vision for engineering education, one that could be accomplished alongside the traditional curriculum. Second, structural conditions in the university and in the local and state governments gave the movement access to key resources that supported E^3 initiatives. Third, various micromobilization contexts (e.g., CFE, study trips to the San Francisco Bay Area, student competitions) served as spaces where movement participants came into frequent contact and

where new members could be recruited. Fourth, movement participants framed curricular ideas in a way that internal and external actors to the university could identify with and bridged differences between them.

The study also revealed how the E^3 movement's framing of curricular ideas and the framing strategies changed over time. The construction of collective action frames proved a critical factor in the emergence of the E^3 movement, demonstrating that in academic contexts, how ideas are presented and debated matter significantly. Even though some university authorities were part of the E^3 effort, the movement was not orchestrated from the top. The movement frames were constructed during ongoing conversations among multiple actors and at different hierarchical levels. The movement successfully elaborated diagnostic, prognostic, and motivational frames that were attractive to multiple constituencies. The movement also used framing strategies such as amplification, bridging, and extension to align its interest with other groups and resource providers. The E^3 movement frames changed over time, moving from a strong focus on technology startup-creation towards the broader notion of an entrepreneurial mindset. Ultimately, when the UM central administration launched a campus-wide entrepreneurship education initiative, the CFE refocused on engineering faculty and graduate students and the commercialization of research.

Finally, the case study illustrates how the E^3 frames created at the local level related to those at the national level. Key actors interviewed for this study stressed that the E^3 movement drew ideas and motivation from the master frame of entrepreneurship present in society. Factors that reinforced the E^3 efforts in the CoE and then at UM include a new pro-entrepreneurship ethos among entering students, a wide celebration of entrepreneurs in the news media and popular culture, and the prominence of entrepreneurship in the public discourse of business and

political leaders. National frames around E^3 were also evident in the case study. E^3 movement leaders participated in national networks, such as NCIIA or Epicenter. The E^3 movement adopted well-known entrepreneurship education frames developed elsewhere and shared among peer institutions. These frames include startup manuals (e.g., the business model canvas, Blank's customer discovery models), co-curricular activities (e.g., trips to Silicon Valley, startup fairs, hacker competition), and educational concepts (e.g., entrepreneurial mindset). In the case study, venture capitalists, entrepreneurs, and student leaders often brought frames to the CoE that were reworked through interactions with faculty, staff, and administrators. In these interactions, novel activities and approaches to entrepreneurship education were developed, such as the 1,000 Pitches competition.

Research Implications

Five broad research implications are particularly salient. The first four concern research on engineering education and STEM fields in general. The final implication is related to research opportunities in the area of entrepreneurship education.

Social Movements and Curricular Change in STEM fields

Even though social movement theories have an established place in higher education research, their use in engineering education, or STEM fields in general, is rare. The case study shows that social movement theories provide conceptual lens that help researchers and practitioners understand a relevant issue: Why do certain curricular ideas progress while other stagnate in engineering education and other STEM fields? Curricular change in STEM fields remains a difficult challenge with low chances of success despite support from renowned scientists and intellectuals, validation through evaluation studies, and the allocation of significant

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resources (DeHaan, 2005; Kezar, 2012). Social movement perspectives offer new insights by taking into account the social and political dynamics that exist in engineering departments and schools. Moreover, recent empirical research has shown that successful and sustainable changes in engineering education require a combination of top-down and bottom-up approaches (Graham, 2012). Previous research has neglected the latter; social movement theories are, in fact, well suited to explain bottom-up initiatives in organizational contexts (Davis, McAdam, Scott, & Zald, 2005).

Social movement research consists of a collection of theoretical branches. In addition to collective action frames, other well established social movement theories are resource mobilization and political opportunity (Snow, 2004). Resource mobilization emphasizes the rational actions embedded in collective action, in particular, how movements attract resources and mobilize members (Edwards & McCarthy, 2004; McCarthy & Zald, 1977). Political opportunity focuses on the institutional conditions that favor or inhibit social change (Kriesi, 2004; McAdam, 1982). The case study of E^3 showed that there were planned and strategic decisions that movement leaders made in order to secure resources for the cause. It also clearly illustrates how the movement benefitted from the economic climate in the region and from UM strategic decisions to improve its engagement with the community, the commercialization of research, and engaged learning. Curricular studies guided by these theoretical frameworks hold strong potential for enhancing higher education researchers' understanding of the complex dynamics between schools, institutional and regional contexts that shape programs of study.

External Actors and Students as Change Agents

External actors have influenced engineering education from its beginnings. As a professional discipline, engineering education is constantly influenced by socioeconomic and

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technological changes in the profession. Over the last three decades, this influence seems to have increased (Genheimer & Shehab, 2009) due to the key role of engineering in economic growth, the environment, and national security (Duderstadt, 2008). Despite their influence, curriculum researchers in higher education often overlook external actors (Genheimer & Shehab, 2009). Moreover, higher education theories, such as academic capitalism (Slaughter & Rhoades, 2004), tend to consolidate external actors' influence into a homogeneous voice, which follows market opportunities. The case study indicates they do not necessarily use a single voice. External actors created coalitions with several groups of students, faculty, and authorities. For instance, in the E^3 movement, the group of manufacturing chairmen pushed for deemphasizing the idea of student startups, especially those focused on web applications. This position contrasted with the inclination of venture capitalists towards supporting startups. As described in Chapter 6, a framing process of alignment was necessary to draw these two groups together around the broad theme of entrepreneurial mindset. To some extent, the dynamics of interest group formation among external actors resembled those that result in vested interest groups among faculty and administrators around curricular change (Arnold 2004; Conrad, 1978; Stark et al., 2002; Tierney, 1989; Trinkaus & Booke, 1980). The case study also shows how external actors play active roles, aside from speaking directly to engineering faculty or through gifts; through their engagement with curricular design, teaching, and mentoring, and through mobilizing support for particular ideas within and across institutions. However, the case study is based on a single institution with a loyal alumni community. Curricular scholars have suggested that this interaction between external influences and particular institutional characteristics—such as alumni commitment to the university— makes the process of curricular change highly sensitive to institutional contexts

(Conrad & Pratt, 1983; Lattuca & Stark, 2009). Therefore, it is important to consider how alumni loyalty and the roles of alumni vary across institutional contexts.

Philanthropy emerged as a relevant arena for collective action in the E^3 movement. As expected, donors sought to influence college education through their gifts. However, the case study suggests that the mechanisms of giving (e.g., endowment versus budget control), evaluation processes, and development strategies influence how collective action around a curricular initiative evolves. More important from a SIMs perspective, CFE main donors engaged in shaping the movement frames and goals, but they allowed other movement leaders to take ownership in the use of their gifts. Their gifts promoted a grassroots approach to change. This approach differs from *strategic philanthropy*, which has been criticized for setting strategic goals from the outset and treating universities as contractors (Gose, July 14, 2013). The role of philanthropy in the emergence of intellectual and social movements is a crucial area of future research as private donations with educational purposes continue to increase in higher education.

According to faculty and administrators, engineering students play a modest role in curricular change (Graham, 2012). This case study, however, demonstrates that students were active protagonists of the E^3 movement. Moreover, they not only "voted with their feet," but also led and affected multiple movement outcomes during the process. Consistent with previous social movement research, faculty were the main E^3 movement initiators but students subsequently took the lead. Students were heavily influenced and supported by CFE faculty and staff and by external actors. Movement leaders carefully nurtured students' involvement with the movement early on. Further research on curricular change in engineering education needs to conceptualize students as active participants in curricular change, rather than the characterization of students as a passive clientele (e.g., Conrad & Pratt, 1983). The case study indicates that

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students can build social movement organizations that persist across successive cohorts and affect the institution. For example, over seven years MPowered has fostered the entrepreneurial ecosystem around UM. Mechanisms of student movement organization maintenance within and across institutions provide another opportunity for future research. This research is important since student mobilization may be critical in sustaining a change initiative during periods of change in university leadership or when external resources decrease.

Curricular and Co-curricular Paths

If the E^3 movement's main outcome is restricted to the numbers of credits or required courses dedicated to entrepreneurship, the movement achieved surprisingly little over the case study period.[9] However, the movement was conceived with a broader goal, to affect the college and university teaching and learning environments. This goal resulted in a rich set of co-curricular activities, centralized campus initiatives, multiple student and academic organizations, and a committed cadre of mentors. In this sense, the E^3 movement was a success. The case study suggests that the combined impact of curricular and co-curricular activities should be considered in future research, especially as engineering schools increase their efforts to provide learning experiences beyond the classroom. However, this poses a key challenge to program assessment and evaluation. What learning outcomes can we expect through co-curricular or through a designed combination of curricular and co-curricular activities? Are different groups of students (e.g., gender, race and ethnicity, academic performance) attracted to curricular and co-curricular paths? These are only few of the evaluation and assessment questions that arise from the case study. Second, bringing co-curricular activities to the analyses of curricular change also suggests

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[9] In December 2014, UM announced a new 15-credit minor beginning in the semester of Winter 2015, open to students from diverse areas of study. The minor was created by Innovate Blue, and it will be hosted in LSA (Kerecman, December 03, 2014).

new dimensions to consider. Is working through the co-curriculum an effective strategy for achieving sustained and institutionalized curricular change? Or is this a focus that distracts us from the battle around changing credit structures and required courses in the core curriculum? Studies with a longer duration are best suited to address these questions.

Local and National Contexts

According to social movement research in higher education, an important stage in the progression of collective action for curricular change occurs when local ideas and resources begin to be linked and shared among groups across the nation. This dynamic is partially reflected in the case study. The key developments in the case study were influenced by organizations across the nation, but only through indirect venues. According to the E^3 movement leaders, collective action frames and actions were mostly constructed locally, with modest influence from other universities and E^3 national networks. This is consistent with Lattuca and Stark's (2009) characterization of the process of academic planning as occurring in a multi-faced sociocultural context. Nevertheless, the case study illustrates how formal and informal information networks and exchanges across institutions shaped curricular changes. For instance, several curricular ideas (e.g., RPM$_{10}$ Summer program, Schox's course) and co-curricular activities (e.g., Bay Area trip, Startup Fair, hacker events) worked their way into the CoE mainly through alumni and student leaders. On the other hand, books (e.g., *The Startup Owner's Manual, Business Model Generation*) and other curricular resources for entrepreneurial education (e.g., Steve Blank's Youtube videos) seemed to have a greater influence at the classroom level than most of the interviewees in this study admitted. Research that looks closely at classroom instruction (Cohen, Raudenbush, & Ball, 2003) might clarify the actual influence of these resources. Also, the influence of Steve Blank's books, videos, and campus visits in the E^3 movement may be partially

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explained by his role as an *epistemic broker* (Herring, 2010), someone who disseminate ideas across multiple networks and geographic distances.

To some extent, curricular dissemination inquiries would replicate research that studies the impact of funding programs in engineering education, such as the NSF-sponsored Foundation Coalitions (Clark et al., 2004). This area of research is important since most governmental and private initiatives that target change in engineering education utilize formal national networks. More studies of how national movement frames influence local collective action frames and vice versa are needed. The case study suggests, for instance, that keeping a collective action frame based on local rather than on national issues may increase movement support. However, the case also demonstrated constant "national-local linkages" (Zald, 1987, p. 333), such as the idea of reviving the tradition of innovation in Michigan that contributes to the national prosperity and the solution of pressing world problems.

Entrepreneurship Education

Even though the case study focuses on curricular change in engineering, the study offers research insights to entrepreneurship education scholars in general. Four areas of future research are highlighted. First, as described in the previous section, the relationship between entrepreneurship education and the local entrepreneurial community, or "ecosystem" in the words of entrepreneurs, was symbiotic. How entrepreneurship education is shaped by the local entrepreneurial ecosystem is an inquiry with potential benefits for educators and entrepreneurial activists. For instance, researchers may ask, what are the differences among entrepreneurship education programs built in ecosystems of different size and maturity? Second, the case study reveals tensions between the engineering and business approaches to teaching entrepreneurship. Part of this tension occurred at the curricular level. For instance, engineering faculty tend to

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minimize the amount of business knowledge required for entrepreneurs to succeed. More research on the different types of associations between business and engineering schools around entrepreneurship is needed. Third, the case study indicates the role of external actors can be intense in entrepreneurship education, especially those of teacher and mentor. Several research questions emerge from this observation: What are the most effective systems and practices that colleges and universities can implement to support and guide the educational activities of external actors to the university? For instance, CFE developed a guide for its mentors. Are academic values at risk or sensitive areas that should be carefully supervised? For example, intellectual property for entrepreneurial students is a sensitive area. Who are the mentors that are attracted to entrepreneurship education programs? What are their individual characteristics and motivations?

Fourth, the case study uncovered tensions around entrepreneurship education's focus on startup-creation. On one hand, the startup experience seems to attract the most students and external actors. Developing new ventures is the essence of entrepreneurship. On the other hand, advocates of the entrepreneurial mindset perspective argue that entrepreneurship can be deployed in multiple contexts, not only through for-profit ventures. The latter perspective is conceptually more inclusive and broader than the former. Key questions for curricular scholars in entrepreneurship are: What are the curricular implications of these perspectives and what is the appropriate balance? And what are the consequences of these perspectives in terms of access and diversity of the student body pursuing entrepreneurship? The case study also suggests that this type of questions may be also attentive to the local context in which entrepreneurship is taught.

Practical Implications

The case study has implications for both curricular change advocates and curricular decision makers. Since the case study includes multiple voices and perspectives on the emergence of E^3, it is possible to draw conclusions from multiple points of view. Implications for six areas are discussed in this section. However, it is important to keep in mind that the case study is circumscribed by the particular conditions and contexts of a single campus over a discrete period of time. The following implications are targeted to administrators, faculty, and advocates in research institutions that share with UM distributed power and a multiplicity of goals across academic units (Cohen & March, 1974).

Faculty and University Authorities as Movement Leaders

Leadership was a crucial resource for the E^3 movement at the CoE. The social movement perspective offers new insights about relevant leadership characteristics for building collective action among internal and external in the context of curricular change in engineering. According to the lessons of the case study, movement leaders must engage in relentless networking with multiple actors related to the movement cause. In the context of engineering, engaging with actors outside the university, in particular from industry, is essential. This networking must empower individuals who take up the causes. Therefore, movement leaders must nurture and give space for new leadership. In the case of E^3, Professor Zurbuchen shared leadership and gave voice to multiple other figures, such as faculty, alumni, CFE staff, and students. Second, movement leaders must be able to challenge university authorities in order to be legitimate representatives of their social movement constituents. In university contexts, this is a tricky task. Top university administrators hold the keys to resources and change. Resisting or questioning their decisions might lead to marginalization. Of course, in university movements tied to social

causes (e.g., African American studies), the pressure can be such that movement leaders can weaken the power position of university authorities (Rojas, 2010). In the case of engineering education, weakening authorities' power to achieve success seems unlikely. The case study shows how Professor Zurbuchen was able to break traditional restrictions and change authorities' positions (e.g., opening CFE courses to all UM students) without weakening their leadership or breaking trust with them. This balance requires advanced of political skill.

Interestingly, the E^3 case did not require its leaders to be intellectual authorities in entrepreneurship. No E^3 movement leader had written books about entrepreneurship education or been a national public figure on this topic. Most were intellectual authorities in their respective fields, but not in entrepreneurship education. This finding suggests that engineering schools do not necessarily need leaders who are expert on the new subjects or teaching approaches promoted in a curricular change. Instead, leaders must show commitment to the change and high level political competencies. Movement leaders' biographies (Lagemann, 1979; Miethe, 2009) might usefully indicate political skills in university contexts. For instance, Professor Zurbuchen's biography contains significant experiences with curricular changes or reforms.

University authorities who support a bottom-up approach to curriculum change have also a challenging balance to maintain between allowing grassroots initiatives and institutionalizing change. Accelerating the institutionalization of the changes might be counterproductive with the empowerment of the bases and achieving widespread support. The CoE authorities executed this balance effectively. Dean Munson, considered the spark of the E^3 movement, delegated to Professor Zurbuchen the initiative and did not institutionalize entrepreneurship education early on. For instance, even though Professor Zurbuchen was appointed as Associate Dean for Entrepreneurship, this position is associated to the dean's priorities. It is a position that may

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change with a new dean. In this sense, the position is not as institutionalized as the Associate Dean for Undergraduate Education or the Associate Dean for Research, for example. When the UM provost decided to centralize entrepreneurship education at the undergraduate level, it followed this noninstitutionalized path by recruiting Professor Zurbuchen as a Senior Counselor of Entrepreneurship Education. This strategy can be summarized as assigning leadership positions that allow autonomy and allocation of resources but without offering a long-term commitment. On the other hand, in engineering, as the E^3 movement progressed, the CoE moved towards a gradual institutionalization of entrepreneurship. A certificate and a master's degree in entrepreneurship were the first steps. The most advanced commitment was to include entrepreneurial activities, including entrepreneurship education, among the tenure decision criteria, which may secure a pro-entrepreneurial faculty in the long run.

The case study also indicates that in addition to tangible support, authorities' symbolic commitment to the cause was crucial for movement participants. For instance, the increasing presence of President Mary Sue Coleman in student and CFE activities was an important motivator for E^3 movement participants. Moreover, President Coleman's frequent mentions of MPowered contributed to the visibility of the E^3 movement across UM and across the nation. External actors also reported the importance of being acknowledged by the UM president. In summary, in order to support grassroots initiatives, authorities must not interfere with the work of movement leaders, but must give them symbolic support as the movement evolves. UM authorities followed closely and celebrated each movement achievement.

The Role of External Actors and Engineering Students

Clearly, the interactions between faculty and students and between external actors and students were effective in the emergence of the E^3 movement. Students were the movement's

"boots on the ground" (Lauren Leland, MPowered President 2009-10), and faculty and external actors gathered great inspiration and motivation from their interaction with entrepreneurial undergraduates. The constant interaction created a vibrant community and a dense network of movement participants (i.e., most participants tied with multiple others). Key to unleashing the entrepreneurial and organizational power of students was a framing that was meaningful to them, frequent interaction with mentors, the co-designing of movement activities, and strong financial, organizational, and network support to their initiatives. External actors also represented a collective "energy waiting to be tapped" (David Munson, Dean of the CoE). In particular, alumni were decidedly attracted to the movement when Dean Munson and Professor Zurbuchen proved eagerly receptive of their ideas and invited them to engage in teaching and mentoring students and in strategic advancing. Thus, their participation was hands-on from the beginning of the movement. Building and maintaining a constant pool of micromobilization contexts (e.g., Bay Area trips, student competitions) was important for augmenting the number of external actors engaged with the movement.

Curricular Experts: Bringing Movement Ideas into the Academic Plan

At some point the product of multiple interactions and discussions must take the shape of an academic plan. When the curricular change involves extensive participation of external and internal actors, the task of designing an academic plan can become daunting. Here, the role of curricular decision-makers, such as deans and associate deans, and specialized staff is critical. The CoE is a well-staffed organization. This feature seemed essential for the consistency and coherence of the academic plan. Within CFE, Associate Director for Academic Programs Aileen Huang-Saad helped organize the educational ideas in practical terms. Huang-Saad supervised the overall CFE curricular focus. Within the CoE, Associate Dean for Undergraduate Education,

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James Holloway and his team connected the E^3 movement to other CoE educational initiatives. For instance, the Engineering Plus Philosophy—the CoE strategic plan for adding broader skills to the core competencies of traditional undergraduate education—included the notion of entrepreneurial mindset as one of its six key competencies. The skill set of these curricular experts includes an understanding of the key elements of an academic plan (Lattuca & Stark, 2009) and knowledge of the cultural dimension of the curriculum (Tierney, 1990).

Organizational and Disciplinary Boundaries

When the curricular idea includes a multidisciplinary dimension, which is very likely in contemporary academic contexts (Association of American Universities, 2005), it adds another level of complexity to the change. Multidisciplinarity is not easy to enact in higher education (Jacobs & Frickel, 2009). It challenges organizational and disciplinary boundaries. The case study offers some lessons in this regard. First, investing CoE resources to bring together students from all disciplines proved extremely beneficial for the movement. It built multidisciplinary courses and multidisciplinary co-curricular activities. Second, disciplinary boundaries were challenged primarily through a constant dialog with the counterparts. At the E^3 movement beginnings, CFE framed entrepreneurial engineering education almost in opposition to the business approach to teaching entrepreneurship. On the other hand, Ross was skeptical of the CoE's entrepreneurial curriculum. However, despite these tensions, both sides worked persistently to build synergic relationships. CFE from the beginning invited ZLI members as advisors. Within a few years, multiple initiatives were jointly launched, including the master's degree in entrepreneurship. A similar dynamic was observed between CFE and LSA. The E^3 movement provided active support to any academic unit at UM that wanted to explore or launch entrepreneurship education initiatives. This level of cross-unit collaboration is explained in part

by the local context. UM is an institution, for instance, with an historic openness to and support for joint faculty appointments and dual degrees. In sum, the E^3 movement promoted multidisciplinarity by challenging organizational and disciplinary boundaries, but without threatening existing academic norms and structures.

The Marketplace of Ideas

One of the most important conclusions of the case study is that the discussion of ideas matters in engineering education. How ideas are framed, justified, and debated influences the potential for curricular change. Movement leaders may pay great attention to the framing of movement ideas. They must achieve frames that resonate with multiple stakeholders. If the initiative is collective, this framing must be constructed through continuous interaction with movement participants and stakeholders. It is not only about good marketing or the selling of ideas but also about their actual collective construction. The case study suggests that change advocates may benefit from opening the initial curricular idea to all stakeholders and letting them take ownership of what is being constructed. In the case of the E^3 movement, the curricular ideas were not orchestrated by a small group of faculty and then sold to external actors and students. The collection of frame alignment processes can be used for a greater awareness of curricular advocates and curricular decision-makers about what is under discussion and what can be achieved. This means, paying attention to what is pointed out as a problem, what the proposed solutions are, and what motivation is offered to potential members and resource providers. In term of alignment processes, this also means knowing what frames can be extended in order to attract new supporters and other resources without compromising the original purpose and consistency of the movement.

Collective Action and Curricular Change in Engineering Education

Finally, an important question needs to be addressed. Is there another curricular idea in engineering education to which the lessons of the E^3 case can be applied? This question is fair because as discussed throughout the study, entrepreneurship is a cultural phenomenon, a master frame that already works as a movement in society. The answer to this question is yes, if the curricular idea is part of a master frame in society, which makes it a concern of a large number of people, then a social movement approach to change seems appropriate. For instance, sustainability in engineering may share collective action features with entrepreneurship education. Pedagogical innovations and technological educational changes may also apply. For example, a hands-on approach that uses elements of do-it-yourself concepts (e.g., hacker spaces to build electronic or mechanical gadgets) might attract a wide audience. On the other hand, if the curricular idea is particularly important to a sub-specialty or is a narrow topic in engineering, then the social movement mechanisms may be less relevant. In summary, those who consider using social movement strategies to change an engineering curriculum need to take into account the nature of their curricular idea because the relevance of these strategies depends on how attractive or important this idea might be for multiple internal and external actors to the university.

Appendix I: Models for Introducing Entrepreneurship to Engineering Students

Based on the academic unit that hosted entrepreneurship education initiatives at six institutions, Standish-Kuon and Rice (2002) identified three different models for presenting entrepreneurship to engineers: In Model A, the curriculum is primarily controlled at the business school; in Model B, the curriculum is primarily controlled by the engineering school; and in Model C, multi-school or campus-wide units lead the entrepreneurship curriculum. I examined 84 engineering school websites in order to verify the relevance of these three models. I found the three categories are useful as a general classification of curricular arrangements on campuses with the largest engineering schools—defined by the number of undergraduate students—and top ranked programs. I found 37 institutions following Model A (44%), 21 Model B (25%), 18 Model C (21%), and 8 institutions with no information in their websites (10%). A sample of these institutions is shown on Table I.A.

Table I.A. Models for introducing entrepreneurship to engineering students based on the main location of the curricular initiatives (n= 84), based on Standish-Kuon and Rice (2002)

Model A Hosted at business schools	Model B Hosted at engineering schools	Model C Hosted at multi-schools
Carnegie Mellon University, Clemson University, Duke University, Florida International University, Georgia Institute of Technology, Iowa State University, Louisiana State University, Notre Dame University, Ohio State University, Oregon State University, Texas A&M University, University of Arizona, University of Central Florida, University of Minnesota, University of Washington, University of Wisconsin, Vanderbilt University, and 20 others	Columbia University, Harvard University, Johns Hopkins University, North Carolina State University, Northwestern University, Pennsylvania State University, Princeton University, Stanford University, University of California at Berkeley, University of California at San Diego, University of Florida, University of Illinois at Urbana-Champaign, University of Maryland, University of Michigan, University of Pennsylvania, and 6 others	Arizona State University, Brown University, California Polytechnic State University at San Luis Obispo, Cornell University, Drexel University, George Mason University, Lehigh University, Massachusetts Institute of Technology, Michigan State University, Michigan Technological University, Purdue University, Rice University, University of California at Davis, University of South Florida, University of Texas at El Paso, Yale University, and 2 others

Note: 1) The sample consists of the 66 largest engineering schools (by undergraduate enrollment) reported by ASEE (http://www.asee.org/papers-and-publications/publications/college-profiles/2011-profile-engineering-statistics.pdf), and 18 other institutions that were not listed in that report but were included in the 2012 USNW Ranking of the 50 best engineering schools (with doctoral level as the highest degree, excluding Caltech because its small size and exclusive focus on science and engineering). 2) The goal of this classification was to find evidence of the program or center that provided entrepreneurship education for undergraduate engineering students (e.g., courses, certificates, or minors). I searched for evidence in the following order: i) Any direct link to entrepreneurship on the home page of the engineering school website, ii) in the academic admission site for undergraduate engineering, iii) in the research centers and institutes site of the school of engineering, iv) if I did not find evidence in those places, I searched in the school's web search engine using the word "entrepre*", v) if that also failed, I would use Google search with the name of the institution plus the word "entrepreneurship," and v) finally, if that step also failed, I stopped the search process. 3) For eight institutions, I found no information.

When I looked within these institutional categories, I found different levels of commitment to the idea of E^3; some institutions offer certificates and minors with programs supported by the engineering school (Model B) to others, where the opportunity for entrepreneurship courses is only promoted by the business school (Model A) or by centers or initiatives hosted by central units[10] with a strong interdisciplinary orientation (Model C). Few Model A institutions manifest some sort of collaboration between faculty in the business and engineering schools. In most Model C institutions, engineering schools are one of the partners in entrepreneurship education on campuses. The colleges traditionally considered leading engineering schools in the U.S. follow Model B (see table I.B for the pairwise correlation table) and few notable schools follow models A and C.

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[10] For instance, Purdue's Certificate in Entrepreneurship and Innovation Program is hosted at Discovery Park, which is an interdisciplinary center hosted at the Office of the Vice President for Research at Purdue University. The Certificate in Entrepreneurship and Innovation "offers the opportunity for Purdue undergraduate students in all discipline to earn an academic credential in entrepreneurship complementary to their major" (www.purdue.edu/discoverypark/entr/). This certificate has an advisory committee with members from 12 different academic areas, including agriculture, education, engineering, and management.

Table I.B. Pairwise correlations between engineering schools' prestige and type of model for presenting entrepreneurship to undergraduate engineering students (n=84), based on Standish-Kuon and Rice (2002)

Best undergraduate engineering schools[a]	Model A Hosted at business schools	Model B Hosted at engineering schools	Model C Hosted at multi-schools
Top 20	-.215	.387***	-.020
Top 40	-.194	.476***	-.076

[a] Based on the 2012 USWN Ranking of the best undergraduate engineering programs (for doctoral degree grating institutions)
* p<.05, ** p<.01, *** p<.001

Reference

Standish-Kuon, T., & Rice, M. (2002). Introducing engineering and science students to

entrepreneurship: Models and influential factors at six American universities. *Journal of*

Engineering Education, 91(1), 33-39.

Appendix II: Semi-structured Interview Protocol

The emergence of the idea of entrepreneurship education in engineering

1. How did you first become interested in the idea of entrepreneurship education? What sparked this interest?
2. When and from where do you think that the idea of teaching entrepreneurship to engineers started at Michigan?
3. Why do you think that teaching entrepreneurship to engineers is needed at the College of Engineering?

Evolution of the idea of entrepreneurship education in engineering

4. How would you explain the growth of entrepreneurship education in the College of Engineering and at the University, in general? What are the main factors that have inhibited its progress?
5. Have you noticed any change in how entrepreneurship has been conceptualized over time at this College? In other colleges and universities?
6. Can you identify other schools, organizations and or individuals that, in your opinion, have been the most influential in promoting entrepreneurship education in the College of Engineering? What is the role of the local community in this promotion?

Final questions

7. What else would you like to share about entrepreneurship education?
8. Do you have any question about this interview?

Appendix III: First Email Message Inviting to Participate in the Study

Dear <INCLUDE NAME>

My name is Sergio Celis, and I am a PhD candidate in higher education at the University of Michigan. My dissertation studies the rise of entrepreneurship education in engineering. My plan is to write the case study of the entrepreneurial movement at the University of Michigan, with a particular focus on its growth and debates around curricular issues. Your perspectives on this case, as <INCLUDE PARTICIPANT RELATIONSHIP TO THE CASE>, are essential to my study.

Is it possible to schedule an interview with you? My interview usually lasts about 45 or 60 minutes. My schedule is pretty flexible, so I could meet you almost any day at any time. I would be happy to provide more background information about this study or about me if needed.

I appreciate your collaboration. I am sure we have many lessons to learn from the entrepreneurial movement here at the University of Michigan.

Best Regards,

Sergio Celis
PhD Candidate
Center for the Study of Higher and Postsecondary Education
University of Michigan

Appendix IV: List of Key Documents

College of Engineering, University of Michigan, Committee on Entrepreneurial Environment and Program for Students (2007). *Report: Empowering Entrepreneurial Students.* Retrieved from http://www.cfe.umich.edu/

College of Engineering, University of Michigan, the Commission on Undergraduate Engineering Education: Curriculum for the 21st Century. (2009). *Michigan Engineering 2020.* Retrieved from http://adue.engin.umich.edu

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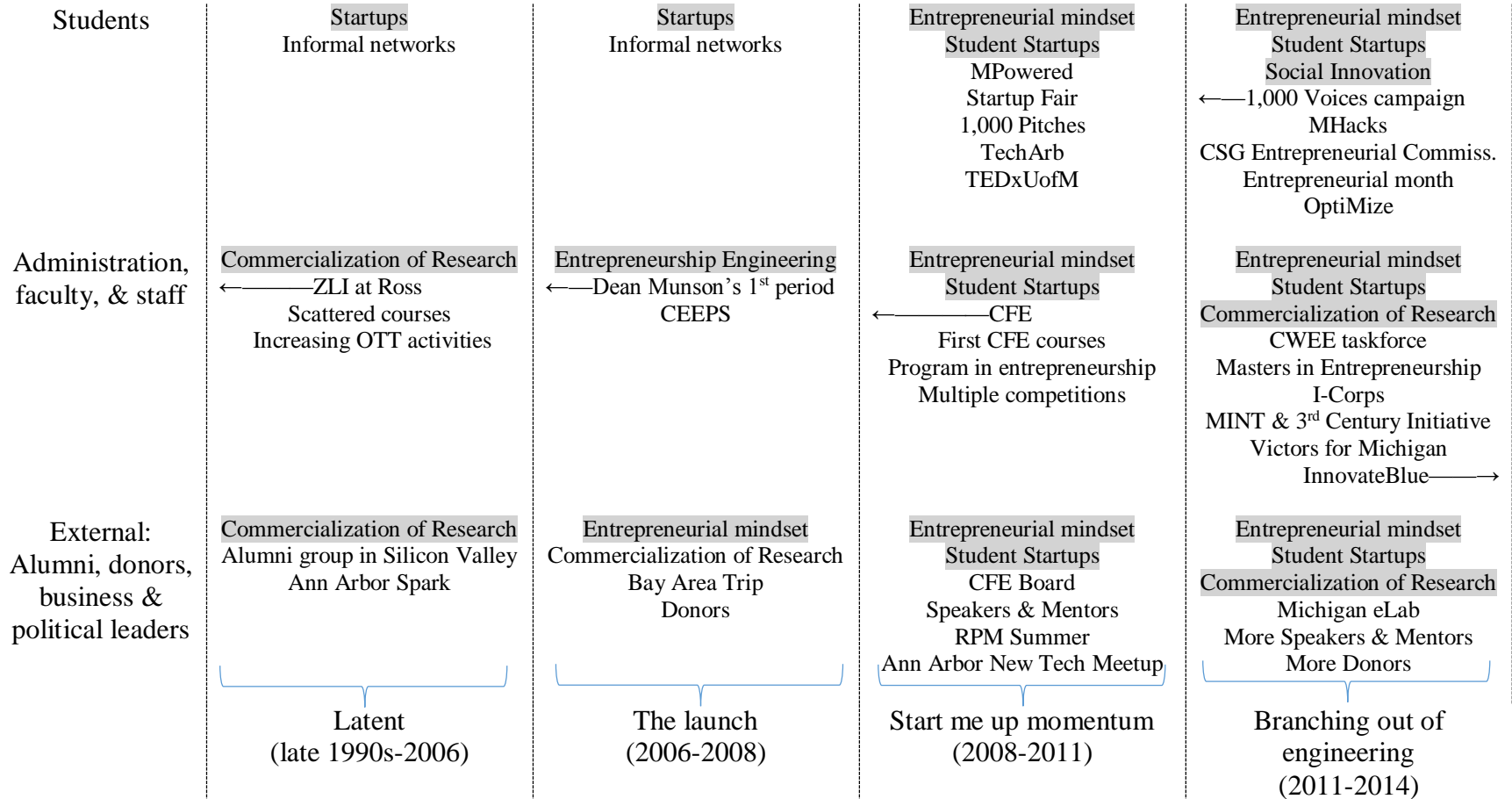
Appendix V: Summary of the Four Periods in the Emergence of E^3 in the CoE

Actors:

Grey area indicates period's key collective action frames or interests
Non-grey area indicates a new organization/activity, or key event
← Indicates event that marks beginning/end of a period

|	Latent (late 1990s-2006)	The launch (2006-2008)	Start me up momentum (2008-2011)	Branching out of engineering (2011-2014)
Students	Startups Informal networks	Startups Informal networks	Entrepreneurial mindset Student Startups MPowered Startup Fair 1,000 Pitches TechArb TEDxUofM	Entrepreneurial mindset Student Startups Social Innovation ←—1,000 Voices campaign MHacks CSG Entrepreneurial Commiss. Entrepreneurial month OptiMize
Administration, faculty, & staff	Commercialization of Research ←————ZLI at Ross Scattered courses Increasing OTT activities	Entrepreneurship Engineering ←—Dean Munson's 1st period CEEPS	Entrepreneurial mindset Student Startups ←————CFE First CFE courses Program in entrepreneurship Multiple competitions	Entrepreneurial mindset Student Startups Commercialization of Research CWEE taskforce Masters in Entrepreneurship I-Corps MINT & 3rd Century Initiative Victors for Michigan InnovateBlue————→
External: Alumni, donors, business & political leaders	Commercialization of Research Alumni group in Silicon Valley Ann Arbor Spark	Entrepreneurial mindset Commercialization of Research Bay Area Trip Donors	Entrepreneurial mindset Student Startups CFE Board Speakers & Mentors RPM Summer Ann Arbor New Tech Meetup	Entrepreneurial mindset Student Startups Commercialization of Research Michigan eLab More Speakers & Mentors More Donors

Notes:
Most of the organizations and activities listed in the figure involved more than one type of actor; the cells represent new actors who took the lead of the initiative. This is not an exhaustive list. For a complete timeline visit http://www.tiki-toki.com/timeline/entry/243646/The-rise-of-E3/ and use the password: e3

Appendix VI: Minimum Number of General Elective Credits by Program

In the 1996, a CoE curriculum taskforce recommended that all undergraduate engineering programs may have at least 12 credits of general elective courses (All CoE bachelor's degree programs required the completion of 128 credit hours). By 2009, only four programs achieved such a goal. The following figure illustrates the number of general elective credits by programs as 2009.
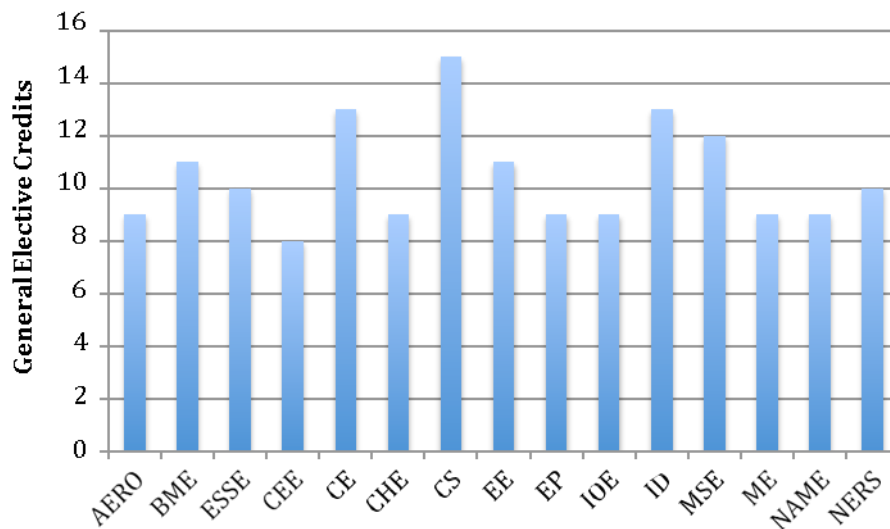
Source: CoE, 2009, p. 24

Note: The programs are AERO: Aerospace Engineering; BME: Biomedical Engineering; ESSE: Earth System Science Engineering; CEE: Civil and Environmental Engineering; CE: Computer Engineering; CHE: Chemical Engineering; CS: Computer Science; EE: Electrical Engineering; EP: Engineering Physics; IOE: Industrial and Operation Engineering; ID: Interdisciplinary Engineering; MSE: Material Science and Engineering; ME: Mechanical Engineering; NAME: Naval Architecture and Marine Engineering; NERS: Nuclear Engineering and Radiological Sciences.

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