

Singapore Management University Institutional Knowledge at Singapore Management University

Research Collection Lee Kong Chian School Of
Business

Lee Kong Chian School of Business

3-2018

Demystifying the genius of entrepreneurship: How design cognition can help create the next generation of entrepreneurs

Massimo GARBUIO
University of Sydney

Andy DONG
University of Sydney

Nidthida LIN
University of Sydney

Ted TSCHANG
Singapore Management University, tedt@smu.edu.sg

Dan LOVALLO
University of Sydney
DOI: <https://doi.org/10.5465/amle.2016.0040>

Follow this and additional works at: https://ink.library.smu.edu.sg/lkcsb_research

Part of the [Education Commons](#), and the [Entrepreneurial and Small Business Operations Commons](#)

Citation

GARBUIO, Massimo; DONG, Andy; LIN, Nidthida; TSCHANG, Ted; and LOVALLO, Dan. Demystifying the genius of entrepreneurship: How design cognition can help create the next generation of entrepreneurs. (2018). *Academy of Management Learning and Education*. 17, (1), 41-61. Research Collection Lee Kong Chian School Of Business.
Available at: https://ink.library.smu.edu.sg/lkcsb_research/5267

This Journal Article is brought to you for free and open access by the Lee Kong Chian School of Business at Institutional Knowledge at Singapore Management University. It has been accepted for inclusion in Research Collection Lee Kong Chian School Of Business by an authorized administrator of Institutional Knowledge at Singapore Management University. For more information, please email libIR@smu.edu.sg.



**Demystifying the Genius of Entrepreneurship: How Design
Cognition Can Help Create the Next Generation of
Entrepreneurs**

Journal:	<i>Academy of Management Learning & Education</i>
Manuscript ID	AMLE-2016-0040-RES.R2
Manuscript Type:	Research & Reviews
Submission Keywords:	Action Learning, Entrepreneurship Education, Future of Management Education, Innovation in management education, Pedagogy, Problem-based Learning

1
2
3 **Demystifying the Genius of Entrepreneurship: How Design**
4 **Cognition Can Help Create the Next Generation of Entrepreneurs**
5
6
7
8
9

10 **Massimo Garbuio***

11 The University of Sydney Business School
12 Rm 4103
13 H70 - Abercrombie Building
14 The University of Sydney
15 NSW 2006 Australia
16 massimo.garbuio@sydney.edu.au
17 Phone: +61 2 9036 5046
18
19

20
21 **Andy Dong**

22 Warren Centre Chair for Engineering
23 Faculty of Engineering and IT
24 The University of Sydney
25 NSW 2006 - Australia
26
27

28
29 **Nidthida Lin**

30 Newcastle Business School
31 Room Syd11-14
32 Sydney NSW 2000
33
34

35
36 **Ted Tschang**

37 Lee Kong Chian School of Business
38 Singapore Management University
39 50 Stamford Road - Singapore 178899
40
41

42 **Dan Lovallo**

43 The University of Sydney Business School
44 Rm 4138
45 H70 - Abercrombie Building
46 The University of Sydney
47 NSW 2006 Australia
48
49
50
51
52
53
54
55

56 *** Corresponding Author**
57
58
59
60

Acknowledgements

This article is the results of engaging with several designers and students over the years. Massimo would like thank Jeanne Liedtka, Angela Meyer, Giulia Teso, Ilaria Mazzoleni and Dreu Harrison.

A very special thank you to Associate Editor Siri Terjesen for her generous guidance through the review process and very insightful comments which helped substantially improve the manuscript.

This research was supported under Australian Research Council's Discovery Projects funding scheme (project DP130101065) to Chief Investigators Dan Lovallo and Andy Dong.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Peer Review Proof - Not Final Version

1
2
3 **DEMYSTIFYING THE GENIUS OF ENTREPRENEURSHIP: HOW DESIGN**
4
5 **COGNITION CAN HELP CREATE THE NEXT GENERATION OF**
6
7 **ENTREPRENEURS**
8
9

10
11 **ABSTRACT**
12

13
14 Entrepreneurship education is a key beneficiary of design thinking's recent momentum. Both
15
16 designers and entrepreneurs create opportunities for innovation in products, services,
17
18 processes, and business models. More specifically, both design thinking and entrepreneurship
19
20 education encourage individuals to look at the world with fresh eyes, create hypotheses to
21
22 explain their surroundings and desired futures, and adopt cognitive acts to reduce the
23
24 psychological uncertainty associated with ambiguous situations. In this article, we illustrate
25
26 how we train students to apply four well-established cognitive acts from the design cognition
27
28 research paradigm—framing, analogical reasoning, abductive reasoning, and mental
29
30 simulation—to opportunity creation. Our pedagogical approach is based on scholarship in
31
32 design cognition that emphasizes creating preferred situations from existing ones rather than
33
34 applying a defined set of tools from management scholarship. In doing so, we provide
35
36 avenues for further development of entrepreneurship education, particularly the integration of
37
38 design cognition, particularly the integration of
39
40 design cognition.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1. INTRODUCTION

As universities around the world have incorporated entrepreneurship education (Oxford, 2013), scholars and entrepreneurs alike have grown increasingly skeptical of the usefulness of traditional teaching methods, which rely on business plans, case studies, and guest speakers (Gartner & Vesper, 1994; O'Connor, 2013; Vesper & Gartner, 1997; Williams Middleton & Donnellon, 2014). After all, entrepreneurs (Busenitz & Barney, 1997; Dyer, Gregersen, & Christensen, 2008; Sarasvathy, 2001) think very differently from managers and the rest of the population. The ill-defined nature of entrepreneurial problems contradicts students' expectations of well-defined processes aimed at reaching a single answer with significant guidance from instructors (Austen, 2012).

In response, many business schools, and even entrepreneurial programs, are adopting design thinking techniques and tools. To strengthen students' understanding of these design thinking tools, we claim that teachers should emphasize their cognitive underpinnings. A lucid comment from one of our students about customer journey maps supports our assertion. The student commented that "due to the complex and personal nature of decision-making, it is not always possible to map an experience as a set of linear, cause-and-effect steps. Doing so results in only a partial understanding of the journey, with no consideration of the user's context and past experiences." At the end of the course, he offered the following reflection. "By supplementing these tools with additional cognitive activities, such as framing and abductive reasoning, we gain a deeper appreciation of not only what the user is feeling, but why they are feeling that way. Ultimately, this allows us to comprehend the root cause of the user's frustrations, but also leads to a broader understanding of the problem. It is this broader

1
2
3 understanding at a higher level of abstraction that leads to genuine and impacting
4
5 innovation.”¹
6

7 This article extends recent contributions to entrepreneurship scholarship (Glen, Suci,
8 & Baughn, 2014; Van Burg & Romme, 2014) to explicate how design thinking, defined as the
9 cognition, processes, and tools designers use to imagine a desired future, informs the process
10 and skills needed to spot and develop opportunities (Garbuio & Lovallo, 2015). Specifically,
11 we respond to Glen et al.’s (2014) call to incorporate design thinking in entrepreneurship
12 education in a way that complements, rather than replaces, the analytical tools and teaching
13 styles of most business schools. To do this, we expand on a stream of design thinking
14 scholarship (Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013) that advocates
15 consideration of the cognition that underlies design thinking methods. Analytical reasoning,
16 the typical mode of reasoning taught in business schools, equips students with cognitive skills
17 and technical methods to deal with varying degrees of uncertainty; however, there is a gap in
18 management education when it comes to addressing complex, ill-defined problems with
19 scarce or ambiguous facts and unclear means-end relationships (Schön, 1983). Design
20 cognition addresses these gaps by identifying specific cognitive acts and structures associated
21 with productive outcomes to open-ended and unstructured situations.
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

41 Four recent and convergent developments support the need for a more nuanced
42 understanding of the contribution of design cognition to entrepreneurship education: (1)
43 opportunity creation as a cognitive skill, (2) the fact that opportunities are created rather than
44 discovered, (3) the popularity of lean start-up approaches (which further exemplifies the
45 practical resolution of the debate between opportunity discovery and creation), and (4) design
46 thinking as a cognitive rather than process-based construct.
47
48
49
50
51
52
53
54

55
56
57 ¹ Massimo Garbuio thanks Rob Dongas for this reflection.
58
59
60

1
2
3 First, the entrepreneurial field increasingly acknowledges that opportunities emerge
4 from cognitive skills (Baron, 2004, 2006; Baron & Shane, 2007; McGrath & MacMillan,
5 2000) that can be developed and enhanced through education (DeTienne & Chandler, 2004;
6 Fiet, 2002; Muñoz, Mosey, & Binks, 2011). Design cognition scholarship provides a well-
7 researched and teachable set of cognitive acts, including convergent and divergent thinking,
8 framing, analogical reasoning, pattern recognition, counterfactual thinking, mental simulation,
9 and abductive reasoning (Baron, 2004; Cornelissen & Clarke, 2010; Gaglio, 2004; Grégoire,
10 Cornelissen, Dimov, & Burg, 2015; Mitchell et al., 2002). Yet many instructors do not know
11 how these processes contribute to opportunity creation and how to effectively introduce
12 students to these acts.
13
14
15
16
17
18
19
20
21
22
23
24

25 Second, the longstanding debate over whether opportunities are discovered or created
26 (Alvarez & Barney, 2010) has been resolved, in practice rather than theory, by budding
27 entrepreneurs' preference for methods that are compatible with creation rather than discovery.
28 Specifically, older scholarship in entrepreneurship has explored how exogenous shocks to
29 preexisting industries form opportunities, which unusually alert individuals or firms discover
30 (Kirzner, 1989; Shane, 2003). Newer approaches instead lean toward the assumption that
31 entrepreneurs themselves form opportunities endogenously through an enactment process
32 (Aldrich & Ruef, 2006; Shane & Venkataraman, 2003). The difference has profound
33 pedagogical implications. In the discovery approach, opportunities can be identified through
34 typical tools of strategic analysis, such as evaluating threats and opportunities in the
35 environment (Porter, 1980). The central features of the creation approach are a willingness to
36 experiment and an ability to learn from experimentation (Alvarez & Barney, 2010). This
37 learning requires creativity, mental flexibility, the ability to be open to conflicting feedback,
38 and a willingness to fail and learn from experience. In contrast, the discovery approach draws
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 on the techniques for strategic analysis for pedagogy; those teaching creation opportunities
4
5 are inspired more by creative design and art (Baker & Nelson, 2005; Sarasvathy, 2001)
6

7 Third, the increasing pace and dynamism of business environments, in which
8
9 entrepreneurs pitch their ideas, suggest that an extensive business plan is often not feasible.
10
11 The lean start-up approaches taught as part of accelerators and incubators provide incentives
12
13 for students to pitch both raw and well-formed ideas, refine them, and iterate until a
14
15 commercially viable concept emerges. Accelerators, incubators, and online programs offer
16
17 both brief and long courses on developing opportunities and business models, often filling the
18
19 gap left by conventional entrepreneurship courses. For entrepreneurs, the frameworks and
20
21 concepts of the lean start-up (Ries, 2011), the business model canvas (Osterwalder & Pigneur,
22
23 2010), the long-term value of customers, and the cost of acquiring a customer are far more
24
25 commonly used than the strategic analysis tools introduced in early entrepreneurship
26
27 education. Both lean start-up and the business model canvas approach refer to design thinking
28
29 tools and processes, though they shy away from explicitly teaching the cognitive acts that
30
31 facilitate the development of new opportunities.
32
33
34
35

36 Finally, as entrepreneurial scholarship has emphasized the cognitive aspects of
37
38 opportunity creation, so has design thinking (in design studies scholarship) emerged as a
39
40 cognitive rather than procedural construct (Visser, 2006, 2009). Teaching cognition rather
41
42 than process has also emerged as a fundamental pedagogical perspective (Eastman, 1999;
43
44 Oxman, 2004) in which the cognitive acts rather than the process of design comprise the
45
46 explicit teaching content. Similarly, in a meta-analysis of creativity training, cognitive
47
48 strategies have indeed been found to play a critical role in enhancing individuals' creative
49
50 skills (Scott, Leritz, & Mumford, 2004). The role of the educator is to challenge students with
51
52 questions that lead them to think differently about problems (Gómez Puente, van Eijck, &
53
54 Jochems, 2013a; Gómez Puente, van Eijck, & Jochems, 2013b). Over the years, and across
55
56
57
58
59
60

1
2
3 disciplines, as design thinking has evolved into different meanings, its foundations often have
4
5 been taken for granted (Johansson-Sköldberg et al., 2013). A fundamental distinction can be
6
7 made between the evolution of design thinking in the *design discourse* and in the
8
9 *management discourse*. Some time ago, the research focus of design discourse shifted toward
10
11 the discovery of cognitive skills, reflective practice, and the creation of meanings, among
12
13 other aspects. Meanwhile, the latter has become popular through a narrower interest on (1)
14
15 how designers work (Brown, 2008, 2009; Kelley, 2007), relying heavily on IDEO's way of
16
17 working with innovation; (2) a way to approach organizational problems from a practical
18
19 perspective (Dunne & Martin, 2006; Liedtka & Ogilvie, 2011; Martin, 2009); and (3)
20
21 management theory, which views design thinking as an organizational resource leading to
22
23 innovation (Collopy & Boland, 2004).
24
25
26

27
28 In this article, we adhere to design thinking rooted in the cognitive design discourse,
29
30 which recommends that designers and educators nurture a set of cognitive skills rather than
31
32 processes and tools. In the cognitive design research paradigm, design practice emanates from
33
34 a set of cognitive acts and forms of knowledge representations associated with the parallel
35
36 feat of creating a new object, service, or system and the way this new creation works (Dorst,
37
38 2011). The cognitive acts presented here are based on empirical research spanning over 60
39
40 years (Cross, 2007), which confirms that the choice of cognitive acts and the forms of
41
42 knowledge representations determine the productivity of the designer and the quality of the
43
44 solution. With this in mind, we are able to provide a clearer contribution to entrepreneurial
45
46 education by building on the most current design discourse.
47
48

49
50 Next, we review current approaches to entrepreneurial education, expand on key
51
52 emerging trends and show how design thinking and design cognition have reached both
53
54 scholarship and practice. Then we briefly expose the four cognitive acts at the basis of design
55
56 and entrepreneurial cognition and follow with a framework for a design-driven
57
58
59
60

entrepreneurship education. We conclude with a discussion of applications of this approach and some final remarks.

2. ENTREPRENEURIAL EDUCATION: A ROAD PAVED BY DESIGN COGNITION

Over the years, entrepreneurship education has evolved dramatically in part due to influences from other fields. Table 1 summarizes key approaches and provides some considerations to contextualize our own approach.

Insert Table 1 about here

Initially, entrepreneurship education was shaped by the *planning school*, suggesting that opportunities are discovered through meticulous business-plan development and systematic search (Fiet, 2002; Herron & Sapienza, 1992). Over time, it became apparent that entrepreneurs themselves can create opportunities through an endogenous enactment process. Some examples include: the *contingency planning approach*, which emphasizes divergent thinking, a perspective that train entrepreneurs to better recognize opportunities through a process that unfolds over time; *opportunities-centered learning*, which focuses on exploration and development of opportunities through case studies; and, *effectual entrepreneurship*, which encourages entrepreneurs to develop goals based on personal strengths and available resources.

Entrepreneurship scholars and practitioners increasingly call for design thinking concepts and design methodologies to assist with entrepreneurship teaching and new venture creation more broadly (see, e.g., Glen et al., 2014; Van Burg & Romme, 2014). Design thinking has been identified as an efficient way of dealing with highly uncertain situations and uncovering unanticipated problems early (Fixson & Rao, 2014; Fixson & Read, 2012).

In the practice of entrepreneurship education, the lean start-up approach and the business model canvas practice both build on the management discourse of design thinking.

1
2
3 The *lean start-up approach* (Blank, 2013; Ries, 2011) incorporates aspects of the
4 management discourse of design thinking. Stemming from quality improvement and
5 engineering, lean methodology encourages entrepreneurs to focus on experimenting and
6 getting feedback from potential customers for the next development iteration rather than
7 following a rigid business plan. A lean start-up creates a “minimal viable product,” a product
8 with the minimum features customers need so that it can be “pivoted” or changed along the
9 way based upon feedback. Like the management discourse, it encourages iteration, but its
10 focus on developing a functioning commercial prototype means that it devotes less time to
11 broadly and deeply characterizing the problem and ideating on solutions, as design thinking
12 emphasizes. It also assumes that the firm should validate hypotheses about product and
13 feature desirability with users in the marketplace. This methodology has been widely adopted,
14 especially by incubators and government agencies such as the U.S. National Science
15 Foundation in its Innovation Corps program.²

16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32 Although the *business model canvas approach* is not derived from design thinking and
33 involves setting up a different problem (i.e., the business model itself), it shares several
34 characteristics with design thinking: a focus on identifying users’ needs, a cross-disciplinary
35 view of the “business model” and its underlying value proposition (the product or service
36 “design”), and significant collaborative work for ideating new business models. Accordingly,
37 the business model canvas approach resembles design thinking’s phases as described in the
38 management discourse of design thinking, and some of its tools, such as empathy maps and
39 persona profiles (Johansson-Sköldberg et al., 2013).

40
41
42
43
44
45
46
47
48
49
50 In managerial scholarship, the concept of design thinking is rather equivocal, largely
51 because design thinking has entered the field from design practice rather than from design
52 scholarship. The tools and processes of design thinking brought into management practice—

53
54
55
56
57
58
59
60
² National Science Foundation (2013). New grants to Innovation Corps "Nodes" further enhance public-private partnership. http://www.nsf.gov/news/news_summ.jsp?cntn_id=127011 (Accessed Oct 1, 2015).

1
2
3 user-centricity, journey mapping, prototyping, and experimentation—differ from those
4
5 prevalent in design scholarship and the focus of our study. Although the processes,
6
7 techniques, and tools of design are indeed relevant to management, in design research, the
8
9 object of study has turned toward the behaviors of design practitioners. Design researchers
10
11 seek to explain designers' behaviors through the causal importance of the structures and
12
13 processes of cognition, such as prototyping and its psychological outcomes, rather than
14
15 through their tools and methods *per se* (Gerber & Carroll, 2012). Hence, design cognition
16
17 research focuses on identifying productive mental representations, structures, and processes
18
19 for various design situations (Goel & Pirolli, 1992).
20
21

22
23 Furthermore, a critical limitation of lean start-up and business model canvas and
24
25 related approaches is their reliance on a structured, step-by-step process (Liedtka & Ogilvie,
26
27 2011), which may restrict their usefulness in dynamic business environments. Linearity may
28
29 be an artifact of pedagogical and communication needs, but we have found, and instructors
30
31 have noted, that proceeding in a fixed linear sequence can help students see where they are in
32
33 the process and, more importantly, what knowledge they are gaining with a discrete stage. Yet
34
35 design scholarship reveals that design as a fixed process does not work, as it may lead to
36
37 design fixation, “a blind, and sometimes counterproductive adherence to a limited set of ideas
38
39 in the design process” (Jansson & Smith, 1991, p.4).
40
41

42
43 Thus, design scholars suggest that problems and solutions must co-evolve to generate
44
45 the most novel yet feasible solutions (Maher, 2000; Wiltchnig, Christensen, & Ball, 2013).
46
47 When problem formulation can be modified, there is no clear linear sequence of problem
48
49 definition, enumeration of solutions, and selection of a solution. Rather, the solution emerges
50
51 from one problem frame that can be modified as a result of an emergent solution, thereby
52
53 yielding different solutions (Dorst & Cross, 2001). Similarly, an understanding of the
54
55
56
57
58
59
60

1
2
3 customer problem to be solved can change over time by iterating the proposed solution and its
4
5 validation, whether through mental simulation (explained later) or physical prototypes.
6

7 Hence, it is critical to master a set of cognitive acts that can be flexibly applied in
8
9 various situations, rather than focus on tools and techniques that risk becoming routinized
10
11 (such as Porter's Five Forces). Some educators might initially find it helpful to follow the
12
13 design stages/cognitive acts in a phased manner. Notably, any process or design tool has a set
14
15 of underlying cognitive acts that can be opaque to practitioners—sometimes deliberately so.
16
17

18 19 **3. THE THINKING IN DESIGN THINKING**

20
21
22 This section establishes the cognitive language of design thinking that we apply to
23
24 entrepreneurship education in the next sections. Design cognition research (Visser, 2006,
25
26 2009), as well as option generation research (Garbuio, Lovallo, Porac, & Dong, 2015), have
27
28 identified four fundamental cognitive acts: framing, analogical reasoning, abductive
29
30 reasoning, and mental simulation. We briefly introduce these four cognitive acts; the
31
32 references in Table 2 offer more in-depth theoretical and empirical investigations of them.
33
34

35
36 A creative solution is based on the novel standpoint from which a problematic
37
38 situation can be tackled, an act referred to as *framing* (Dorst, 2011). The cognitive act of
39
40 framing (or reframing a “stale” problem) is widely regarded as a key creative aspect of the
41
42 design process (Cross, 2006; Lawson, 1997). In entrepreneurship and design, every problem
43
44 has a problem frame and a solution frame, which are defined through *problem framing* and
45
46 *solution framing*.
47

48
49 *Analogical reasoning* is the cognitive act of transferring the properties of a source
50
51 domain to a target domain based on an abstract conceptualization (mental representation) of
52
53 structured similarity between the two domains (Holyoak & Thagard, 1995). Analogical
54
55 reasoning is a part of human cognition (Hofstadter & Sander, 2013), as it can occur
56
57 spontaneously (Goldschmidt, 1999; Hofstadter, 2001).
58
59
60

1
2
3 Unlike deductive and inductive reasoning, which seek to produce logically true
4 conclusions, *abductive reasoning* is a form of logical reasoning that introduces a hypothesis
5 aimed at explaining observations or data (Peirce, 1931, 1998). The hypothesis may or may not
6 be logically or empirically true. In classical logical reasoning, abductive reasoning proposes
7 the most plausible and parsimonious explanation for observations. Dorst (2011) describes two
8 types of abduction in design: explanatory abduction and innovative abduction. Explanatory
9 abductions introduce hypotheses to explain surprising observations. While innovative
10 abductions introduce hypotheses about a new product, service, or system and its working
11 principle that influence the production of the only known observation: the intended value.
12
13

14
15
16
17
18
19
20
21
22
23 *Mental simulation* involves reassessing past events and imagining future environments
24 before making decisions and taking action (Sanna, 2000). According to Gaglio (2004), mental
25 simulation is a key cognitive act of entrepreneurs as it allows emotions to be re-experienced
26 and helps individuals anticipate physical and social environments by envisioning strategies
27 and tactics to make accurate estimates and enable goal achievement.
28
29
30
31
32

33
34 -----
35 Insert Table 2 about here
36 -----
37

38 **4. APPLYING DESIGN COGNITION TO OPPORTUNITY CREATION**

39
40
41 In this section, we elaborate on a fundamental theme in entrepreneurial education (Kickul,
42 Janssen-Selvadurai, & Griffiths, 2012) for which the integration of design cognition provides
43 the greatest value: opportunity discovery.³ We discuss key cognitive acts from design
44 cognition and integrate them into opportunity creation (see Figure 1). Notably, we focus on
45 the thinking aspect of design thinking rather than on tools, techniques, and processes, as the
46
47
48
49
50
51
52
53
54

55
56
57
58
59
60

³ There is no doubt that business model design, scalability, and financial resources are fundamental to the success of startup companies. However, opportunity creation appears to be the most urgent area for cognition, both theoretically and from an educational point of view.

1
2
3 latter have been extensively discussed in design thinking toolkits (see, e.g., Fraser, 2012;
4
5 Liedtka & Ogilvie, 2011).
6
7

8 -----
9 Insert Figure 1 about here
10 -----

11 The emergence of opportunities, whether recognized or created, is one of the most
12 discussed topics in entrepreneurial research (Ardichvili, Cardozo, & Ray, 2003; Kirzner,
13 1973; Schumpeter, 1934; Short, Ketchen, Shook, & Ireland, 2010). A wealth of research
14 identifies preconditions of opportunity recognition, including prior knowledge and external
15 conditions (Shane, 2000; Shepherd & DeTienne, 2005), the thought processes that transform
16 knowledge and observations of the environment into opportunities (Cornelissen & Clarke,
17 2010; Ucbasaran, Westhead, & Wright, 2009) and the impetus to act on them (Dimov, 2007).
18 Importantly, opportunity creation comprises a large component of entrepreneurship courses
19 and a very specific aspect of entrepreneurial education. Whereas marketing, operations, and
20 strategy are assumed to be prerequisite knowledge for entrepreneurship courses, opportunity
21 creation and the creation of new business models for resource-constrained startups are
22 peculiar aspects of entrepreneurial education (Kickul et al., 2012). While entrepreneurship
23 education research identifies various approaches to search for problems to solve, opportunity
24 creation has often been described as a creative process (Lumpkin, Hills, & Shrader, 2004).
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

43 Overcoming the comfort of familiar situations is the key hurdle facing opportunity
44 creation (Berns, 2008). Alvarez and Barney (2010) highlight that prior industry or market
45 experience may actually hinder learning (Sine, Haveman, & Tolbert, 2005; Weick, 1979).
46 While “natural” entrepreneurs and innovators alike constantly question the existing order
47 (Dyer et al., 2008), students often have difficulty looking at the world with fresh eyes to
48 discover unmet needs. Entrepreneurial alertness, information asymmetry, prior knowledge,
49 social networks, personality traits, and type of opportunity all influence the process of
50
51
52
53
54
55
56
57
58
59
60

1
2
3 opportunity creation (Ardichvili et al., 2003).

4
5 Studies in entrepreneurial cognition have highlighted that opportunity emerges from
6
7 pattern recognition (Baron, 2006; Baron & Ensley, 2006), similarity judgments (Grégoire,
8
9 Barr, & Shepherd, 2010), and associational thinking (Dyer et al., 2008). Gielnik and
10
11 coauthors (2012; 2014) investigate the role of divergent thinking, or the general ability to
12
13 identify multiple original ideas (Guilford, 1950), in opportunity recognition. They postulate
14
15 that divergent thinking is the end product of more specific cognitive acts, such as conceptual
16
17 combination, analogical reasoning, and abstraction (Mumford, 2003; Ward, 2007; Welling,
18
19 2007). However, from a pedagogical (and experimental) perspective, there is reason to
20
21 examine these processes separately, as we have done. During opportunity identification, we
22
23 help students use all four cognitive acts to define and elaborate on ambiguous problems and
24
25 identify new opportunities (see Figure 2 for examples of usage).
26
27

28
29
30 -----
31 Insert Figure 2 about here
32 -----
33

34 **4.1.1. Framing in opportunity creation**

35
36 Framing aims to establish alternative ways of interpreting situations in accordance
37
38 with different perspectives on various dimensions. These may be achieved by observing
39
40 situations involving user behavior, user- or designer-generated problem statements, and even
41
42 solution concepts and their underlying principles (used to induce backwards the “problems
43
44 solved”). Specifying when and where framing occurs allows the designer to name and clarify
45
46 the bounds of problem and solution spaces and provides a systematic way of expanding those
47
48 spaces.
49

50
51 The most common act of framing is to help students see different types of users and
52
53 stakeholders as individuals rather than as “average users.” For example, when working on a
54
55 credit card project, it is important to interview not only card users and their families, but also
56
57
58
59
60

1
2
3 call-center staff, employees in shops where the cards will be used, and even those who cannot
4 afford to use credit cards. In general, the range of problem frames encountered will depend on
5
6 the sample of users and the manner of data collection.
7
8

9
10 An in-class reframing exercise that we find effective is inspired by the reframing
11 approach of the Austin Center for Design. In this exercise, Center instructors use a toothbrush
12 as the object of design and ask students to consider three new scenarios. First, they ask them
13 to reframe the toothbrush as it would be used in an atypical environment (e.g., in the kitchen,
14 in an airplane, at a conference). Second, they ask the students to reframe the toothbrush from
15 a different perspective (e.g., for use by a dentist, a hotel housekeeper, a blind date). Third,
16 they ask the students to reframe the toothbrush as a different type of object; what if it were a
17 plant, a spray, or a service? The new frames help students observe unmet customer values,
18 which become novel problems to address.
19
20
21
22
23
24
25
26
27
28

29
30 There are several ways we can induce framing and reframing. *Abstraction* is a means
31 of stepping back and reconsidering problems more generally or through opposites. Based on
32 design creativity, abstraction involves prompting students with abstract variations of
33 statements of their current design problem or solution formulation to help them think
34 creatively about problem or solution (Chiu & Shu, 2008; de Vries, Jessurun, Segers, &
35 Achten, 2005; Linsey, Markman, & Wood, 2012). Abstract variations use words that subsume
36 a concept, such as is-a (e.g., a dog is a pet) and has-a (e.g., a dog has a companion)
37 relationships. For example, we prompt students who imagine a start-up aiming to challenge
38 the insurance industry to think in terms of pricing risks rather than selling insurance policies.
39 We could reframe the opportunity in terms of a more abstract concept, pricing intangible
40 value, because risk is an intangible value.
41
42
43
44
45
46
47
48
49
50
51
52

53
54 In the classroom, we have implemented abstraction in the spirit, if not the form, of
55 experiential learning (Amador, Miles, & Peters, 2006; Duch, Groh, & Allen, 2001; Kolb,
56
57
58
59
60

1
2
3 1984). Rather than teaching this framing technique to students directly, we let them explore
4
5 different ways of looking at a situation by organizing a simulated experimental session in
6
7 class. After organizing the class into two groups, we ask one group to redesign an object (e.g.,
8
9 the classroom) and the other to redesign a concept (e.g., how we educate people). When we
10
11 move toward the solution stage, the second group systematically provides many and more
12
13 interesting solutions because it had a larger problem space. Some of these solutions might not
14
15 be feasible, but this is not important during the opportunity-identification stage.
16
17

18
19 Directing students to *think in opposites and extremes* can help them frame situations
20
21 in novel ways to reveal new dimensions and perspectives. Thinking in opposites is a common
22
23 method of creative thinking (Rothenberg, 1973). For example, when students are looking for
24
25 opportunities for a new insurance startup, instead of having them focus on innovative ways to
26
27 “price risk” (the fundamental activity of an insurance company), we ask them to “price love.”
28
29 This challenge sparks ideas they would not have discovered if the focus had been on the
30
31 insurance business itself. They may then apply analogical reasoning, as they wonder how they
32
33 can adopt principles from companies that price love (e.g., De Beers) to the situation at hand.
34
35
36

37 **4.1.2. Abduction in opportunity creation**

38
39 Abductive reasoning is a cognitive act in which we invent a hypothesis to explain
40
41 observations that are often surprising. Importantly, these hypotheses may or may not be
42
43 logically or scientifically true. If the hypotheses were already known to be true, there would
44
45 not be much scope for entrepreneurial action since revenue generation models would be well
46
47 established. Getting students to recognize that they are involved in abductive reasoning is
48
49 important, as it helps alleviate the bias of prior knowledge or known reasons.
50
51

52
53 The two types of abductive reasoning are useful in two different circumstances: when
54
55 we are inferring reasons for an observation (e.g., a user behavior) and when we infer an idea
56
57 that a user will respond to in certain ways. *Explanatory abduction*, is a form of reasoning in
58
59
60

1
2
3 which individuals hypothesize novel explanations to empirical observations. The aim is to
4
5 avoid pattern-recognition bias by explaining observations through recourse to alternative
6
7 relationships between causes and effects. This is the typical instance in which we ask students
8
9 to explicitly search for surprising facts and observations that show some value to users and
10
11 then find a cause-effect relationship that explains them.
12

13
14 The second, *innovative abduction*, is a form of reasoning in which we hypothesize
15
16 about what to create (i.e., product, service, or system) and its working principle to arrive at an
17
18 aspired value (the only “known”) (Dorst, 2011). The hypothesis explains the causal reasons
19
20 for the existence of the value; that is, if the hypothesis turns out to be empirically true, then
21
22 the value exists. In this case, the challenge is not only to understand what needs to be true to
23
24 support the observation or what new value to create for the user, but also to come up with a
25
26 new rule that makes the new value come alive, such as the need to create a new business
27
28 model (for more details, see Dong, Garbuio, and Lovallo (2016a, 2016b)).
29
30
31

32 In facilitating prospective and actual entrepreneurs in our classes to construct
33
34 abductive hypotheses, we have observed two characteristics. First, the process helps
35
36 prospective entrepreneurs better qualify and quantify the market need and value of their
37
38 proposed offering, as it grounds their assumptions in actual behaviors and observations rather
39
40 than in secondary research on markets and segments. Second, we find that prospective
41
42 entrepreneurs generate opportunities to satisfy needs that go beyond the offering they
43
44 originally had in mind. For instance, during the study of a user experience at the movies,
45
46 students originally hypothesized that the user who was going to the movies regularly was
47
48 looking for “a convenient offer”. A more robust ethnography (e.g., observations of filmgoers),
49
50 open-ended interviewing, and a lecturer’s recollection of seeing Japanese businessmen
51
52 dressed in suits watching movies in the middle of the day identified the surprising observation
53
54 that many filmgoers did not search for a movie to watch – they simply went into the theater.
55
56
57
58
59
60

1
2
3 The students hypothesized instead that moviegoers were looking for “an escape-life
4
5 opportunity.
6

7 Overall, to help students in their journey, we stress the importance of observations that
8
9 students find surprising (given their knowledge), workarounds that users employ, and
10
11 contradictions (e.g., between what the user says and her behavior). These points are often
12
13 sufficient to help students create hypotheses to explain their observations of (possibly true
14
15 reasons for) customers’ behaviors and, in so doing, to help them break free of existing
16
17 preconceptions, such as “believed sources of problems.”
18
19

20 21 22 **4.1.3. Analogical reasoning in opportunity creation**

23
24 New opportunities can emerge from making novel associations between existing
25
26 things (Bar, 2009) and learning from others’ success and mistakes. Analogical reasoning
27
28 hence assists in increasing opportunity creation and productivity. Analogies have figured
29
30 prominently as inspirations for architectural design, wherein a building is designed to “look
31
32 like” a natural object, but also to exert a framework over subsequent sequences of problem
33
34 formulation, interpretation, and solution assessment (Rowe, 1982). In design cognition,
35
36 analogies are used in problem formulation (Visser, 1996), problem solving (i.e., ideation of
37
38 solutions and “inspiration” (Goel, 1997; Holyoak & Thagard, 1996; Rowe, 1982)), and
39
40 uncertainty resolution to explain whether proposed solutions could work (Ball & Christensen,
41
42 2009). Scholars have identified two types of analogies: within-domain (close field) and
43
44 between-domain (far field) analogies (Vosniadou & Ortony, 1989). Between-domain
45
46 analogies typically are used in problem formulation (in our case, primarily in opportunity
47
48 creation); within-domain analogies are primarily used in uncertainty resolution; and solution-
49
50 oriented analogies are a mixture of within- and between-domain analogies (Christensen &
51
52 Schunn, 2009).
53
54
55
56
57
58
59
60

1
2
3 At the most basic level, working with analogies forces students to explore the source
4 of the analogy (the exemplar) and its structural characteristics, and to transfer these solution
5 principles to the case at hand (Blanchette & Dunbar, 2000). Instead of letting students use the
6 exemplar at a very basic level (e.g., we should be the Uber of our industry), we ask them to
7 identify key characteristics of the exemplar (e.g., the matching mechanisms, the entry
8 strategy) and examine the extent to which these characteristics can be transferred to the target
9 domain.
10

11
12 An intriguing application of analogical reasoning lies in thinking about a new product,
13 service or business model using the analogs and antilogs technique. As Mullins and Komisar
14 (2009) discuss, business ideas do not have to be revolutionary; rather, entrepreneurs can
15 develop them by looking at analogs—what has worked in the past—and imitating or building
16 on these exemplars. Ideas can also be developed by looking at antilogs—businesses that have
17 been unsuccessful—and avoiding past mistakes (Mullins & Komisar, 2009).
18

19
20 We use the example of Apple's iPod to explain analogs and antilogs. In a reverse-
21 engineering exercise, we could say that the Sony Walkman is the analog that inspired Apple.
22 Because the Walkman proved that millions of people were willing to pay for a device that
23 allow them to listen to music on the go, Apple did not need to create or validate this
24 hypothesis.⁴ Apple also could have developed valuable insights by looking at antilogs, such as
25 Napster, to develop a legitimate platform for downloading music: the iTunes store. The
26 popularity of Napster as a peer-to-peer music-sharing site signified a growing trend toward
27 downloading music. After piracy and illegal downloading led to Napster's ultimate failure,
28 Apple created an online store where people could download and save music after paying a
29 small fee to avoid such legal issues.
30
31

32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
⁴ Note how this hypothesis was confirmed. Prior to this confirmation, it was an abductive hypothesis. In this case, we used analogical reasoning to confirm a hypothesis. In fact, the invention of the Walkman itself also depended on the abductive hypothesis and analogy that people would enjoy personalized music on the go, just as they enjoy other personalized experiences on the go, such as reading newspapers or talking.

4.1.4. Mental simulation in opportunity creation

Mental simulation is proposed as a key cognitive act for opportunity creation (Gaglio, 2004), especially once a proposal for a new product, service or business model has been devised. Mental simulation helps the transition from a newly identified opportunity to a better one, allowing for predictions of the outcomes of its possible implementation, even in the absence of data or previous experience. Unlike traditional means of prototyping, which only focus on a single user's perspective, mental simulation illustrates the broad class of simulative experiences necessary to operate a competitive business.

Once students have identified a new opportunity, we ask them to mental simulate in two areas. First, we focus on how to make the opportunity work in the marketplace from a business model perspective. Next, we ask them to simulate the scaling of the business, such as expanding into new occasions of consumption and new geographies. Third, we ask students to mentally simulate competitors' reactions. We ask them to go beyond identifying which competitors and competing technologies are capable of thwarting the new venture to stress-test the opportunity. This last step can be supported by traditional business model and strategy frameworks (Hambrick & Frederickson, 2001; Porter, 1980). More specifically, we encourage students to consider the following questions: Are these customer needs scalable to other customer segments? How will competitors react? How will we defend our position? Who are we displacing in the value chain? Do we have the capabilities needed to produce the new offering? Which capabilities are we missing? Do we need partners? Will we create value for them? In sum, mental simulation help them identify deficiencies and contradictions within the structure of the solution and fundamentally improve it (Dörner, 1999).

5. A THOUGHT EXPERIMENT

In this section, we illustrate how we use the cognitive acts to help students identify new opportunities, whether products, services, or business models. Figure 3 summarizes our

1
2
3 eight-step approach to better understanding opportunity creation, which we describe in detail
4
5 below. Notably, educators do not have to follow this process step by step, just as their
6
7 students won't as they identify extraordinary opportunities. However, this process should help
8
9 them get a flavor for the cognitive acts that are in play.
10

11
12 -----
13 Insert Figure 2 about here
14
15 -----

16 At the very start, we ask the students to identify the problem they are trying to
17
18 solve—e.g., from a user perspective—and any solution that is already available or that they
19
20 have in mind (typically, a very rough idea of what the new product or service will look like).
21
22 For the first step, we question students to help them reframe the problem from a different user
23
24 perspective or by describe the problem more abstractly. For example, we might reframe the
25
26 problem of reducing street violence by reframing it as the problem of how to help young
27
28 people have fun in their free time. This allows us to view the problem broadly and solve
29
30 different kinds of problems. An example from a different industry or even a different
31
32 biological system (analogical reasoning) can also be useful. We might ask, how would nature
33
34 solve this problem? Bio-mimicry and biological analogies are fairly common sources of
35
36 inspiration for new frames in architecture and design (Benyus, 1997; Mazzoleni, 2013).
37
38
39

40 Second, we ask students to create (innovative abductive) hypothesis for a new
41
42 offering. When students are stuck, we prompt them to think about different user needs,
43
44 different types of users, and completely new services and occasions of consumption. The
45
46 innovative abduction will help generate a new problem frame and solution frame.
47
48

49 Third, we ask them to state the new frames, which will be the focus of the rest of the
50
51 thought process. Generally, the new frames tend to be broader than the initial ones, allowing
52
53 for greater opportunities for innovation as they target larger, new, or emerging markets.
54
55
56
57
58
59
60

1
2
3 Fourth, we ask students to consider how to make an opportunity work in practice. At
4 this stage, the solution concept might still be very hypothetical (Is it technically feasible?
5 Financially viable?). It is often useful to find an analogy and transfer the principles from one
6 existing, proven solution to the case at hand. Typical prompts might include: “What would
7 you do if you were Uber? What would you do if you were eBay?” Such questions help
8 students think about a problem more abstractly (for example, as a platform business or a
9 platform-based marketplace). Design by analogy is a powerful technique, as numerous
10 products and architectural forms have been designed through being based on analogies with
11 nature or forms in other domains. In architecture for instance, one of the most well-known is
12 the Sydney Opera House, whose roofs mimics sails (Dorst, 2015). In business, the common
13 business model of a razor and blades mimics Gillette’s original sales proposition.
14
15
16
17
18
19
20
21
22
23
24
25
26

27 The fifth step is to create an explanatory (abductive) hypothesis to explain the
28 existence of the new product and a hypothesis that would negate the existence of the new
29 product. Typical questions we use to encourage explanatory abduction include, “Is there a
30 market for this problem if we use this kind of solution? Can it work?”
31
32
33
34
35

36 Sixth, we ask students to state the new opportunity in terms of “value that is delivered
37 to the customers” as well as the business models that emerged from the previous two steps.
38
39

40 Seventh, since the opportunity might still have several uncertainties (e.g., Is there a
41 market? How big is it? How urgent is the need for a solution? What will competitors do?), we
42 use mental simulation to prune off ideas that might be interesting but not currently feasible,
43 such as a lack of capabilities or available customers. Once these non-ideal solutions have been
44 eliminated, we are left with a solution that the students feel comfortable pushing forward (that
45 is, we have reduced the psychological uncertainty of facing the unknown).
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Finally, we can restate the problem and solution frames, and use more traditional
4 tools, such as strategic analysis, marketing planning, financial planning, to further develop
5 and validate the solution.
6
7
8
9

10 **6. RECOMMENDATIONS FOR EDUCATORS**

11
12 Educators of design thinking have to transition to teaching in a team-, project-, and studio-
13 based learning environment. This section provides recommendations on introducing design
14 cognition within a problem- and team-based pedagogy, which is the common approach to
15 entrepreneurship education. We then discuss the environment, based on studio learning; the
16 role of lecturers as coaches; external support from designers and the design community; and
17 the importance of students' critical reflection as a key learning tool.
18
19
20
21
22
23
24
25
26

27 **6.1. Design and Project-based Education**

28
29 Design education is fundamentally different from managerial education, as it is more about
30 coaching students in the discovery of problem and solution spaces than spoon-feeding them
31 information. Students who are accustomed to more common, traditional didactic teaching
32 methods tend to resist this new approach due to its uncertainty, messiness, and highly
33 qualitative, real-world aspects.
34
35
36
37
38
39

40
41 It is useful to keep in mind certain practices common to all project-based learning
42 approaches. First, if a client buys into the design process and is willing to accept, a modifiable
43 brief can be a useful starting point to transform a traditional course into a design-based one.
44
45 The problem statement is often bounded by the client's needs, which can address some of the
46 variables that students would otherwise have to explore themselves (e.g., Which real problem
47 should we solve? What situation should we study?). This "realness" comes from the client
48 providing objective and real feedback on the usefulness and appropriateness within the actual
49 domain for the output of each step. Of course, this is not always possible or even advisable
50
51
52
53
54
55
56
57
58
59
60

1
2
3 when the goal of the course is a full-immersion entrepreneurial journey from opportunity
4 identification to business model design. However, when the goal is to nurture entrepreneurial
5 mindsets in a relatively safe environment, the use of a client brief has proven to be helpful.
6
7

8
9
10 Second, continuous assessment is necessary in project-based learning. Having
11 milestones related to specific deliverables and “stages” of the process will help keep projects
12 aligned and moving forward. Under the true design approach, each team may slip back or
13 move ahead in stages, depending on its effort and returns on effort. However, teams should
14 illustrate learning points from their project on a regular basis.
15
16

17
18 Third, as project-based learning is effectively team-based learning, traditional
19 measures used to assure effective teamwork are needed (e.g., team composition, leadership,
20 and management processes). Much of the learning also comes from an appreciation of how
21 teams generate different or unique solutions to the same problem. Therefore, it is important
22 that teams share their intermediate and final outputs wherever possible.
23
24

25
26 Finally, design projects are often most effective when teams are multidisciplinary.
27 Well-known multidisciplinary programs such as Stanford’s d.school and Rotman’s
28 DesignWorks actively seek to “seed” their teams with students from different disciplines,
29 such as business, engineering, and design (Fixson, 2009; Fixson, Greenberg, & Zacharakis,
30 2015a; Fraser, 2012; Vogel, Cagan, & Mather, 1997). An engineering or medical student will
31 bring different perspectives on user problems and available technologies, as well as different
32 problem-solving mindsets than those found in business schools.
33
34

35 36 37 38 39 40 41 42 43 44 45 46 47 48 **6.2. The Environment: Studio Learning**

49
50 To facilitate this work, students need space to develop their ideas, both individually and as a
51 group. Design studios commonly used in fields such as architecture, industrial design, and art
52 have been adopted for design thinking spaces (Barry & Meisiek, 2015; Doorley & Witthoft,
53 2011). Many design studios have artifacts as their output require physical space. Similarly,
54
55
56
57
58
59
60

1
2
3 design-driven entrepreneurship education needs a space where we can display and continually
4
5 see research (as suggested by cognitive load theory, see Lee and Anderson (2013)) to remind
6
7 students of their journey toward a final goal. The team is usually composed in a very close
8
9 setting that encourages collaborative work. In the studio-learning environment, we bring the
10
11 entire class together to share moments that facilitate additional cross-team learning and
12
13 reflection while instructors serve as mentors, advisors, consultants, and critics (Fixson, 2009).
14
15

16
17 Spaces should be reconfigurable and readily available (Doorley & Witthoft, 2011),
18
19 and they should feel comfortable and relaxed. Teams working for long periods may need
20
21 space to store artifacts, whiteboards, and prototypes. Physical space should be designed to
22
23 support the skills and mindsets required by innovating activities (Fixson, Seidel, & Bailey,
24
25 2015b) and the practice of the cognitive acts. Well-known design spaces, such as those at
26
27 Stanford's d.school and Babson College's Design Zone, have a sparse, industrial look and
28
29 reconfigurable furniture that encourages participants to explore and rearrange the space as
30
31 their projects and ideas evolve (Barry & Meisiek, 2015; Doorley & Witthoft, 2011; Fixson et
32
33 al., 2015b). Rapid prototyping tools are increasingly a part of the setting, especially
34
35 entrepreneurship spaces associated with engineering schools.
36
37
38

39 **6.3. The Instructors: Lecturers as Coaches**

40
41 As a mentor and advisor, the lecturer's role is to help students examine a problem or solution
42
43 from different angles and see each perspective's strengths and weaknesses (Gómez Puente et
44
45 al., 2013a). Students often have a hard time recognizing the purpose of "following process,"
46
47 which is not to tie them down but to strengthen and organize their thinking. An examination
48
49 of the conversation in design reviews and entrepreneurship pitches found substantial
50
51 differences in the thinking processes of groups taught with the traditional didactic approach
52
53 and those taught with a design-driven approach (Dong, Garbuio, & Lovallo, 2016c). In the
54
55
56
57
58
59
60

1
2
3 former groups, questions were aimed at killing ideas, somewhat prematurely in the design
4
5 process; in the latter, questions were asked to stimulate new hypotheses and opportunities.
6

7 In our classes, we have found it is useful to clarify our position at the beginning of the
8 semester. We highlight how we assist students in generating questions that lead them to the
9 answers (describing it as a sort of Socratic method for philosophy and law students), whether
10 they need to bring it to the fore or search for it. We also explain that, due to the open-ended
11 nature of the problems we are dealing with, the answers are sometimes unknown.
12
13
14
15
16
17
18

19 **6.4. External support: Leveraging designers in class**

20 While designers may be new to business practice, instructors can benefit from encouraging
21 them to creatively cross-fertilize ideas, practices, and knowledge. To effectively implement
22 the design-driven approach, we recommend that instructors look for assistance from designers
23 who understand design cognition rather than design processes and who are able to mentor
24 students in the co-evolution of problem and solution frames or to co-mentor with business-
25 trained instructors in framing exercises. Students should learn the cognitive acts, which are
26 more generalizable and useful for them in the long run than specific tools and techniques.
27
28
29
30
31
32
33
34
35

36 For instructors seeking to adopt a design-driven approach to entrepreneurship
37 education, we recommend a gradual transformation that begins with shadowing someone else,
38 then developing one's own materials. In the end, design is still a "practiced" art more than a
39 science. We have found it useful to attend classes taught by designers or design-trained
40 faculty to absorb teaching methods and to understand the subtleties of various processes and
41 tools. Designers from traditional design professions can shed light on their creative processes
42 and ways of thinking. But unless they have been working in a real-world domain related to
43 what is being designed, they may not be as helpful at solving actual service-design problems.
44 We also find that inviting designers to class to discuss their problems (or, if serving as clients,
45 to discuss the problems they are posing to the class) and problem-solving approaches as "case
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 studies” can help introduce students to the “whys” of design thinking and its methods (i.e.,
4
5 why employ a certain technique at a certain point in time).
6

7
8 Importantly, the teaching team should include not only designers but also staff from
9
10 multiple fields. Indeed, the discovery of opportunities is not a single-person or single-insight
11
12 attribution (Dimov, 2007), but rather the result of a process in which a set of unitary, distinct
13
14 events lead to the emergence of a pattern (Oliver & Roos, 2005). Hence, we encourage a
15
16 multidisciplinary approach in which design, engineering, and law students attend
17
18 entrepreneurship classes with business students.
19

20 21 **6.5. The Students: Critical Reflection**

22
23 Fundamental to both design (Dong, Kleinsmann, & Deken, 2013; Valkenburg &
24
25 Dorst, 1998) and management (Schön, 1983), reflection helps students extrapolate learning
26
27 from a situation and improve their cognitive skills. At the end of each activity (e.g.,
28
29 observation or interview), we ask the students to reflect in a systematic way using a learning
30
31 template. We first ask them to acknowledge their previous knowledge and experiences on a
32
33 similar task, then about the surprises that emerged from this new application, and ultimately
34
35 how the experience is changing the way they will approach similar situations.
36
37
38
39

40 41 **7. CONCLUDING THOUGHTS**

42 43 **7.1. Implications for Entrepreneurship Scholarship**

44
45 Applying design cognition to entrepreneurship education raises several potentially
46
47 fruitful implications for the teaching of entrepreneurship. First, entrepreneurs’ awareness of
48
49 cognitive acts enables them to apply these acts with the most appropriate tools or even to
50
51 design their own tools. Importantly, whereas the processes, techniques, and tools are
52
53 sometimes not transferable to other domains, cognition is. For example, applying an overly
54
55 rigid user experience perspective when designing a market entry strategy for a start-up creates
56
57
58
59
60

1
2
3 the risk of developing a myopic strategy that only satisfies customers who have been
4
5 observed or interviewed as part of the opportunity discovery phase. By contrast, through the
6
7 continuous act of observing and framing, entrepreneurs can recognize evolving needs and
8
9 thus adapt their offerings and strategies.
10

11 Another appealing aspect of the cognitive view on design thinking is that the cognitive
12
13 acts demystify notions of creative insight or “genius” in both design and entrepreneurship.
14
15 Instead, fluency in a relatively ordinary set of cognitive acts can support the framing of a
16
17 novel problem space through distant analogical references and the formation of possible
18
19 corresponding solutions. This fluency can also increase confidence (and decrease
20
21 psychological uncertainty) that the correct problem and a set of plausible solutions have been
22
23 identified through within-domain analogies and mental simulation. As such, design thinking
24
25 does not arise solely from the application of a defined set of activities but rather through the
26
27 application of particular ways of thinking. As we have attempted to convey, it is not possible
28
29 to provide a set of tools for design, from journey mapping to prototyping, without teaching a
30
31 set of cognitive acts to accompany them (Kumar, 2012).⁵ The cognitive acts are at least as
32
33 important as mechanical design skills, such as diagramming, sketching, and prototyping.
34
35
36
37
38

39 **7.2. Future Research**

40
41 Design-driven entrepreneurial education opens further research opportunities. First,
42
43 much of our discussion has discussed how individual cognition is exercised in class settings
44
45 and as a result of in-class activities. However, several studies find that opportunity discovery
46
47 is not a single-person and single-insight attribution (Dimov, 2007), but rather the result of a
48
49

50
51
52
53 ⁵ Typical tools used in design thinking include, for gathering data on customers’ experiences: customer
54
55 journey mapping, empathy maps, and employment of the “five whys” (root cause analysis); for brainstorming,
56
57 tools include classical group brainstorming techniques, mnemonics for helping transform knowledge such as the
58
59 SCAMPER technique; and finally, tools for prototyping include sketching, rough prototyping, storyboarding,
60
61 and various service prototypes. Cognitive tools are ones that naturally rely more on the cognitive faculties, such
62
63 as keen observational skills for data gathering, analogical mappings for brainstorming, and mental simulation for
64
65 prototyping.

1
2
3 process in which a set of unitary, distinct events lead to the emergence of a pattern (Oliver &
4 Roos, 2005). This is particularly relevant in technology entrepreneurship, which has been
5 found to be more effective when it is built on the efforts of many (Garud & Karnøe, 2003).
6
7
8
9
10 Van Burg and Romme (2014) suggest social aspects of entrepreneurial cognition that can be
11 studied in conjunction with the design cognition approach. We encourage further studies that
12 examine the application of cognitive acts to team-based learning in the context of
13 entrepreneurial opportunity creation.
14
15
16
17

18
19 Further, while we treat a problem and its solutions as separate elements in a design
20 process, we recognize that they coexist and, often, when treated as separate activities (e.g.,
21 problem identification through fieldwork), coevolve over time (Dorst & Cross, 2001): new
22 solutions may suggest a new presentation of the problem, and new problems may require new
23 solutions. Qualitative and quantitative studies that investigate how problems and solutions co-
24 evolve over time in entrepreneurial education could suggest more effective teaching methods.
25
26
27
28
29
30
31

32 The approach presented in this paper is corroborated by many years of global design
33 research and design disciplines, but is based only on our experience teaching entrepreneurship
34 over the past seven years. Our hope is that we have begun to spread a new way of looking at
35 design that can be effectively applied to entrepreneurship education. The lean start-up and
36 business model canvas approaches have been widely adapted but largely untested as
37 educational tools. In fact, although appealing from an educational perspective, these
38 approaches might not be appropriate for complex engineered products with long lead times
39 and high capital requirements. We hope that educators now have a greater choice of tools to
40 experiment with in the classroom.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

TABLE 1: Summary of key entrepreneurship education approaches

Approach and main references	Approach to teaching and learning	Key Benefits	Key Criticisms
<p>Business plan development (Barringer, 2009; Honig, 2004; Kaplan & Warren, 2009; Kuratko, 2003)</p> <p>The systematic analysis and business plan are used to collect information that helps entrepreneurs make decisions in highly complex and uncertain environments.</p>	<ul style="list-style-type: none"> - Teach and monitor production of business plans internally or via jury - Usually done in groups where individuals split tasks and produce a report 	<ul style="list-style-type: none"> - A positive influence on performance, in terms of growth and profitability (Bracker, Keats, & Pearson, 1988; Schwenk & Shrader, 1993) and firm's survival after 18 months (Delmar & Shane, 2003) 	<ul style="list-style-type: none"> - Controversial debate on the positive impact on performance (Boyd, 1991; Robinson, 1979; Robinson & Pearce, 1984; Robinson, 1984) - Environmental uncertainty and dynamism diminish value of business planning (Honig, 2004) in favor of more agile approaches (e.g., lean startup) - Focus on ideas rather than actions
<p>Contingency planning (Abetti & Phan, 2004; Gruber, 2007; Honig, 2004)</p> <p>Adaptive business planning that takes into account environmental factors. In highly dynamic environments, only specific activities are planned to speed up the starting up process, while, in slow environments, an in-depth planning is preferred.</p>	<ul style="list-style-type: none"> - Taught as unrelated modules - Similar to approach used to train medical interns who follow an expert and make diagnoses. 	<ul style="list-style-type: none"> - Positive impact on venture performance (Gruber, 2007); value varies with the type of activities, effort devoted to specific activities, and time spent on planning - Lead students to practice divergent thinking, try out new ideas, and receive feedbacks on specific elements at any time (Honig, 2004) 	<ul style="list-style-type: none"> - Limited empirical evidences to support the positive effect on performance - Difficulty in assessment design, as educators have to be content with completed modules (instead of completed business plan) that may not be related to one another - Exhaustive planning is inferior to selective planning in highly dynamic environment where speed is critical.

Approach and main references	Approach to teaching and learning	Key Benefits	Key Criticisms
<p>Effectual entrepreneurship (Dew, Read, Sarasvathy, & Wiltbank, 2009; Sarasvathy, 2001)</p> <p>Entrepreneurs do not start with concrete goals but constantly develop them on the fly through personal strengths and available resources.</p>	<ul style="list-style-type: none"> - Use cases and guided discussions to help students adopt and practice an entrepreneurial mindset - Focus on differences in framing between expert entrepreneurs who redefine the frame to look for new solutions (effectual) and novices who accept the frame and look for opportunities within it - Analogical reasoning allows students to go beyond data 	<ul style="list-style-type: none"> - Assist in creating opportunities and new solutions to control a future that is inherently unpredictable - Realization that surprises are not always bad (as opposed to the avoidance of surprises in causal reasoning) 	<ul style="list-style-type: none"> - Effectual research is only now transitioning from a nascent to an intermediate state - A need for more empirical studies. Existing findings are inconsistent, relying on a small sample size and relatively open-ended data that requires interpretation (Perry, Chandler, & Markova, 2012)
<p>Process perspective (Aulet, 2013; Baron, 2006; Hjorth & Johannisson, 2007)</p> <p>Entrepreneurial process begins with opportunity recognition and can be learned and entrepreneurs can be trained to better recognize opportunities.</p>	<ul style="list-style-type: none"> - Focus on a process which unfolds over time, with each stage requiring different knowledge and skills - Opportunity identification is taught through classic strategy tools (e.g., market segmentation, end user profile) and cognitive framework - Focus on training entrepreneurs when to direct their attention and on the process of searching for patterns 	<ul style="list-style-type: none"> - Offer a systematic guide and help avoid a static view that ignores ever-changing challenges - Draw attention to the key activities that must be performed as ideas are converted into businesses - Emphasize the varying effects of each factor over time and over the course of new venture creation 	<ul style="list-style-type: none"> - Only a few models of entrepreneurial process are grounded in empirical investigation (Moroz & Hindle, 2012) - Only a few studies in this approach focus on providing practical implications that address the "how" of entrepreneurship

Approach and main references	Approach to teaching and learning	Key Benefits	Key Criticisms
<p data-bbox="163 321 569 386">Opportunity-centered learning (Rae, 2003)</p> <p data-bbox="163 418 569 570">Exploration and development of an opportunity through individual and group investigation, understanding, selecting, and acting on an opportunity</p>	<p data-bbox="617 321 1031 505">- Students to explore the opportunity (through brainstorming, use of post-it notes, and directed creativity); relate the opportunity to personal goals, plan to realize the opportunity, and act to make the opportunity happen</p> <p data-bbox="617 513 1031 602">- Use of exploratory questions and a short case to illustrate an entrepreneurial learning process</p>	<p data-bbox="1062 321 1436 440">- Ideal approach when learning outcomes are to transfer theory to practice and develop personal and team skills</p> <p data-bbox="1062 448 1436 537">- Allow students from different backgrounds to use the approach within a single session</p> <p data-bbox="1062 545 1436 602">- More engaging than problem-solving approach</p>	<p data-bbox="1503 321 1919 505">- Only appropriate for a small class (20-30 students) with a minimum of three two-hour sessions, as the learning value is significantly reduced in large groups and compressed time scales</p> <p data-bbox="1503 513 1919 602">- Tutors with strong leadership (e.g., multi-group facilitation) are critical for the success of this approach</p> <p data-bbox="1503 610 1919 727">- Students with low self-confidence or underdeveloped self-organization and teamwork skills might be at disadvantage</p>
<p data-bbox="163 748 569 813">Lean start-up approach (Blank, 2013; Ries, 2011)</p> <p data-bbox="163 837 569 1052">Hypothesis-driven approach that focuses on experimenting rather than planning. Directly engaging with customers through a minimum viable product, which is built iteratively and incrementally according to customer feedback</p>	<p data-bbox="617 748 1031 932">- Often uses graphical representation of business models, such as lean canvas (Maurya, 2012) or business model canvas (Osterwalder & Pigneur, 2010), to develop testable hypotheses</p> <p data-bbox="617 940 1031 1057">- Engage in a dialogue with customers about product development (agile development) instead of forecasting financial return</p>	<p data-bbox="1062 748 1478 867">- May reduce the failure rate, as the new product goes through several iterations of refinement based on customer feedback</p> <p data-bbox="1062 875 1478 992">- Minimal viable product (MPV) allows for fast and cheap launches to test an idea and eliminates wasteful time on features customers don't want</p>	<p data-bbox="1503 748 1919 932">- Only suitable for certain types of products, as MPV might lead students to overlook basic issues (e.g., viability, quality) and discourage them from trying to solve and test comprehensive solutions</p> <p data-bbox="1503 940 1919 1029">- Encourage students to think short-term (e.g., superficial new features that lead to a product that is not deep)</p> <p data-bbox="1503 1037 1919 1122">- Very demanding, in terms of resources that could prematurely burn out a team</p>

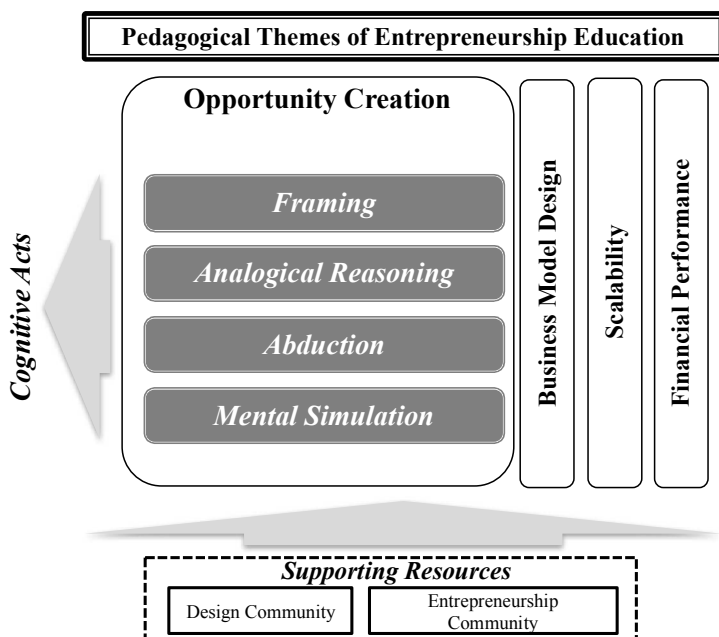
Table 2: Summary of the four cognitive acts in design cognition research

	<i>Design cognition</i>	<i>Further specifications and examples</i>
Framing <input type="checkbox"/> <input type="checkbox"/>	<p>Generative process of drawing associations and dissociations between the situation, assumptions, and precedence to produce a schema for their interpretation, which makes it possible to clarify the detailed requirements of the problem and determine the extent to which the proposed solution can satisfy them.</p> <p><i>Key works: Schön (1983); Dorst (2011); Stumpf and McDonnell (2002); Cross (2006); Lawson (1997)</i></p>	<p>In solving the problem of crime in a neighborhood, framing the problem from a policing perspective may regard the problem as one of curbing anti-social behavior, whereas framing the problem from a resident's perspective may regard the problem as one of improving social amenities. The content of the frame makes it possible for the designer to identify salient requirements and determine the extent to which the proposed solution can satisfy them. The frame connects surveillance to curbing anti-social behavior, and parks and social clubs to improving social amenities. It is considered by some to be a key strategy in design cognition. See Dorst (2011).</p>
Analogical reasoning <input type="checkbox"/>	<p>Act of identifying and carrying over knowledge from prior situations to support the current situation. Analogical reasoning can involve within-domain (close field) and between-domain (far field) analogies. Between-domain analogies are normally used in problem formulation; within-domain analogies are primarily used in uncertainty resolution; and solution-oriented analogies are a mixture of within- and between-domain. Research shows that introducing between-domain design cases to prime analogical reasoning results in novel solutions when the goals of the design situation are open.</p> <p><i>Key works: Dorst (2011); Holyoak and Thagard (1995); Hofstadter and Sander (2013); Leclercq and Heylighen (2002); Christensen and Schunn (2007); Ball and Christensen (2009); Ahmed and Christensen (2009); Ball et al. (2004)</i></p>	<p>Within-domain analogical reasoning is straightforward. Example of between-domain analogies: to identify a new opportunity for a company operating in the healthcare industry (a heavily regulated environment that has numerous dynamic startups), you can study companies that operate with innovative business models in challenging environments. Alternatively, you can investigate how microorganisms have overcome challenges to survive in hostile environments. While healthcare delivery and microorganisms are indeed very different on the surface, the use of analogical reasoning forces you to focus on whether the problems might share some important characteristics.</p>

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

<p>Abductive reasoning</p> <p>□</p>	<p>Act of proposing a hypothesis to explain the data, especially surprising information, to identify “what might be” rather than the current or previous state of affairs. Abductive reasoning can have either explanatory or innovative purposes.</p> <p><i>Key work: Dorst (2011); Kolko (2010); Peirce (1931, 1998); Roozenburg (1993);</i></p>	<p><i>Explanatory abduction</i> creates hypotheses to explain some (surprising) news while working with a limited set of data to come up with the <i>most plausible and parsimonious explanation for given observations</i> – for instance, this happens when an entrepreneur is trying to interpret the reaction of an incumbent in the industry.</p> <p><i>Innovative abduction</i> is employed by inventing a new product or business model. An entrepreneur must propose both a new idea (e.g., a new value to create for customers) and the means for executing the new idea (e.g., a business model), with the premises (links between the components) that are surmised to allow it to work.</p>
<p>Mental simulation (mental time travel in cognitive science)</p> <p>□</p>	<p>The act of mentally trying out the operation of an opportunity or business model to predict its outcomes in the absence of data or previous experiences.</p> <p><i>Key works: Markman, Klein, and Suhr (2012); Ball and Christensen (2009); Ball, Onarheim, and Christensen (2010); Heylighen and Nijs (in-press); Bilda and Gero (2007)</i></p>	<p>Mental simulation is used when there is less than complete knowledge about an anticipated future into which a new design will be introduced, often entailing a large number of possibilities. The mental representation of a design solution entails the assembly, combination, and recombination of individual elements; mental simulation is brought in to consider the effects caused by a change in any elements.</p> <p>Mental simulation appears to reduce the psychological uncertainties that designers face during the course of their work, such as the concern that they do not fully understand a somewhat complex design problem, the efficacy of proposed design solutions, or how end-users will interact with the product.</p> <p>For example, using well-established frameworks, such as the business model canvas, PESTEL, or the strategy diamond, we ask students to mentally simulate all possible scenarios and in particular how external shocks (e.g., changes in regulation and technology) and competitors’ actions will affect the new venture.</p>

FIGURE 1: How design cognition supports entrepreneurship education

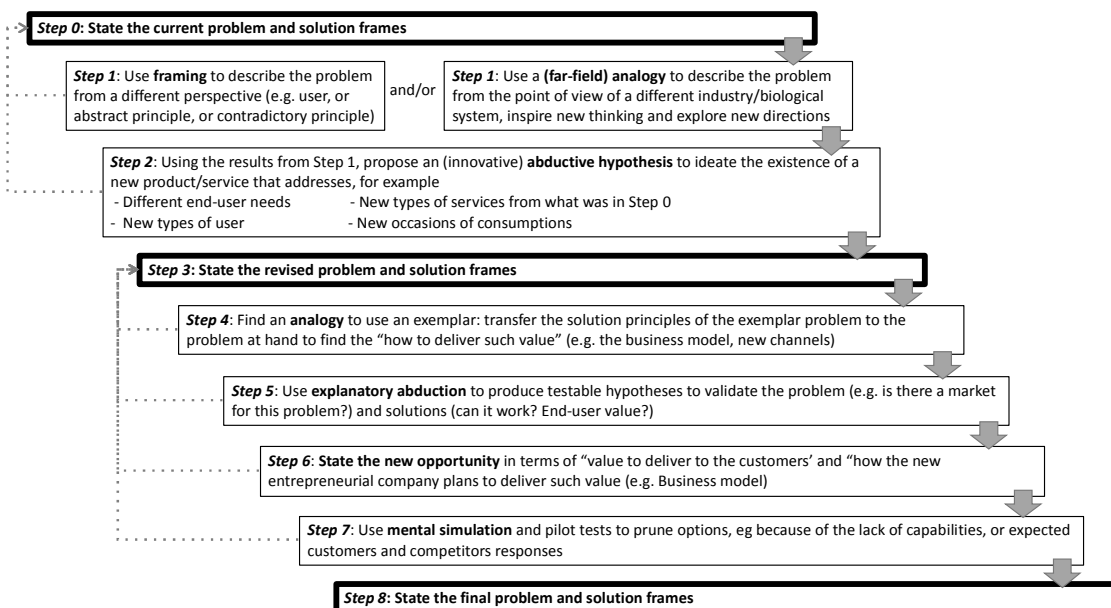


Not Final Version

FIGURE 2: Examples of usage of cognitive acts in entrepreneurship education

Cognitive act	Example of application
Framing	Abstract Variation to observe the opportunity from different points of view
Analogical Reasoning	Opposites to identify constrains and boundaries to generate solution concepts Between domains comparisons to transfer solutions from one domain to another
Abduction	Analog & Antilog to generate solution concepts starting from business models that worked and did not work in past situations Hypothesizing novel solution principles to existing problems Hypothesizing novel explanations to emerging business models
Mental Simulation	Validating solution ideas in different contexts of use Validating new products and services

FIGURE 3: AN EIGHT STEP APPROACH TO BETTER OPPORTUNITY GENERATION AND BUSINESS MODEL IDEATION



8. REFERENCES

- Abetti, P. A., & Phan, P. H. 2004. Zobe Chemical Industries: the Evolution of a Family Company from Flypaper to Globalization (1919–2001). *Journal of Business Venturing*, 19(4): 589-600.
- Ahmed, S., & Christensen, B. T. 2009. An In Situ Study of Analogical Reasoning in Novice and Experienced Design Engineers. *Journal of Mechanical Design*, 131(11): 111004-111004.
- Aldrich, H. E., & Ruef, M. 2006. *Organizations evolving*. Padstow, Cornwall: TJ International.
- Alvarez, S. A., & Barney, J. B. 2010. Entrepreneurship and epistemology: The philosophical underpinnings of the study of entrepreneurial opportunities. *Academy of Management Annals*, 4(1): 557-583.
- Amador, J. A., Miles, L., & Peters, C. B. 2006. *The practice of problem-based learning: A guide to implementing PBL in the college classroom*: Anker Publishing.
- Ardichvili, A., Cardozo, R., & Ray, S. 2003. A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, 18: 105-123.
- Aulet, B. 2013. *Disciplined entrepreneurship: 24 steps to a successful startup*: John Wiley & Sons.
- Austen, H. 2012. The open mind: letting go of single-answer certainty. *Rotman Magazine* (Winter): 58-64.
- Baker, T., & Nelson, R. E. 2005. Creating Something from Nothing: Resource Construction through Entrepreneurial Bricolage. *Administrative Science Quarterly*, 50(3): 329-366.
- Ball, L. J., & Christensen, B. T. 2009. Analogical reasoning and mental simulation in design: two strategies linked to uncertainty resolution. *Design Studies*, 30(2): 169-186.
- Ball, L. J., Onarheim, B., & Christensen, B. T. 2010. Design requirements, epistemic uncertainty and solution development strategies in software design. *Design Studies*, 31(6): 567-589.
- Ball, L. J., Ormerod, T. C., & Morley, N. J. 2004. Spontaneous analogising in engineering design: a comparative analysis of experts and novices. *Design Studies*, 25(5): 495-508.
- Bar, M. 2009. The proactive brain: memory for predictions. *Philosophical Transactions of the Royal Society B*, 364: 1235–1243.

- 1
2
3 □ Baron, R. A. 2004. The cognitive perspective: a valuable tool for answering entrepreneurship's
4 basic “why” questions. *Journal of Business Venturing*, 19(2): 221-239.
5
6
7 □ Baron, R. A. 2006. Opportunity recognition as pattern recognition: How entrepreneurs “connect the
8 dots” to identify new business opportunities. *Academy of Management Perspectives*, 20(1): 104-
9 119.
10
11
12
13 □ Baron, R. A., & Ensley, M. D. 2006. Opportunity recognition as the detection of meaningful
14 patterns: Evidence from comparisons of novice and experienced entrepreneurs. *Management*
15 *Science*, 52(9): 1331-1344.
16
17
18
19 □ Baron, R. A., & Shane, S. A. 2007. *Entrepreneurship: A process perspective*: Cengage Learning.
20
21
22 □ Barringer, B. R. 2009. Preparing Effective Business Plans: an Entrepreneurial Approach. *Upper*
23 *Saddle River*.
24
25
26 □ Barry, D., & Meisiek, S. 2015. Discovering the business studio. *Journal of Management*
27 *Education*, 39(1): 153-175.
28
29
30 □ Benyus, J. M. 1997. *Biomimicry*: William Morrow New York.
31
32 □ Berns, G. 2008. *Iconoclast: A neuroscientist reveals how to think differently*. Cambridge, MA:
33 Harvard Business School Press.
34
35
36 □ Bilda, Z., & Gero, J. S. 2007. The impact of working memory limitations on the design process
37 during conceptualization. *Design Studies*, 28(4): 343-367.
38
39
40 □ Björklund, T. A. 2013. Initial mental representations of design problems: Differences between
41 experts and novices. *Design Studies*, 34(2): 135-160.
42
43
44 □ Blanchette, I., & Dunbar, K. 2000. How analogies are generated: The roles of structural and
45 superficial similarity. *Memory & Cognition*, 28(1): 108-124.
46
47
48 □ Blank, S. 2013. Why the Lean Start-up Changes Everything. *Harvard Business Review*, 91(5): 63-
49 72.
50
51
52
53 □ Boyd, B. K. 1991. Strategic planning and financial performance: a meta - analytic review. *Journal*
54 *of Management Studies*, 28(4): 353-374.
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Bracker, J. S., Keats, B. W., & Pearson, J. N. 1988. Planning and Financial Performance Among Small Firms in a Growth Industry. *Strategic Management Journal*, 9(6): 591-603.
 - Brown, T. 2008. Design Thinking. *Harvard Business Review*: 82-92.
 - Brown, T. 2009. *Change By Design: how design thinking transforms organizations and inspires innovation*. New York: HarperBusiness.
 - Busenitz, L. W., & Barney, J. B. 1997. Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing*, 12(1): 9-30.
 - Chiu, I., & Shu, L. H. 2008. Using language as related stimuli for concept generation. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 21(2): 103-121.
 - Christensen, B., & Schunn, C. 2007. The relationship of analogical distance to analogical function and preinventive structure: the case of engineering design. *Memory & Cognition*, 35(1): 29-38.
 - Christensen, B. T., & Schunn, C. D. 2009. The role and impact of mental simulation in design. *Applied Cognitive Psychology*, 23(3): 327-344.
 - Collopy, F., & Boland, R. 2004. *Managing as designing*: Stanford University Press Redwood City, CA.
 - Cornelissen, J. P., & Clarke, J. S. 2010. Imagining and rationalizing opportunities: Inductive reasoning and the creation and justification of new ventures. *Academy of Management Review*, 35(4): 539-557.
 - Cross, N. 2006. *Designerly Ways of Knowing*. London: Springer-Verlag London Limited.
 - Cross, N. 2007. Forty years of design research. *Design Studies*, 28(1): 1-4.
 - de Vries, B., Jessurun, J., Segers, N., & Achten, H. 2005. Word graphs in architectural design. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 19(4): 277-288.
 - Delmar, F., & Shane, S. 2003. Does Business Planning Facilitate the Development of New Ventures? *Strategic Management Journal*, 24(12): 1165-1185.

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- DeTienne, D. R., & Chandler, G. N. 2004. Opportunity identification and its role in the entrepreneurial classroom: A pedagogical approach and empirical test. *Academy of Management Learning & Education*, 3(3): 242-257.
 - Dew, N., Read, S., Sarasvathy, S. D., & Wiltbank, R. 2009. Effectual Versus Predictive Logics in Entrepreneurial Decision-Making: Differences between Experts and Novices. *Journal of Business Venturing*, 24(4): 287-309.
 - Dimov, D. 2007. Beyond the single - person, single - insight attribution in understanding entrepreneurial opportunities. *Entrepreneurship Theory & Practice*, 31(5): 713-731.
 - Dong, A., Garbuio, M., & Lovallo, D. 2016a. Generative Sensing. *California Management Review*, 58(4): 97-117.
 - Dong, A., Garbuio, M., & Lovallo, D. 2016b. Generative sensing in design evaluation. *Design Studies*, 45, Part A: 68-91.
 - Dong, A., Garbuio, M., & Lovallo, D. 2016c. Strategic designerly review conversations. In R. S. Adams, R. S. Buzzanell, & J. A. Siddiqui (Eds.), *Analyzing Design Review Conversations*: Purdue University Press.
 - Dong, A., Kleinsmann, M., & Deken, F. 2013. Investigating Design Cognition in the Construction and Enactment of Team Mental Models. *Design Studies*, 34(1): 1-33.
 - Doorley, S., & Witthoft, S. 2011. *Make space: How to set the stage for creative collaboration*: John Wiley & Sons.
 - Dörner, D. 1999. Approaching Design Thinking Research. *Design Studies*, 20(5): 407-415.
 - Dorst, K. 2011. The core of 'design thinking' and its application. *Design Studies*, 32(6): 521-532.
 - Dorst, K. 2015. *Frame innovation: Create new thinking by design*: MIT Press.
 - Dorst, K., & Cross, N. 2001. Creativity in the design process: co-evolution of problem-solution. *Design Studies*, 22(5): 425-437.
 - Duch, B. J., Groh, S. E., & Allen, D. E. 2001. *The power of problem-based Learning: A practical "How to" for teaching undergraduate courses in any discipline*: Stylus Publishing.

- 1
2
3 □ Dunne, D., & Martin, R. 2006. Design Thinking and How It Will Change Management Education:
4 An Interview and Discussion. *Academy of Management Learning & Education*, 5(4): 512-523.
5
6
7 □ Dyer, J. H., Gregersen, H. B., & Christensen, C. 2008. Entrepreneur behaviors, opportunity
8 recognition, and the origins of innovative ventures. *Strategic Entrepreneurship Journal*, 2: 317–
9 338.
10
11
12 □ Eastman, C. M. 1999. Special Issue on Design Education. *Design Studies*, 20(2): 99-103.
13
14 □ Fiet, J. O. 2002. *The systematic search for entrepreneurial discoveries*: ABC-CLIO.
15
16
17 □ Fixson, S. K. 2009. Teaching Innovation through Interdisciplinary Courses and Programmes in
18 Product Design and Development: An Analysis at 16 US Schools. *Creativity and Innovation*
19 *Management*, 18(3): 199-208.
20
21
22 □ Fixson, S. K., Greenberg, D. N., & Zacharakis, A. 2015a. Babson’s New Masters of Science in
23 Management in Entrepreneurial Leadership Program. *Evolving Entrepreneurial Education:*
24 *Innovation in the Babson Classroom*: 175.
25
26
27 □ Fixson, S. K., & Rao, J. 2014. Learning emergent strategies through design thinking. *Design*
28 *Management Review*, 25(1): 46-53.
29
30
31 □ Fixson, S. K., & Read, J. M. 2012. Creating innovation leaders: Why we need to blend business
32 and design education. *Design Management Review*, 23(4): 4-12.
33
34
35 □ Fixson, S. K., Seidel, V. P., & Bailey, J. 2015b. Creating Space for Innovation: The Role of a
36 “Design Zone” within a Business School. *Evolving Entrepreneurial Education: Innovation in the*
37 *Babson Classroom*: 217.
38
39
40 □ Fraser, H. M. 2012. *Design Works: How to Tackle Your Toughest Innovation Challenges*
41 *Through Business Design*: University of Toronto Press.
42
43
44 □ Gaglio, C. M. 2004. The role of mental simulations and counterfactual thinking in the opportunity
45 identification process. *Entrepreneurship Theory & Practice*, 28(6): 533-552.
46
47
48 □ Garbuio, M., & Lovallo, D. 2015. Design thinking. In M. Augier, & D. J. Teece (Eds.), *The*
49 *Palgrave Encyclopedia of Strategic Management*. Basingstoke: Palgrave Macmillan.
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Garbuio, M., Lovallo, D., Porac, J. F., & Dong, A. 2015. A design cognition perspective on strategic option generation. In G. Gavetti, & W. Ocasio (Eds.), *Advances in Strategic Management*, Vol. 32: 437-465: Emerald.
 - Gartner, W. B., & Vesper, K. H. 1994. Experiments in entrepreneurship education: successes and failures. *Journal of Business Venturing*, 9(3): 179-187.
 - Garud, R., & Karnøe, P. 2003. Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. *Research Policy*, 32(2): 277-300.
 - Gerber, E., & Carroll, M. 2012. The psychological experience of prototyping. *Design Studies*, 33(1): 64-84.
 - Gielnik, M. M., Frese, M., Graf, J. M., & Kampschulte, A. 2012. Creativity in the opportunity identification process and the moderating effect of diversity of information. *Journal of Business Venturing*, 27(5): 559-576.
 - Gielnik, M. M., Kraemer, A.-C., Kappel, B., & Frese, M. 2014. Antecedents of business opportunity identification and innovation: Investigating the interplay of information processing and information acquisition. *Applied Psychology- An International Review*, 63(2): 344-381.
 - Glen, R., Suciu, C., & Baughn, C. 2014. The need for design thinking in business schools. *Academy of Management Learning & Education*: amle. 2012.0308.
 - Goel, A. K. 1997. Design, analogy, and creativity. *IEEE Expert*, 12(3): 62-70.
 - Goel, V., & Pirolli, P. 1992. The structure of Design Problem Spaces. *Cognitive Science*, 16(3): 395-429.
 - Goldschmidt, G. 1999. Visual Analogy - a Strategy for Design Reasoning and Learning. In C. Eastman, W. McCracken, & W. Newstetter (Eds.), *Design knowing and learning: cognition in design education*: 199-219. New York: Elsevier.
 - Gómez Puente, S., van Eijck, M., & Jochems, W. 2013a. Facilitating the learning process in design-based learning practices: an investigation of teachers' actions in supervising students. *Research in Science & Technological Education*, 31(3): 288-307.

- 1
2
3 □ Gómez Puente, S. M., van Eijck, M., & Jochems, W. 2013b. A sampled literature review of design-
4 based learning approaches: a search for key characteristics. *International Journal of Technology*
5 *and Design Education*, 23(3): 717-732.
6
7
8
9 □ Grégoire, D. A., Barr, P. S., & Shepherd, D. A. 2010. Cognitive processes of opportunity
10 recognition: The role of structural alignment. *Organization Science*, 21(2): 413-431.
11
12 □ Grégoire, D. A., Cornelissen, J., Dimov, D., & Burg, E. 2015. The mind in the middle: Taking
13 stock of affect and cognition research in entrepreneurship. *International Journal of Management*
14 *Reviews*, 17(2): 125-142.
15
16 □ Gruber, M. 2007. Uncovering the Value of Planning in New Venture Creation: A Process and
17 Contingency Perspective. *Journal of Business Venturing*, 22(6): 782-807.
18
19 □ Guilford, J. P. 1950. Creativity. *American Psychologist*, 5: 444-454.
20
21 □ Hambrick, D. C., & Frederickson, J. W. 2001. Are you sure you have a strategy? *Academy of*
22 *Management Executives*, 15(4): 48-59.
23
24 □ Herron, L., & Sapienza, H. J. 1992. The entrepreneur and the initiation of new venture launch
25 activities. *Entrepreneurship Theory & Practice*, 17: 49-49.
26
27 □ Heylighen, A., & Nijs, G. in-press. Designing in the absence of sight: Design cognition re-
28 articulated. *Design Studies*.
29
30 □ Hjorth, D., & Johannisson, B. 2007. Learning as an entrepreneurial process. *Handbook of*
31 *Research in Entrepreneurship Education*, 3: 46.
32
33 □ Hofstadter, D., & Sander, E. 2013. *Surfaces and essences: Analogy as the fuel and fire of*
34 *thinking*. New York: Basic Books.
35
36 □ Hofstadter, D. R. 2001. Analogy as the core of cognition. In D. Gentner, K. J. Holyoak, & B. N.
37 Kokinov (Eds.), *The Analogical Mind: Perspectives from Cognitive Science*: 499-538.
38 Cambridge: MIT Press.
39
40 □ Holyoak, K. J., & Thagard, P. 1995. *Mental leaps: analogy in creative thought*. Cambridge, MA:
41 MIT Press.
42
43 □ Holyoak, K. J., & Thagard, P. 1996. *Mental leaps: Analogy in creative thought*. MIT press.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Honig, B. 2004. Entrepreneurship Education: Toward a Model of Contingency-Based Business Planning. *Academy of Management Learning & Education*, 3(3): 258-273.
 - Jansson, D. G., & Smith, S. M. 1991. Design fixation. *Design studies*, 12(1): 3-11.
 - Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. 2013. Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management*, 22(2): 121-146.
 - Kaplan, J. M., & Warren, A. C. 2009. *Patterns of entrepreneurship management*: John Wiley & Sons.
 - Kelley, T. 2007. *The art of innovation: Lessons in creativity from IDEO, America's leading design firm*: Crown Business.
 - Kickul, J., Janssen-Selvadurai, C., & Griffiths, M. D. 2012. A blended value framework for educating the next cadre of social entrepreneurs. *Academy of Management Learning & Education*, 11(3): 479-493.
 - Kirzner, I. M. 1973. *Competition and entrepreneurship*: University of Chicago Press.
 - Kirzner, I. M. 1989. *Discovery, capitalism, and distributive justice*. New York: Basil Blackwell.
 - Kolb, D. A. 1984. *Experiential learning: Experience as the source of learning and development*: Prentice-Hall Englewood Cliffs, NJ.
 - Kolko, J. 2010. Abductive Thinking and Sensemaking: The Drivers of Design Synthesis. *Design Issues*, 26(1): 15-28.
 - Kumar, V. 2012. *101 design methods: A structured approach for driving innovation in your organization*: John Wiley & Sons.
 - Kuratko, D. F. 2003. Entrepreneurship Education: Emerging Trends and Challenges for the 21st Century. *White Paper, US Association of Small Business Education*, 22.
 - Lawson, B. 1997. *How Designers Think* (3 ed.). Oxford: Architectural Press.
 - Leclercq, P., & Heylighen, A. 2002. Analogies per hour: A designer's view on analogical reasoning. In J. S. Gero (Ed.), *Artificial intelligence in design '02*: 285-303. Dordrecht: Kluwer Academic Publishers.

- 1
2
3 □ Lee, H. S., & Anderson, J. R. 2013. Student learning: What has instruction got to do with it?
4
5 *Annual Review of Psychology*, 64: 445-469.
6
7 □ Liedtka, J., & Ogilvie, T. 2011. *Designing for Growth*. New York: Columbia University Press.
8
9 □ Linsey, J. S., Markman, A. B., & Wood, K. L. 2012. Design by analogy: A study of the WordTree
10 method for problem re-representation. *Journal of Mechanical Design*, 134(4): 041009.
11
12 □ Lumpkin, G. T., Hills, G. E., & Shrader, R. C. 2004. Opportunity recognition. In H. P. Welsch
13 (Ed.), *Entrepreneurship: The Way Ahead*: 73-90: Psychology Press.
14
15 □ Maher, M. L. 2000. A model of co-evolutionary design. *Engineering with Computers*, 16(3-4):
16 195-208.
17
18 □ Markman, K. D., Klein, W. M., & Suhr, J. A. 2012. *Handbook of imagination and mental*
19 *simulation*: Psychology Press.
20
21 □ Martin, R. 2009. *The Design of Business: Why Design Thinking is the Next Competitive*
22 *Advantage*: Harvard Business School Press.
23
24 □ Maurya, A. 2012. *Running lean: iterate from plan A to a plan that works*: O'Reilly Media.
25
26 □ Mazzoleni, I. 2013. *Architecture Follows Nature-Biomimetic Principles for Innovative Design*:
27 CRC Press.
28
29 □ McGrath, R. G., & MacMillan, I. C. 2000. *The entrepreneurial mindset: Strategies for*
30 *continuously creating opportunity in an age of uncertainty*: Harvard Business Press.
31
32 □ Mitchell, R. K., Busenitz, L., Lant, T., McDougall, P. P., Morse, E. A., & Smith, J. B. 2002.
33 Toward a theory of entrepreneurial cognition: Rethinking the people side of entrepreneurship
34 research. *Entrepreneurship Theory & Practice*, 27(2): 93-104.
35
36 □ Moroz, P. W., & Hindle, K. 2012. Entrepreneurship as a Process: Toward Harmonizing Multiple
37 Perspectives. *Entrepreneurship Theory & Practice*, 36(4): 781-818.
38
39 □ Mullins, J., & Komisar, R. 2009. *Getting to Plan B: Breaking through to a better business model*.
40 Cambridge, MA: Harvard Business Review Press.
41
42 □ Mumford, M. D. 2003. Where Have We Been, Where Are We Going? Taking Stock in Creativity
43 Research. *Creativity Research Journal*, 15(2-3): 107-120.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Muñoz, C. A., Mosey, S., & Binks, M. 2011. Developing opportunity-identification capabilities in the classroom: visual evidence for changing mental frames. *Academy of Management Learning & Education*, 10(2): 277-295.
 - O'Connor, A. 2013. A conceptual framework for entrepreneurship education policy: Meeting government and economic purposes. *Journal of Business Venturing*, 28(4): 546-563.
 - Oliver, D., & Roos, J. 2005. Decision-making in high-velocity environments: The importance of guiding principles. *Organization Studies*, 26(6): 889-913.
 - Osterwalder, A., & Pigneur, Y. 2010. *Business model generation: A handbook for visionaries, game changers, and challengers*: OSF.
 - Oxford, C. 2013. Assessing whether entrepreneurs should get M.B.A.'s. *New York Times*.
 - Oxman, R. 2004. Think-maps: teaching design thinking in design education. *Design Studies*, 25: 63-91.
 - Peirce, C. S. 1931. *Collected papers [1931-1958]*. Cambridge.
 - Peirce, C. S. 1998. *The Essential Peirce, Volume 2: Selected Philosophical Writings, 1893-1913*. Bloomington: Indiana University Press.
 - Perry, J. T., Chandler, G. N., & Markova, G. 2012. Entrepreneurial Effectuation: a Review and Suggestions for Future Research. *Entrepreneurship Theory & Practice*, 36(4): 837-861.
 - Porter, M. E. 1980. *Competitive strategy*. New York: The Free Press.
 - Rae, D. 2003. Opportunity Centred Learning: an Innovation in Enterprise Education? *Education & Training*, 45(8/9): 542-549.
 - Ries, E. 2011. *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful susinnesses*: Random House LLC.
 - Robinson, R. 1979. Forecasting an d small business a study of the strategic planning process. *Journal of Small Business Management*, 17(3): 19.
 - Robinson, R. B., & Pearce, J. A. 1984. Research Thrusts in Small Firm Strategic Planning. *Academy of Management Review*, 9(1): 128-137.
 - Robinson, R. D. 1984. *Internationalization of business: An introduction*: Dryden Pr.

- 1
2
3 □ Roozenburg, N. F. 1993. On the pattern of reasoning in innovative design. *Design Studies*, 14(1):
4 4-18.
5
6
7 □ Rothenberg, A. 1973. Word association and creativity. *Psychological Reports*, 33(1): 3-12.
8
9 □ Rowe, P. G. 1982. A Priori Knowledge and Heuristic Reasoning in Architectural Design. *Journal*
10 *of Architectural Education*, 36(1): 18-23.
11
12 □ Sanna, L. J. 2000. Mental Simulation, Affect, and Personality A Conceptual Framework. *Current*
13 *Directions in Psychological Science*, 9(5): 168-173.
14
15 □ Sarasvathy, S. D. 2001. Causation and effectuation: Toward a theoretical shift from economic
16 inevitability to entrepreneurial contingency. *Academy of Management Review*, 26(2): 243-263.
17
18 □ Schön, D. A. 1983. *The reflective practitioner: How professionals think in action*: Basic Books.
19
20 □ Schumpeter, J. A. 1934. *Capitalism, socialism, and democracy*: Harper & Row.
21
22 □ Schwenk, C. R., & Shrader, C. B. 1993. Effects of Formal Strategic Planning on Financial
23 Performance in Small Firms: A Meta-Analysis. *Entrepreneurship: Theory & Practice*, 17(3): 53-
24 65.
25
26 □ Scott, G., Leritz, L. E., & Mumford, M. D. 2004. The effectiveness of creativity training: A
27 quantitative review. *Creativity Research Journal*, 16(4): 361-388.
28
29 □ Shane, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization*
30 *Science*, 11(4): 448-469.
31
32 □ Shane, S., & Venkataraman, S. 2003. Guest editors' introduction to the special issue on technology
33 entrepreneurship. *Research Policy*, 32(2): 181-184.
34
35 □ Shane, S. A. 2003. *A general theory of entrepreneurship: The individual-opportunity nexus*:
36 Edward Elgar.
37
38 □ Shepherd, D. A., & DeTienne, D. R. 2005. Prior knowledge, potential financial reward, and
39 opportunity identification. *Entrepreneurship Theory & Practice*, 29(1): 91-112.
40
41 □ Short, J. C., Ketchen, D. J., Shook, C. L., & Ireland, R. D. 2010. The concept of "opportunity" in
42 entrepreneurship research: Past accomplishments and future challenges. *Journal of Management*,
43 36(1): 40-65.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Sine, W. D., Haveman, H. A., & Tolbert, P. S. 2005. Risky Business? Entrepreneurship in the New Independent-Power Sector. *Administrative Science Quarterly*, 50(2): 200-232.
 - Stumpf, S. C., & McDonnell, J. T. 2002. Talking about team framing: using argumentation to analyse and support experiential learning in early design episodes. *Design Studies*, 23(1): 5-23.
 - Ucbasaran, D., Westhead, P., & Wright, M. 2009. The extent and nature of opportunity identification by experienced entrepreneurs. *Journal of Business Venturing*, 24(2): 99-115.
 - Valkenburg, R. C., & Dorst, K. 1998. The reflective practice of design teams. *Design Studies*, 19(3): 249-271.
 - Van Burg, E., & Romme, A. G. L. 2014. Creating the future together: toward a framework for research synthesis in entrepreneurship. *Entrepreneurship Theory & Practice*, 38(2): 369-397.
 - Vesper, K. H., & Gartner, W. B. 1997. Measuring progress in entrepreneurship education. *Journal of Business venturing*, 12(5): 403-421.
 - Visser, W. 1996. Two functions of analogical reasoning in design: a cognitive-psychology approach. *Design Studies*, 17(4): 417-434.
 - Visser, W. 2006. *The cognitive artifacts of designing*. Mahwah, NJ: Lawrence Erlbaum Associates.
 - Visser, W. 2009. Design: one, but in different forms. *Design Studies*, 30(3): 187-223.
 - Vogel, C. M., Cagan, J., & Mather, J. H. 1997. Teaching Integrated Product Development: Educational Innovation at Carnegie Mellon University. *Design Management Journal*, 8(4): 58-65.
 - Vosniadou, S., & Ortony, A. 1989. Similarity and analogical reasoning: A synthesis. In S. Vosniadou, & A. Ortony (Eds.), *Similarity and Analogical Reasoning*: 1-7. New York: Cambridge University Press.
 - Ward, T. B. 2007. Creative cognition as a window on creativity. *Methods*, 42(1): 28-37.
 - Weick, K. E. 1979. Cognitive Processes in Organizations. *Research in Organizational Behavior*, 1(1): 41-74.
 - Welling, H. 2007. Four Mental Operations in Creative Cognition: The Importance of Abstraction. *Creativity Research Journal*, 19(2-3): 163-177.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- Williams Middleton, K., & Donnellon, A. 2014. Personalizing entrepreneurial learning: A pedagogy for facilitating the know why. *Entrepreneurship Research Journal*, 4(2): 167-204.
- Wiltschnig, S., Christensen, B. T., & Ball, L. J. 2013. Collaborative problem–solution co-evolution in creative design. *Design Studies*, 34(5): 515-542.

Peer Review Proof - Not Final Version