



**A REVIEW AND RECONCEPTUALIZATION OF RADICAL INNOVATION COMPETENCIES
AND THEIR IMPLICATIONS FOR MANAGEMENT EDUCATION**

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SUMMARY

This review paper aims to synthesize literature and to identify research gaps in the sphere of radical innovation. Nonetheless, we highlight emerging patterns and recommend a new research area which is radical innovation competencies. The research method employed in this article is a systematic and extended literature review. We present our conceptualization of radical innovation competencies after screening the results of the literature review. The implications of this reconceptualization for management education are discussed.

Key words: Radical innovation competencies, breakthrough innovation competencies, disruptive innovation competencies, management education.

JEL Classification : O31, O32, O36, I23, I21, A22, A23, J24

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INTRODUCTION

This review aims to enumerate works that treated radical innovation and radical innovation competencies. The term “competency” used here is the same employed by Tuning program. It refers to a quality, ability, capacity or skill which is developed by and belongs to the student (Tuning, 2010). We mean by radical innovation competencies that dynamic combination of cognitive and metacognitive skills, demonstration of knowledge and understanding, interpersonal, intellectual and practical skills and ethical values that one will use to propose a new prototype of product which will be bought easily in a targeted market. This product will create its own market as a need seeker strategy’s user and will put barriers to new enterers. This purpose claims the use and mastering of core competencies that one must identify and after that to self-develop and to co-develop. We start with key words : “radical innovation”, “breakthrough innovation” and “disruptive innovation”. Then, we move to key words : “radical innovation competencies”, breakthrough innovation competencies” and “disruptive innovation competencies”. After that, we propose a reconceptualization for the radical innovation competencies based on the recent works of Yannou (Yannou et al., 2013). At the end, we discuss the implications of this reconceptualization for management education.

1 – REVIEW OF THE RADICAL INNOVATION LITERATURE :

Many works were done about the definition of radical, disruptive or breakthrough innovation. Despite the term used at each work, we will use in this review the term “radical” innovation for the same meaning of “disruptive” or “breakthrough” innovations.

The origin of the concept of *radical innovation* is found on the works of Schumpeter since 1934 (Schumpeter, 1934,1942), but the term *Radical Innovation* became strongly used in the literature since the 1980s.

In their working paper of Basic Research Program at Higher School of Economics in Russia, Kotsemir and company (Kotsemir, Abroskin, & Dirk, 2013) highlighted the concept of innovation starting from the works of other previous scholars since 1890s to nowadays. We can summarize from their work what follows concerning *radical innovation*:

-Ahmed and Shephred (Ahmed & Shepherd, 2010) define 6 aspects of innovation. From these aspects, we find the *Change* as an aspect of innovation. They use this aspect to show if the innovation is incremental or radical because some innovations are minor adjustments whilst other are radical or discontinuous in nature.

-Bretel et al. (Brettel, Heinemann, Engelen, & Neubauer, 2011) make a relevant study on the conceptualization of innovation. Radical innovation as considered in economic theory as a driving force for economic growth (Schumpeter, 1942). Innovation means for economy theory, the "new", while for management, it means "value creation".

-The term radical innovation itself is associated with the content of a various concepts and definitions (Mcdermott & O'Connor, 2002), (Tellis, Prabhu, & Chandy, 2009), and in different studies, the terminology used and the definition of radical innovation vary and depends on the context of the research (Verganti, 2008). Some researchers use the concept of "really new" (Schmidt & Calantone, 1998), (Song & Montoya-Weiss, 1998), others use "breakthrough" (Rice, Colarelli O'Connor, Peters, & Morone, 1998) or "discrete innovation" (Priest & Hill, 1980).

-The measurement of radical innovation is no clear in Schumpeterian theory. Dahlin and Behrens (Dahlin & Behrens, 2005) associate the degree of radicality of inventions to the nature of ideas, the base of innovation activity, and finally the content of new knowledge or systematic data in innovation.

-According to the degree of innovativeness, some researchers (Mensch, 1979), (Freeman C. , 1994), (Kleinschmidt & Cooper, 1991), (Wheelwright & Clark, 1992) use this term (or concept) to indicate a strong degree of innovation.

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-(Johnson & Jones, 1957) established a multilayer classification of innovation based on two direction of newness(technological and market) and three degree of this newness in each direction. Zawislak et al. (Zawislak et al., 2011) identify two types of innovations: technology-driven and business-driven. Each type is divided into two subtypes. We can define radical innovation on the basis of the mentioned multilayer classifications as innovation which seeks a new market for Johnson & Jones Classification and Technology subtype innovation under technology driven classification for Zawislak and company. Table 1 shows other examples of classification of innovation.

Table 1 : Examples of dichotomical and dually-dichotomical classification of innovation types in scientific literature

Dichotomical classification	
Authors	Types of innovations
Strong Innovation/ Weak Innovation dimensions	
(Arrow, 1962), (Gilbert & Newbery, 1982)	Non drastic/drastring
(Utterback, 1975)	Evolutionary/revolutionary
(Coccia, 2005)	Elementary (micro-incremental)/cluster(new technological system)
"Genuine innovation"/renovation dimension	
(Maidique & Zirger, 1984)	True/adoption
(Yoon & Lilien, 1985)	Original/reformulated
Everydayinnovation/disruptive innovation dimension	
(Grossman, 1970)	Instrumental/ultimate
Other dimensions	
(Robertson, 1967), (Anderson & Tushman, 1990)	Discontinuous/continuous
Dually-dichotomical classification	
Authors	Types of innovations
(Abernathy & Clark, 1985)	Regular/revolutionary; Niche architectural
(Moriarty & Kosnik, 1990)	Incremental/radical; evolutionary market/ evolutionary technical
(Tidd, 1995)	Incremental breakthrough; Architectural/fusion
(Chandy & Tellis, 2000)	Incremental/radical; market breakthrough/technological breakthrough

Source : (Kotsemir, Abroskin, & Dirk, 2013)

Then, we perform our screening with *Semantic Scholar* filter tools on July 2020 (www.semanticscholar.org). *Semantic Scholar* applies artificial intelligence to extract the meaning from the scientific literature allowing scholars to navigate research much more efficiently than a traditional search engine. We obtain 10.300 results for "radical Innovation", 2.370 results for "breakthrough innovation" and 9.080 results for "disruptive innovation". After that, we rearranged these results in the basis of the date of publication, the publication type and the top 10 most published authors as indicated on table. 2.

As a synthesis, we can say that the concept of radical innovation appeared over the last eighty years. According to many authors (Burns and Stalker, 1966; Mansfield, 1968; Cooper and Schendel, 1976; Moch and Morse, 1977; Freeman, 1982; Ettlle et al., 1984; Clark, 1985; Rothwell, 1986; Markides and Geroski, 2004) radical innovation is opposed to incremental innovation in terms of knowledge challenge. Indeed, incremental innovation addresses no peculiar knowledge or concept stakes, involves no considerable skills or ingenuity and, consequently it introduces minor changes to the existing product or service offers. It uses existing solution principles or architectures and reinforces the dominance of existing firms in the field. Contrarily, a radical innovation introduces major changes in creating new values based on disruptions on habits and behaviours of customers. It creates a new markets challenging at the same time traditional competencies and assets of the company. Whereas incremental innovation reinforces the capabilities of established organizations, radical innovation forces them to ask a new kind of questions, to acquire and develop a new technical and commercial skills, to innovatively set the problem and undertake their solving process.

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Table 2 : Results of the literature review reordered across date, type of publication and most published author

Key word : "radical innovation"											
Publication date										Publication Type	
1937	1	1957	0	1977	1	1997	26	2017	362	Review	960
1938	0	1958	1	1978	3	1998	54	2018	323	Journal article	426
1939	0	1959	0	1979	7	1999	31	2019	295	Conference	127
1940	2	1960	0	1980	2	2000	66	2020	96	Other	32
1941	0	1961	0	1981	7	2001	81	until 07/2020		Editorial	14
1942	0	1962	3	1982	3	2002	67	-	-	Letters & comments	4
1943	1	1963	1	1983	6	2003	91	-	-	Study	4
1944	0	1964	0	1984	1	2004	109	-	-	Case report	2
1945	1	1965	1	1985	7	2005	148	-	-	Clinical trial	1
1946	3	1966	2	1986	6	2006	143	-	-	Top 10 most published authors	
1947	1	1967	0	1987	12	2007	219	-	-	Gina Colarelli O'Connor	30
1948	0	1968	4	1988	10	2008	229	-	-	Bernard Yannou	20
1949	0	1969	4	1989	9	2009	257	-	-	Roberto Verganti	19
1950	0	1970	4	1990	15	2010	244	-	-	John Bessant	18
1951	1	1971	2	1991	10	2011	299	-	-	Mario Coccia	17
1952	1	1972	1	1992	10	2012	277	-	-	Cornelius Herstatt	14
1953	0	1973	3	1993	15	2013	348	-	-	Benoit Weil	13
1954	0	1974	3	1994	14	2014	459	-	-	Frank Gertsen	13
1955	0	1975	0	1995	21	2015	431	-	-	Lois Peters	13
1956	1	1976	3	1996	17	2016	396	-	-	Pascal Le Masson	13
Key word : "breakthrough innovation"											
Publication date										Publication Type	
1937	-	1957	-	1977	0	1997	9	2017	97	Review	216
1938	-	1958	-	1978	0	1998	11	2018	92	Journal article	127
1939	-	1959	-	1979	0	1999	5	2019	102	Conference	47
1940	-	1960	-	1980	0	2000	16	2020	36	Other	18
1941	-	1961	-	1981	0	2001	22	until 07/2020		Editorial	11
1942	-	1962	-	1982	0	2002	34	-	-	Letters & comments	7
1943	-	1963	-	1983	0	2003	29	-	-	News	2
1944	-	1964	-	1984	0	2004	24	-	-	Case report	1
1945	-	1965	-	1985	0	2005	30	-	-	-	-
1946	-	1966	-	1986	1	2006	35	-	-	Top 10 most published authors	
1947	-	1967	-	1987	0	2007	50	-	-	Gina Colarelli O'Connor	18
1948	-	1968	-	1988	1	2008	76	-	-	Jim Euchner	12
1949	-	1969	-	1989	3	2009	87	-	-	Bruce A. Vojak	8
1950	-	1970	2	1990	1	2010	84	-	-	Christophe Midler	7
1951	-	1971	0	1991	2	2011	121	-	-	Keyvan Vakili	7
1952	-	1972	0	1992	1	2012	96	-	-	Mark P. Rice	7
1953	-	1973	0	1993	3	2013	120	-	-	Bill Poston	6
1954	-	1974	0	1994	1	2014	115	-	-	Manish K. Srivastava	6
1955	-	1975	0	1995	3	2015	125	-	-	Oliver Gassmann	6
1956	-	1976	0	1996	4	2016	102	-	-	Alexander Sann	5
Key word : "disruptive innovation"											
Publication date										Publication Type	
1937	-	1957	-	1977	0	1997	1	2017	498	Review	767
1938	-	1958	-	1978	1	1998	1	2018	482	Journal article	646
1939	-	1959	-	1979	1	1999	5	2019	485	Conference	158
1940	-	1960	-	1980	0	2000	10	2020	190	Editorial	72
1941	-	1961	-	1981	0	2001	28	until 07/2020		Other	64
1942	-	1962	-	1982	0	2002	17	-	-	Letters & comments	54
1943	-	1963	-	1983	2	2003	31	-	-	Study	8
1944	-	1964	-	1984	0	2004	51	-	-	Case report	3
1945	-	1965	-	1985	1	2005	49	-	-	Meta analysis	1
1946	-	1966	-	1986	0	2006	77	-	-	Top 10 most published authors	
1947	-	1967	-	1987	0	2007	56	-	-	Clayton M. Christensen	32
1948	-	1968	-	1988	0	2008	95	-	-	Chang Chieh Hang	13
1949	-	1969	-	1989	0	2009	111	-	-	Captain Terry C. Pierce	11
1950	-	1970	2	1990	0	2010	135	-	-	Michael B. Horn	10
1951	-	1971	0	1991	1	2011	157	-	-	Runhua Tan	10
1952	-	1972	1	1992	1	2012	244	-	-	Christian Sandstrom	9
1953	-	1973	1	1993	1	2013	267	-	-	Cornelius Herstatt	9
1954	-	1974	0	1994	1	2014	339	-	-	Jianguang Sun	9
1955	-	1975	0	1995	0	2015	442	-	-	Mats Magnusson	9
1956	-	1976	1	1996	2	2016	495	-	-	Aditi Ramdorai	8

Source: www.semanticscholar.org on July 2020

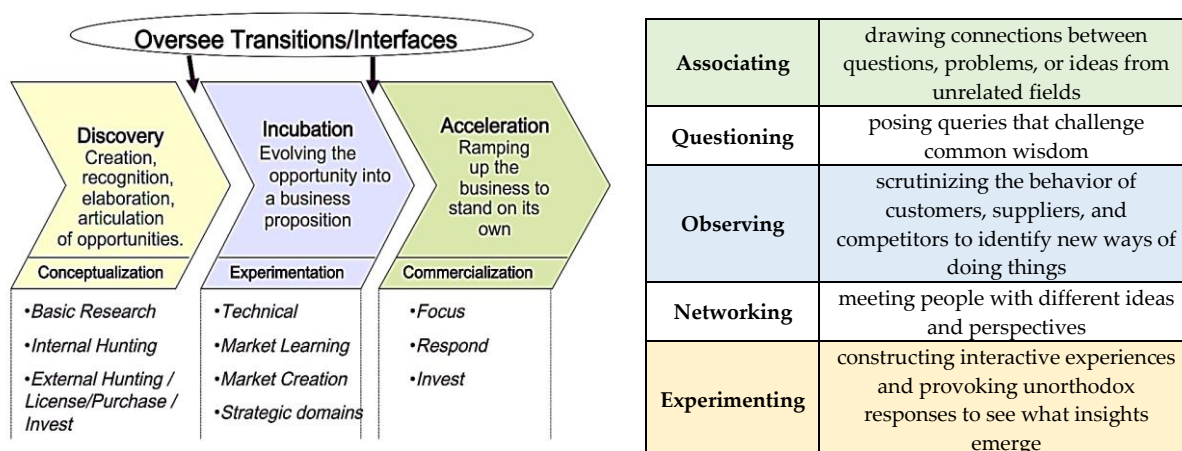
2- THE CASE FOR RADICAL INNOVATION COMPETENCIES :

2.1 – REVIEW OF THE RADICAL INNOVATION COMPETENCIES LITERATURE:

When we did a first round literature review from Google Scholar on January 2019 with the successively use of the three key words : “Radical Innovation Competencies”, “Disruptive Innovation Competencies” and “Breakthrough Innovation Competencies”, and after an alphabetical screening applied to titles and abstracts, we found works which are most alphabetically nearest to our work according to their titles or abstracts. They are : 4 works about Radical Innovation Competencies, 7 about Disruptive Innovation Competencies and 7 about Breakthrough Innovation Competencies and we summarize them in table. 3.

A second round of selection after reading the whole articles, allow us to discover three typical works. The first work starts at 1995 by Gina O’connor and company. They define radical innovations competency as the ability for a firm to commercialize radical innovations repeatedly (O’Connor & De Martino, 2006). As radical innovations, they mean products and technologies that have high impact on the market in terms of offering an entirely new benefits, significant improvement in known benefits or significant reduction in cost (Leifer et al., 2000). In the basis of this definition, they built a model which describes the experiments of companies in nurturing and commercializing radical innovations constantly. It represents the radical innovation project life cycle of Discovery, Incubation and Acceleration. The second work published on 2009 concerns Clayton M. Christensen and company about the five skills of disruptive innovators : associating, questioning, observing, networking and experimenting (Dyer, Gregersen, & Christensen, 2009). Christensen published a wholly category of books on innovation since 1997. He starts with The Innovator’s Dilemma (Christensen, 1997), then The Innovator’s Solution (Christensen & Raynor, 2003). In 2003, he began with Jeff Dyer and Hal Gregersen an eight-year study concerning the characteristics of business innovators that contribute to their ability to generate disruptive business ideas. This goal open to them the opportunity to understand the thinking of the innovators like Apple’s Steve Jobs, Amazon’s Jeff Bezos or eBay’s Pierre Omidyar. Figure.1 presents two models: Radical Innovation Capability by O’Connor and company (O’Connor et al., 2008) and the Innovator’s DNA by Christensen and company (Dyer, Gregersen, & Christensen, 2009). The third work is the work of Yannou and company (Moubdi et al., 2018). They built a competency framework to support a need seeker innovation training composed from 36 sub competencies organised on four groups : Ability to exercise a knowledge, attitudes or behavioural competencies, collective competencies and strategic leadership behaviour, as indicated on Table. 4.

Figure 1 : Radical Innovation Capability & Innovator’s DNA



Source : (O’Connor & Ayers, 2005) and (Dyer, Gregersen, & Christensen, 2009)

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Table 3 : Pertinent works inventoried in Google Scholar on January 2019

N°	References with APA
	Key words : "radical innovation competencies"
1	Gina Colarelli O'Connor, Alan D. Ayers. (2005). Building a Radical Innovation Competency. <i>Research-Technology Management</i> . Vol. 48. Issue 1. pp 23-31
2	Christopher M. Mc Dermott, Gina Colarelli O'Connor. (2002). Managing radical innovation : an overview of emergent strategy issues. <i>The Journal of Product Innovation Management</i> . Vol. 19. Issue 6. November 2002. pp 424-438
3	Richard Leifer, Gina Collarelli O'Connor, Mark Rice. (2001). Implementing radical innovation in mature firms : The role of hubs. <i>Academy of Management Perspectives</i> . Vol. 15. N° 3. August 2001. pp 102-113
4	Gina Colarelli O'Connor, Richard DeMartino. (2006). Organizing for Radical Innovation : An Exploratory Study of the Structural Aspects of RI Management Systems in Large Established Firms. (2006). <i>The Journal of Product Innovation Management</i> . Vol. 23. Issue 6. November 2006. pp 475-497
	Key words : "disruptive innovation competencies"
1	Dan Yu, Chang Chich Hang. (2010). A Reflective Review of Disruptive Innovation Theory. <i>International Journal of Management Reviews</i> . Vol. 12. Issue 4. December 2010. pp 435-452
2	Scott D. Anthony, Matt Eyring, Lib Gibson.(2006). Mapping your Innovation Strategy. <i>Harvard Business Review</i> . 84(5). May 2006. pp 104-13, 157.
3	Marnix Assink. (2006). Inhibitors of disruptive innovation capability : a conceptual model. <i>European Journal of Innovation Management</i> . Vol. 9. Issue 2. pp 215-233
4	Marco Zeschky, Bastian Widenmayer, Oliver Gassmann. (2011). Frugal Innovation in Emerging Markets. <i>Research-Technology Management</i> . Vol. 54. Issue 4 : Innovation in Emerging Markets. pp 38-45
5	Vijay Govindarajan, Praveen K. Kopalle. (2006). Disruptiveness of innovations: measurement and an assessment of reliability and validity. <i>Strategic Management Journal</i> . Vol. 27. Issue 2. (February 2006). pp 189-199
6	Jeremy k. Hall, Michael J. C. Martin. (2005). Disruptive technologies, stakeholders and the innovation value-added chain: a framework for evaluating radical technology development. <i>R&D Management</i> . Vol. 35. Issue 3. (June 2005). pp 273-284
7	Scott D. Anthony, Mark W. Johnson, Joseph V. Sinfield, Elizabeth J. Altman. (2008). <i>The Innovator's Guide to Growth: Putting Disruptive Innovation to Work</i> . Boston, Massachusetts: Harvard Business Press
	Key words : "breakthrough innovation competencies"
1	Gina C. O'Connor, Richard Leifer, Albert S. Paulson, Lois S. Peters. (2008). <i>Grabbing lightning: building a capability for breakthrough innovation</i> . San Francisco, CA, USA: Jossey-Bass A Wiley Imprint John Wiley & Sons, Inc.
2	Robert B. Tucker. (2001). Innovation : the new core competency. <i>Strategy & Leadership</i> . Vol. 29. Issue 1. pp 11-14
3	Koen Peter A., Bertels Heidi, Elsum Ian R., Orroth Mike, Tollett Brenda L. (2010). Breakthrough Innovation Dilemmas. <i>Research Technology Management</i> . Vol. 53. N° 6. Nov/Dec 2010. pp 48-51
4	Manish K. Srivastava, Devi R. Gnyawali. (2011). When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. <i>Academy of Management Journal</i> . Vol. 54. N° 4. August 2011. pp 797-810
5	Anupama Phene, Karin Fladmoe-Lindquist, Laurence Marsh. (2006). Breakthrough innovations in the U.S. biotechnology industry : the effects of technological space and geographic origin. <i>Strategic Management Journal</i> . Vol. 27. Issue 4. April 2006. pp 369-388
6	Christopher Mcdermott, Robert Handfield. (2000). Concurrent development and strategic outsourcing: Do the rules change in breakthrough innovation? <i>The Journal of High Technology Management Research</i> . Vol. 11. Issue 1. Spring 2000. pp 35-57
7	Gina Colarelli O'Connor. (2008). Major Innovation as a Dynamic Capability : A Systems Approach. <i>The Journal of Product Innovation Management</i> . Vol. 25. Issue 4. July 2008. pp 313-330

Key words : "Radical innovation competencies", "disruptive innovation competencies" and "breakthrough innovation competencies".

According to *Semantic Scholar* filter tools applied on July 2020, we get : 5 results for "radical innovation competencies" and 2 results for "radical innovation skills"; 2 results for "breakthrough innovation competencies" and 0 result for "breakthrough innovation skills"; 0 result for "disruptive innovation competencies" and 1 result for "disruptive innovation skills". Table. 5 shows these findings.

Table 4 : The competency framework supporting the need seeker innovation training

	Analyzing phase : Problem discovery phase	Idea generation phase: Problem synthesis phase	Idea evaluation phase : solution finding and testing phase	New business development phase
Ability to exercise a knowledge	-Ability to tackle ill structured problem -Empathy skills -Analytical skills	-Synthesising skills -Knowledge management skills -Project portfolio management skills	-Ability to grasp aspects of intellectual property -Experimenting and prototyping skills -Problem-solution pairing	-Opportunity recognising skills -System thinking skills -Project time management Skills
Attitudes : Behavioural competencies	-Curiosity -Perseverance -Communication skills	-Networking -Creativity	-Idea association skills -Independent thinking -Priority management skills	-Assertiveness -Responsibility
Collective competencies	-Collective motivation by the strategic intent of the project -Openness	-Mutual trust -Collective knowledge sharing	-Collective learning -Collective intelligence	-Team focused effort -Team networking
Strategic leadership behaviour		-Facilitation skills -Influencing skills	-Convincing skills -Accountability	-Priority identification skills -Uncertainty reducing skills

Source: (Moubdi et al., 2018)

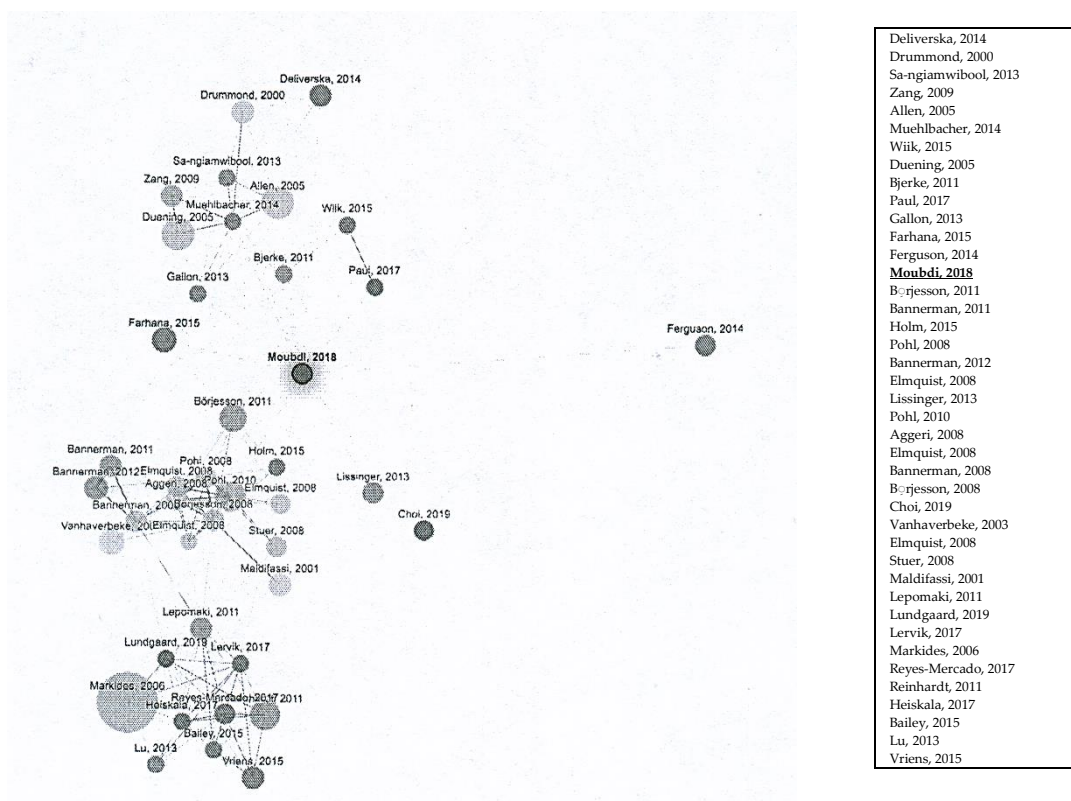
Table 5 : Total of results extracted from Semantic Scholar on July 2020

N°	References with APA
	Key words : "radical innovation competencies"
1	Gina Colarelli O'Connor, Richard De Martino.(2006). Organizing for Radical Innovation:An Exploratory Study of the Structural Aspects of RI Management Systems in Large Established Firms. Journal of Product Innovation Management.Vol. 23. pp 475-497
2	Gina Colarelli O'Connor, Alan D. Ayers. (2005). Building a Radical Innovation Competency. Research-Technology Management. Vol. 48. Issue 1. pp 23-31
3	Jimmi Normann Kristiansen. (2014). Managing Radical Innovation Projects : Understanding Competency Building in a Complex Discipline. PhD Thesis. Social Science. Aalborg University
4	Simon J. Ford, Simone Ferriani, David R. Probert. (2013). Overcoming the innovation barrier : A search-selection model of breakthrough innovation in large firms . In Pfeffermann N., Minshall T., Mortara L. (eds). Strategy and Communication for Innovation. Springer, Berlin, Heidelberg.
5	Mitsuru Kodama. (2007). Radical Innovation through Integrative Competencies of Project-Based Organizations: Case Study of Mitsubishi Electric. Series on Technology Management. Vol. 12 : Project-Based Organization in the Knowledge-Based Society. Imperial College Press. pp 83-113.
	Key words : "radical innovation skills"
1	Chenjua Hu. (2016). Chinese Innovation Research to Industrial Transformation and Upgrading Processing Innovation in Case Company. Master's thesis in Science of Economics and Business Administration: Industrial Management. University of Vaasa.
2	Samira Bourgeois-Bougrine, Souad Latorre, Florence Mourey. (2018). Promoting Creative Imagination of Non-Expressed Needs: Exploring a Combined Approach to Enhance Design Thinking Creativity Studies. Vol. 11. Issue 2. pp 377-394
	Key words : "breakthrough innovation competencies"
1	Gina C. O'Connor, Richard Leifer, Albert S. Paulson, Lois S. Peters. (2008). Grabbing Lightning: Building a Capability for Breakthrough Innovation. San Francisco, CA, USA:Jossey-Bass A Wiley Imprint John Wiley & Sons, Inc.
2	Ted Farrington, Bruce Kirk, Lois S. Peters and Gina O'Connor. (2011). Institutionalizing Innovation Competency Through People. Research Technology Management. Vol. 54. N° 6. pp 56-59
	Key words : "disruptive innovation skills"
1	James J. Sluss Jr. (2019). Plenary : Integrating Concepts of Disruptive Innovation and Ideation into the Curriculum. 2019 IEEE World Conference on Engineering Education (EDUNINE). 17-20 March 2019. Lima, Peru. IEEE Xplore.

Key words : (radical innovation competencies, radical innovation skills); (breakthrough innovation competencies, breakthrough innovation skills); (disruptive innovation competencies, disruptive innovation skills).

Connected Papers creates a graph for a selected paper after analysing around 50.000 papers and select a few dozen with the strongest connections to it (www.connectedpapers.com). Thanks to “co-citation” and “bibliographic coupling”, a Force Directed Graph FDG is built from Semantic Scholar Paper Corpus (licensed under ODC-BY) which contains hundreds of millions of published papers across many scientific fields. Each node is an academic paper related to the selected paper. Papers are rearranged according to their similarity (It is not a citation tree). Node size is the number of citations. Node color is the publishing year. Similar papers have strong connecting lines and cluster together. We apply this technology on three papers : (Moubdi et al., 2018), (O’Connor & Ayers, 2005) and (Dyer, Gregersen, & Christensen, 2009) . Despite (O’Connor & Ayers, 2005) is the alphabetically nearest paper to our work, those of (Dyer, Gregersen, & Christensen, 2009) and (Moubdi et al., 2018) are the most relevant papers closer to it. Moreover, their FDGs presented in Figure. 2 indicate that the (O’Connor & Ayers, 2005) work is in a centre of the cluster, while both of (Moubdi et al., 2018) and (Dyer, Gregersen, & Christensen, 2009) works stand alone and far from any cluster. This fact indicates that literature about innovator competencies or need seeker strategy competencies are still absent.

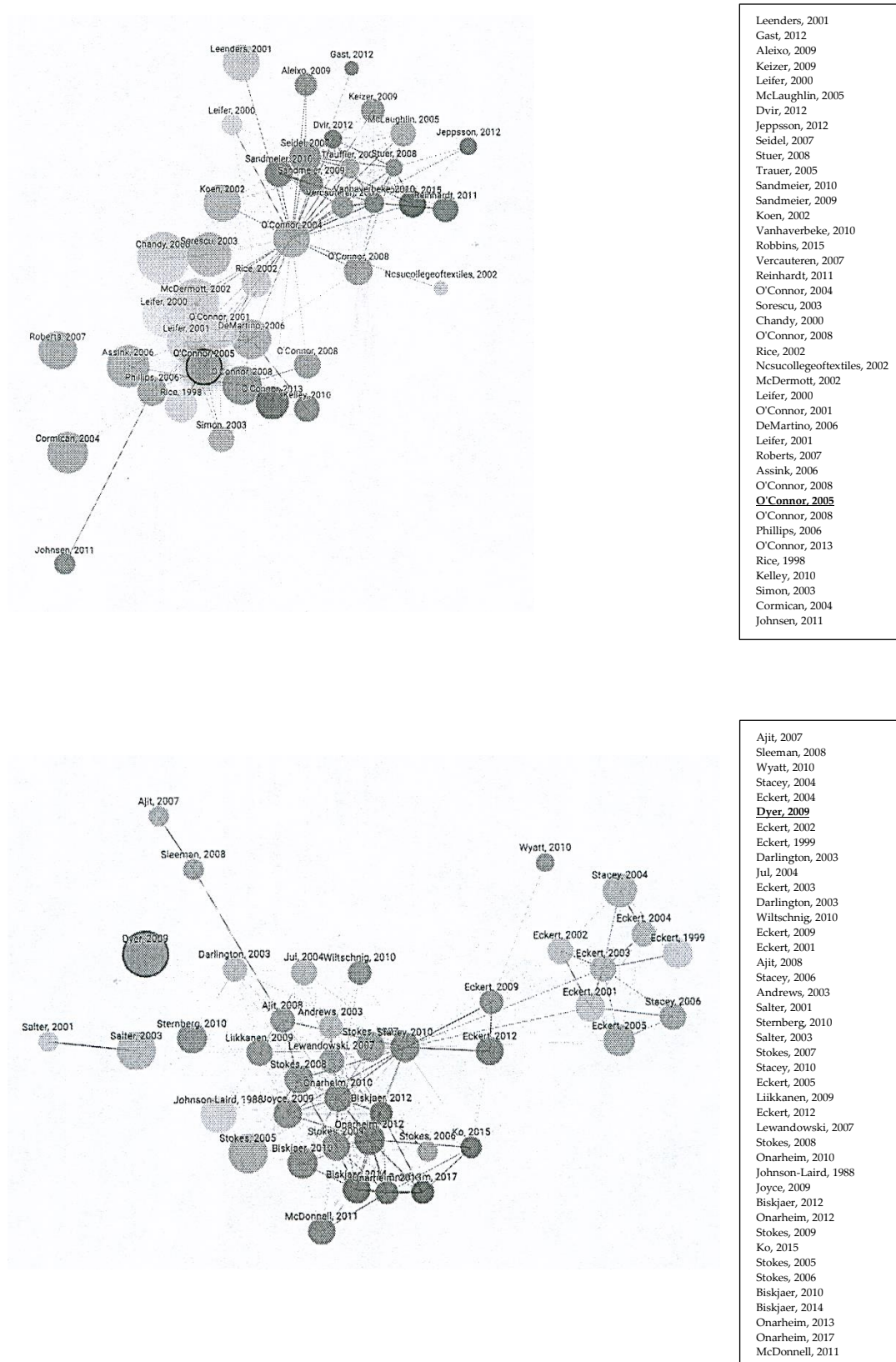
Figure 2 : The *ConnectedPapers* algorithm applied to (Moubdi et al., 2018), (O’Connor & Ayers, 2005) and (Dyer, Gregersen, & Christensen, 2009)¹



¹ All the references used are retranscribed on the right of the page according to their appearance in the graph from top to bottom.

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Figure 2 : The ConnectedPapers algorithm applied to (Moubdi et al., 2018), (O'Connor & Ayers, 2005) and (Dyer, Gregersen, & Christensen, 2009) (Continued)



Source: www.connectedpapers.com on July 2020

2.2 – A PROPOSED RECONCEPTUALIZATION OF RADICAL INNOVATION COMPETENCIES:

Jaruzelski and company have stipulated that between 2004 and 2014, firms follow at least one of three innovation strategies: Need Seeker, Market Reader or Technology Driver, depending on the focus put on the customer, the market or the technology (Jaruzelski, Staack, & Goehle, 2014). They define them as follow:

-Need Seekers, such as : Apple, Procter & Gamble and Tesla, engage customers directly to generate new ideas. They develop new products and services based on superior end-user understanding.

-Market Readers, such as : Samsung, Caterpillar and Visteon, use a variety of means to generate ideas by closely monitoring their markets, customers, and competitors, focusing largely on creating value through incremental innovations.

-Technology Drivers, such as : Google, Bosch and Siemens, depend heavily on their internal technological capabilities to develop new products and services.

According to their study, following a Need Seekers strategy offers the greatest potential for superior performance in the long term. Companies adopting this strategy are effective at both the ideation and conversion stages of innovation and they consistently outperform financially.

Being Need Seeker can be made by two ways:

1. Using lead-users (Hippel, Ogawa, & De Jong, 2011), their insightful refreshing ideas and dreams and their testimonies on usage and pain points.
2. Having a visionary leader like Steve Jobs (Apple) or James Dyson (Dyson), the company growth and the number of product references being limited by the imagination and control power of single visionary entrepreneur, as specified by (Dyer, Gregersen, & Christensen, 2009).

In fact, there is a need for a methodology investigating growth territories or strategic value niches for generating disruptive innovations beyond current customer expectations, in a cooperative and multidisciplinary manner and a secure way. If successful, the new product or service will create a new market that the company can expect to dominate at least for a while until the competition strikes back.

Hence, we adopt the following concept for radical innovation competencies:

They are the qualities, abilities, capacities or skills which is developed by and belongs to the student. They represent a dynamic combination of cognitive and metacognitive skills, demonstration of knowledge and understanding, interpersonal, intellectual and practical skills and ethical values (Tuning, 2010). Here, radical innovation does not mean necessarily a "technological revolution", but an innovation which study the pain points of the users or the costumers. Thus, we adopt the approach of Motte and company (Motte, Yannou, & Bjärnemo, 2011) for the definition of radical innovation. As they mention, we are in situation of radical innovation when only the company desires to go outside a current saturated market, and it is necessary to propose a new offer radically different from the competition. A radical innovation means here a specific new product development case where the market is unknown and the focus is as much on customer understanding than on the design of solutions. Consequently, a radical innovation consists on to developing an adequate offering, to sustaining the advantages of a first mover and also to finding a new set of core value-drivers. (Yannou et al., 2013) propose a set of core value-drivers composed by four types of proofs that are built and reinforced throughout the conceptual design stage of a radical innovation projects. These proofs are defined in Table. 6. In the reconceptualization of radical innovation competencies, we adopt the approach of (Yannou et al., 2013) for the value drivers of a radical innovation project named the UNPC proofs.

Table 6 : UNPC proofs of radical innovation

Proof type	Definition
Proofs of Usefulness (U)	Coverage of usage and needs situations of users/stakeholders for which important needs are covered, suffering alleviated and/or malfunctions of existing systems improved
Proofs of Newness (N)	Real innovation, claimable, protectable, perceived and valued by users and costumers
Proofs of Profitability (P)	Expected profitability for the company and costumers. Tendency to improve brand image, to increase the average revenue par user, to conquer new markets or to make more fidel clients (re-purshasing).
Proofs of Concept (C)	The conceptual solution or prototype functions works effectively and efficiently in expected situations. Technological and indutrial feasibility

Source : (Yannou et al., 2013)

3- IMPLICATIONS FOR MANAGEMENT EDUCATION :

3.1- ABOUT RADICAL INNOVATION COMPETENCIES' LITERATURE ON MANAGEMENT EDUCATION:

We have not found a literature about competencies must owned and performed by the management students in order to fostering radical innovation. As a related works concerning this issue, some pertinent works seems important to be cited. Pr. Henry Mintzberg, listed on his book: *the nature of managerial work* in 1973 (Mintzberg, 1973), ten managerial roles divided into three groups: Interpersonal, Informational, and Decisional (See table. 7). Skills about radical innovation were absent in this work.

Table 7 : Set of 10 Managerial Roles Divided Into 3 Groups: Interpersonal, Informational, and Decisional

Group Roles	Managerial Roles	Definition
Interpersonal Roles	Figurehead	The manager is a symbol, obliged to perform a number of duties.
	Leader	The manager defines the atmosphere in which the organization will work. Powers of charisma or position of office are used to transmit information, make strategic decisions, integrate individual needs and organizational goals, to bring individual and organizational needs into common accord, and it is the leader role that the managerial power manifests itself (legitimate, formal authority).
	Liaison	The manager deals with the significant web of relationships that the manager maintains with numerous individuals and groups outside the organization.
Informational Roles	Monitor	The manager is continually seeking, and being bombarded with information that enables him to understand what is taking place in the organization and its environment by monitoring a) internal operations, b) external events, c) analyses, d) ideas and trends, e) pressures.
	Disseminator	The manager sends external information into his organization and internal information from one subordinate to another. 2 types of information: a) factual, b) value (preferences versus facts).
	Spokesman	The manager transmits information out to his organization's environment to speak on behalf of the organization.
Decisional Roles	Entrepreneur	The manager acts as initiator and designer of much of the controlled change of the organization. By using the monitoring role, he seeks opportunities, sees problems, and initiates actions to improve situations. Managers can be involved in improvement project design at 3 levels: a) delegation (all responsibility to others), b) authoritarian (delegates design, but retains choice making), c) supervision (retains design and decision in projects).
	Disturbance handler	The manager deals with involuntary situations and change beyond their control, such as crisis or emergencies.
	Resource allocator	As a formal authority, the manager must oversee the system by which organizational resources are allocated. 3 essential elements of resource allocation: a) scheduling of time, b) programming work, c) authorizing actions.
	Negotiator	Managers participate in negotiation activities.

Source :(Mintzberg, 1973)

After that, in his book: *Managers not MBA'S* (Mintzberg, 2004), he adds three new managerial roles. **Designer** is one of them. From the H. Simon point of view (Simon, 1969), he underlines the relation between design and management. He advocates for a deep exploitation of the skills derived from Design Sciences and Designers into Management Education. At this level, Mintzberg started to speak about some skills not yet highlighted before 2004 on management education. We consider this as an appeal for taking on an account the importance of Radical Innovation Skills on Management Education.

Yannou and Bigand (YANNOU & BIGAND, 2004) dress a number of 8 skills must be owned by an industrial and/or project manager (See table. 8). Three of these skills (Design, Produce and Innovate) are most correlated to Radical Innovation Skills.

Table 8 : Eight (08) expected skills into industrial and project managers

Competency	Definition
To design	To formulate a problem, to formalize, to model, to imagine solutions from the model, to choose satisfactory solutions.
To produce	To transform a realistic model and ensure its feasibility, to experiment, to produce.
To innovate	To mobilize and stimulate personal or team creativity, to be open-minded to outer ideas and environment, to target creativity toward an objective.
To drive	To structure and valorize a project, to egg on dynamics in a project, to ensure the project management.
To organize	To make use of appropriate means and methods to ensure information exchange or instructions between the actors of a system.
To communicate	To exchange clear and precise information, to be open-minded to outer ideas and environment, to develop an ease-to-contact feeling, to organize information flow using adapted methods and tools, to argue orientations.
To train	To select people who will receive a training, to elaborate a training plan. To supervise all or part of a training, to assess the people's progress
To undertake	To manage, to market, to create value, to negotiate, to evaluate risks, to be autonomous.

Source : (Yannou & Bigand, 2004)

We can also mention here the discussion made with Roger Martin, the dean of the Rotman School of Management, University of Toronto in AMLE on 2006 (Dunne & Martin, 2006) about Design Thinking. He advocated for teaching this type of thinking into Management Education.

After 2006, we can talk about Tuning Project (Tuning, 2010). Tuning Project divided the skills must be mastered by graduates on two categories: Generic Competencies which must be owned by all graduates in all the fields, and Specific Competences assigned to one domain like: Business/Management. **31** Generic Competencies and **25** Specific Competencies are inventoried. As a competencies related to radical innovation, we can mention **16** Generic Competencies and **10** Specific Competencies as mentioned on Table. 9. We can see clearly that Academics and Employers haven't the same vision about the importance of some skills but strangely, they allowed the same ranking 22 from 25 for *Understanding principles of engineering and link them with business*. We realize that both academics and employers did not allow great importance for Specific Competencies which are directly related to the radical innovation competencies on 2010 (so 10 years earlier).

The reality of the ground on Management Education shows us that academics are typically job-oriented. They concentrated their efforts to produce managers for all the functions and jobs in a company: operations management, strategic management, accounting, finance, marketing, supply chain management, etc. They do not care about the importance of radical innovation skills in management education. Accurately, they duplicate the same type of courses like the first educators on management education, whose a century ago,

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Table 9 : The Generic and Specific competencies related to Radical Innovation Competencies ranked by academics (A.R.) and employers (E.R.) in Tuning Project 2010

Tuning Competencies	Generic Competences (from 31)	A. R.	E. R.	Specific Competences (from 25)	E. R.	A. R.
Competences related to Radical Innovation Competencies	Ability for abstract thinking, analysis and reasoning	1	2	Ability to analyze and structure an enterprise problem + design solution (eg. Entering a new market)	1	9
	Ability to apply knowledge in practical situations	2	1	Identify and use adequate tools (eg. Market research, statistical analysis, comparative ratios)	2	8
	Ability to identify, pose and solve problems	4	3	Understand existent and new technology and its impact for new /future markets	3	18
	Capacity to learn and to stay up-to-date with learning	5	9	Learning to learn (how, when, where new personal developments are needed)	4	3
	Capacity to generate new ideas (creativity)	6	8	Define criteria by which an enterprise is defined and link the results with an analysis of the environment	13	12
	Ability to be critical and self-critical	7	19	Use the respective instruments for business environment analysis	15	11
	Ability to search for, process and analyze information from a variety of sources	9	15	Identify impact of macro and microeconomics elements on business organizations	16	15
	Ability to undertake research at an appropriate level	10	22	Understand details of business functions, size, sectors and link with theories	17	10
	Ability to work in a team	11	5	Change management	20	23
	Interpersonal and interaction skills	12	11	Understand principles of engineering and link them with business	22	22
	Ability to adapt to and act in new situations	15	7			
	Skills in the use of information and communication technologies	19	23			
	Determination and perseverance in the tasks given and responsibilities taken	22	14			
	Ability to evaluate and maintain the quality of work produced	23	21			
	Ability to design and manage projects	25	20			
	Spirit of enterprise, ability to take initiative	29	17			

Source : (Tuning, 2010)

3.2- IMPACT OF RADICAL INNOVATION COMPETENCIES ON MANAGEMENT EDUCATION:

If students of Business/Management learn how to master radical innovation and its core competencies, they will be able to : 1-Solving wicked or ill-structured problems using abductive reasoning, in addition to deductive and inductive skills they already possess ; 2- Developing collaborative skills and going much deeper on understanding the user and the user experience (Dunne & Martin, 2006); 3- Exploring, iterating, observing, visualizing and prototyping; 4- Developping design thinking approach that represents a more general cognitive process to facilitate adaptive reasoning (Glen et al., 2014).

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An interview with Pr. Bernard Yannou, inventor of the Radical Innovation Design® methodology² allow us to dress table. 10 crossing educational systems of managers, industrial designers and design engineers with UNPC proofs.

Table 10 : Mastering of UNPC abilities by Management, Industrial Design and Design Engineering' Educational Systems

Businesses UNPC Proofs	Mangers	Industrial designers	Design Engineers
Usefulness Proofs	Average Because: -They know market behaviour and needs, customer needs but not customer uses of the product or a service.	Good Because: -Very close to user, they understand it better and are able to produce an usual creativity	Weak Because: -They have some weaknesses with the uses of product.
Newness Proofs	Average Because: -They have only knowledge about competitors and trends	Average	Good Because: -They have much Knowledge about patents and business Intelligence.
Profitability Proofs	Good Because: -They are able to determining general costs and prices	Weak	Average Because: -They are able to determining the cost of product development and launching.
Concept Proofs	Weak	Weak	Good Because: -They are able to know the state of technologies on the field.

Source : An interview accorded from Pr. Bernard Yannou on Spring 2014

Regarding students of industrial design or design engineering, the students of management are weak on providing abilities to master concept proofs and are average on those of newness and usefulness proofs. In the ground, we can say that they fail in prototyping skills, providing conceptual solutions, sketching, changing ideas to tangible objects, absence of adequate equipment and its training to allow prototyping, software modelling, simulating, and sketching; and they have no network with designers or engineers. As we mention on a precedent works (Mehddeb, 2014, 2015), the management students' entire curricula does not allow them to prototype or to bring conceptual solutions. That is why more openness on design and engineering educations must be made in the business schools.

Introducing radical innovation competencies on management education by specific courses, multidisciplinary curriculums, funding research programs or simply hiring of students of engineering or design in a dedicated business school' masters will develop many disciplines linked directly to the notion of innovation. We can mention here: R&D management, entrepreneurship management, technology management, design management and innovation management. But systemically propagated, and according

² We conducted this interview in Spring 2014 at the Industrial Engineering Research Department (Laboratoire Génie Industriel) of Ecole Centrale Paris in Châtenay- Malabry, France.

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to the Concept-Knowledge theory, we can see the transformation happen in the behaviour of the graduates from other disciplines like: business administration, public management and crisis management.

Here it is crucial to indicate that the educational system of Management allow students to achieve great level on the mastering of profitability proofs, particularly in what rely to the costs management, return per investments and financial key performance indicators.

CONCLUSION :

Radical innovation is a domain that knows a sustainable growth since many decades. To master it, core competencies must be taught and outperformed. A deep and systematic literature review let us to discover a real gap on the study of this type of competencies. To undertake this study, we start with the reconceptualization of the notion of radical innovation competencies RIC. For us, RIC is associated directly to the notion of need seeker strategy, developing new products and services based on superior end-user understanding and UNPC proofs (Yannou et al. ,2013), in contrast with the notions of the visionary leader or entrepreneur as a genius person. All in all, we observe that there is no literature concerning RIC in management education and there are more weaknesses on management education about usefulness, newness and concept abilities. More solutions must be implemented in order to see the rising of RIC on Management education like : specific courses, multidisciplinary curriculums, funding research programs or simply hiring of students of engineering or design in a dedicated business school' masters.

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