A Review of Fuzzy Front End Toolkits

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1 Appraisal Criteria for Toolkits of 266 Fuzzy Front End Studies

– Park, D, and Childs, PRN, Dyson School of Design Engineering, Imperial College London, UK

Criteria	Description	
Definition of Toolkit	A structural and functional frameset in which input and outputs related to product development parameters, variables and constrains are yielded.	
1 Materiality	How much detail is provided to structure and operate the toolkits?	
	O	The provided toolkits are specific, so that users can understand and use them step by step without difficulties.
	△1	Self-development type (the FFE study developed its own toolkits) : The toolkits provided are basic, so that users have difficulties not only understanding the methods of implementation but also in using the toolkits, step by step.
	△2	Representative toolkit type (the FFE study borrowed well-known toolkits) : Representative toolkits which are broadly used in academia and industry are presented with brief instructions or the names of toolkits only.
	X	Toolkits are not specific, so that users cannot understand and use them step by step.
2 Functionality	How much do the toolkits cover the various functional domains?	
	O	Toolkits are devised for diverse functional areas (at least two areas), e.g. marketing, R&D, design, etc.
	△	The toolkits provided target one functional domain only.
	X	The toolkits provided do not target any functional areas, e.g. toolkits are aimed at managing FFE issues, such as uncertainty control and critical success factors.
3 Contextuality	How well do the toolkits interlock with each other for contextual performance?	
	O	The toolkits are well devised with contextual performance in mind. : The outputs of a previous toolkit can be directly inferred, based on the input of the previous toolkit.
	△	Toolkits provided are partially devised with contextual performance in mind. : The outputs of a previous toolkit cannot be directly inferred, based on the input of the previous toolkit.
	X	Toolkits provided are not devised with contextual performance in mind. : Each toolkit exists independently, or those are enumerated in a fragmented list.
4 Cooperability	How are the toolkits structured and operated for collaboration?	
	O	The toolkits are devised, widely used, and are integrated with considerations for collaboration. : The inputs and outputs can be physically and functionally yielded from the collaboration element.
	△	Toolkits are devised with limited considerations for collaboration. : The inputs and outputs can be yielded, considering two functional domains only.
	X	No toolkits are provided which consider collaboration. : The inputs and outputs of toolkits cannot be yielded from the collaboration element.
X	The FFE study does not provide any toolkits for any FFE task, activity, and performance method.	

2 Analysis Table of Toolkits of 266 Fuzzy Front End Studies

– Park, D, and Childs, PRN, Dyson School of Design Engineering, Imperial College London, UK

#	Criteria				#	Criteria				#	Criteria				#	Criteria				#	Criteria			
	1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4
M 001	X				M 055	X				M 109	△2	○	X	X	M 163	△2	○	X	X	M 217	○	○	○	△
M 002	X				M 056	X				M 110	X				M 164	○	○	△	X	M 218	○	△	○	X
M 003	X				M 057	X				M 11	X				M 165	X				M 219	X			
M 004	X				M 058	△2	△	△	X	M 112	X				M 166	X				M 220	X			
M 005	X				M 059	○	△	○	X	M 113	○	○	△	X	M 167	X				M 221	○	△	○	X
M 006	X				M 060	○	△	○	X	M 114	X				M 168	△2	○	X	X	M 222	△2	△	△	X
M 007	○	△	○	○	△	X				M 115	X				M 169	X				M 223	△2	△	△	X
M 008	X				M 062	○	△	○	X	M 116	△2	○	X	X	M 170	△1	○	X	X	M 224	X			
M 009	X				M 063	X				M 117	○	△	○	X	M 171	X				M 225	X			
M 010	X				M 064	○	○	△	X	M 118	△2	○	△	X	M 172	X				M 226	X			
M 011	○	△	△	X	M 065	△2	△	X	X	M 119	○	△	○	X	M 173	△2	○	X	X	M 227	X			
M 012	△1	△	X	X	M 066	X				M 120	X				M 174	○ + △2	○	X	X	M 228	X			
M 013	○	△	△	X	M 067	△2	○	△	△	M 121	○ + △2	○	X	X	M 175	○ + △2	○	△	△	M 229	△2	○	△	△
M 014	X				M 068	○ + △2	○	△	△	M 122	○	△	X	X	M 176	△2	○	X	X	M 230	△2	○	X	X
M 015	X				M 069	X				M 123	X				M 177	X				M 231	X			
M 016	X				M 070	○	△	○	X	M 124	△2	○	X	X	M 178	○	○	○	△	M 232	△2	○	X	X
M 017	X				M 071	○	△	○	X	M 125	△2	○	X	X	M 179	○	○	○	△	M 233	△2	○	X	X
M 018	X				M 072	X				M 126	X				M 180	△2	○	X	X	M 234	X			
M 019	○	△	△	X	M 073	○	○	○	△	M 127	○ + △2	○	△	X	M 181	X				M 235	X			
M 020	△2	△	X	X	M 074	X				M 128	X				M 182	△2	○	X	X	M 236	X			
M 021	X				M 075	△2	○	X	X	M 129	X				M 183	○	△	△	X	M 237	△2	○	X	X
M 022	○	△	△	△	M 076	X				M 130	△2	△	X	X	M 184	X				M 238	△2	○	X	X
M 023	○	△	○	X	M 077	X				M 131	△1	△	○	X	M 185	X				M 239	△2	○	X	X
M 024	X				M 078	○ + △2	△	△	X	M 132	△2	○	X	X	M 186	X				M 240	△2	○	X	△
M 025	X				M 079	△2	○	△	X	M 133	○	○	○	△	M 187	△1	○	X	X	M 241	○	○	○	△
M 026	○	△	△	X	M 080	△2	○	X	X	M 134	△2	○	X	X	M 188	△2	○	X	X	M 242	X			
M 027	○	△	△	X	M 081	○ + △2	○	△	△	M 135	○	△	△	X	M 189	X				M 243	X			
M 028	X				M 082	X				M 136	X				M 190	○ + △2	○	△	△	M 244	X			
M 029	X				M 083	X				M 137	△2	○	X	X	M 191	○ + △2	○	X	X	M 245	X			
M 030	△2	○	X	X	M 084	○	△	△	X	M 138	X				M 192	△2	△	△	X	M 246	X			
M 031	X				M 085	○	○	○	△	M 139	X				M 193	X				M 247	△2	○	X	X
M 032	○	△	△	X	M 086	○ + △2	△	△	X	M 140	X				M 194	X				M 248	X			
M 033	○	△	△	X	M 087	○	○	○	△	M 141	X				M 195	○	△	○	X	M 249	○ + △2	△	△	X

M 034	○	◦	△	△	M 088	○	○	○	△	M 142	X				M 196	X				M 250	X			
M 035	○	△	◦	X	M 089	X				M 143	△2	○	X	X	M 197	X				M 251	△2	○	X	X
M 036	△2	○	X	X	M 090	X				M 144	△2	△	○	X	M 198	X				M 252	△2	○	X	X
M 037	△2	○	X	X	M 091	△2	○	X	X	M 145	△2	○	△	△	M 199	△2	○	X	X	M 253	△2	○	X	X
M 038	X				M 092	○	△	△	X	M 146	△2	○	X	X	M 200	△2	△	X	X	M 254	X			
M 039	○	△	△	X	M 093	△2	○	X	X	M 147	X				M 201	○ + △2	△	X	X	M 255	△2	○	X	X
M 040	X				M 094	△2	○	X	X	M 148	X				M 202	○	○	△	△	M 256	X			
M 041	△2	○	X	X	M 095	△2	○	X	X	M 149	△2	○	X	X	M 203	△2	○	X	X	M 257	X			
M 042	○	○	△	X	M 096	○	○	◦	△	M 150	○	△	○	X	M 204	○ + △2	○	X	X	M 258	△2	○	X	X
M 043	△2	○	X	X	M 097	○ + △2	○	△	△	M 151	X				M 205	○ + △2	○	X	X	M 259	○ + △2	○	△	△
M 044	○	○	X	X	M 098	○ + △2	△	△	X	M 152	○	○	○	△	M 206	○ + △2	○	X	X	M 260	△2	△	X	X
M 045	○	○	X	X	M 099	X				M 153	X				M 207	○ + △2	○	X	X	M 261	△2	○	X	X
M 046	○	△	○	X	M 100	X				M 154	○	○	○	△	M 208	X				M 262	△2	○	X	X
M 047	X				M 101	X				M 155	○	△	○	X	M 209	X				M 263	X			
M 048	△2	△	△	X	M 102	X				M 156	X				M 210	X				M 264	X			
M 049	X				M 103	X				M 157	X				M 211	△2	○	X	X	M 265	△2	○	X	X
M 050	X				M 104	X				M 158	X				M 212	○	△	△	X	M 266	X			
M 051	X				M 105	X				M 159	X				M 213	X								
M 052	○	△	X	X	M 106	△1	△	○	X	M 160	△2	△	X	X	M 214	△2	△	X	X					
M 053	○	○	△	X	M 107	X				M 161	X				M 215	△2	○	X	X					
M 054	△2	○	X	X	M 108	△2	○	X	X	M 162	X				M 216	△2	○	X	X					

3 Analysis of Toolkits of 266 Fuzzy Front End Studies

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As shown in **Fig. 1** and **Table 1**, where the development trend and the portion of characteristics of toolkit sets (decided by the four sub-criteria) are depicted, a total of 24 distinct patterns were observed.

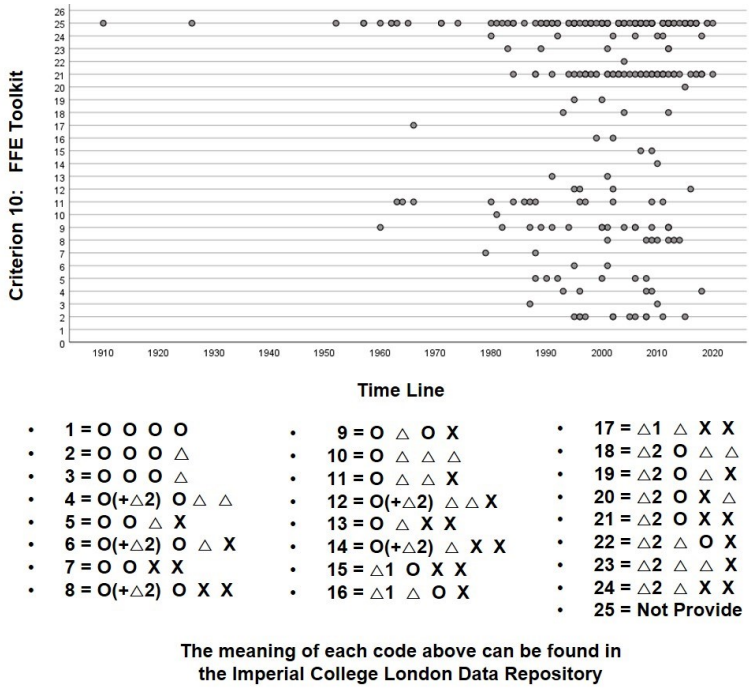

Fig. 1 Historical trend for criterion 10: FFE toolkit

Table 1 Frequency analysis for criterion 10: FFE toolkit

Valid	Frequency	Percent	Valid (%)	Cumulative (%)
1	0	0	0	0
2	12	4.5	4.5	4.5
3	2	0.8	0.8	5.3
4	5	1.9	1.9	7.1
5	6	2.3	2.3	9.4
6	2	0.8	0.8	10.2
7	2	0.8	0.8	10.9
8	7	2.6	2.6	13.4
9	16	6.0	6.0	19.4
10	1	0.4	0.4	19.9
11	13	4.9	4.9	24.8
12	4	1.5	1.5	26.3
11	2	0.8	0.8	27.1
14	1	0.4	0.4	27.4
15	2	0.8	0.8	28.2
16	2	0.8	0.8	28.9

17	1	0.4	0.4	29.3
18	3	1.1	1.1	30.5
19	2	0.8	0.8	31.2
20	1	0.4	0.4	31.6
21	48	18.0	18.0	49.6
22	1	0.4	0.4	50.0
23	5	1.9	1.9	51.9
24	7	2.6	2.6	54.4
25	121	45.5	45.5	100.0
Total	266	100.0	100.0	

As noted in our review of these 24 patterns (See **Table 1**), none were identified to contain toolkit sets which could entirely fulfil with all four sub-criteria. For those that aimed at one or two FFE tasks and covered a single functional domain, the toolkit set has strength in terms of contextual performance although limitations could be identified in the domain of concurrent collaboration. Indeed, these limitations can also be found in toolkit sets that aim at all elements of the front-end from the viewpoint of a single functional domain. On the other hand, toolkit sets that encompass the entire range of FFE tasks from the perspective of multiple functional domains typically lack an interrelationship with each other in regard to contextual performance and concurrent collaboration. The reason is that the toolkit sets heavily reference representative toolkits which have already been provided from various prior studies with little consideration of their linkage. Then it can be seen that the limitations and challenges in both contextual performance and concurrent collaboration will increase relying upon the increasing number of FFE tasks and functional domains that these toolkit sets aim to cover.

In terms of toolkit development trend (see **Fig. 1**), model structures with self-developed toolkits received a great deal of attention in the 1960s and 1970s. It would appear that the development of these toolkits commenced in earnest alongside the development of prescriptive FFE models. From then until the late 1990s, attention on studies about model structures, operation methods, and the correlation between relevant issues were much more stressed, producing both the descriptive and prescriptive model types. Those studies had also tendency to recommend referencing toolkits previously developed; there were very few cases of models devising their own toolkits. With the cross-functional work trend on the rise, there was a tendency to propose many toolkit sets developed in multiple functional fields for use in new models. From the early 2000s, when the potential to represent particular differences in structures and operating systems of models was initiating to decline, efforts to determine how to perform tasks and activities more efficiently seemed to resume. A movement towards offering more specific toolkits reached a peak in the late 2000s. Around this time, many studies on concrete toolkits and their guidelines were carried out, which resulted in various educational materials for a massive set of toolkits, e.g. Human-Centred Design Toolkit (IDEO, 2003, 2009), Universal Design Toolkit 1 and 2 (Lidwell et al. 2010; Hanington and Martin 2012), 101 Design Toolkit (Kumar 2012), Cambridge's Inclusive Design Toolkit (Clarkson et al. 2007, 2013), TU Delft's Design Guide (van Boeijen et al., 2014).

4 A List of 266 Fuzzy Front End Studies

– Park, D, and Childs, PRN, Dyson School of Design Engineering, Imperial College London, UK

Model Number	References
M001 (Dewey, 1910)	. Dewey, J. (1910). *How We Think, DC Heath & Co.* Boston, Mass 224.
M002 (Wallas, 1926)	. Wallas, G. (1926). *The Art of Thought, ed.* Jonathan Cape *(London: Jonathan Cape, 1926)*: 79-96. . Truman, S. (2011). A generative framework for creative learning: A tool for planning creative-collaborative tasks in the classroom. *Border Crossing* 1(1): 1-13. . Larsen, M. A. (2013). Possibilities of Courageous Creativity in Comparative and International Education Research. *Comparative and International Education* 42(1): 1.
M003 (Kris, 1952)	. Kris, E. (1952). *Psychoanalytic explorations in art.* International Universities Press, *New York*.
M004 (Polya, 1957)	. Polya, G. (1957). *How to solve it*: *A new aspect of mathematical method:* Princeton university press. . Polya, G. (2014). *How to solve it*: *A new aspect of mathematical method:* Princeton university press.
M005 (Guilford,1957)	. Guilford, J. P. (1957). *A Revised Structure of Intellect: Studies of Aptitudes of High-level Personnel:* University of Southern California.
M006 (Buhl, 1960)	. Buhl, H. R. (1960). *Creative engineering design:* Iowa State University Press. . Cropley, D. H. (2016). Creativity in engineering. *Multidisciplinary Contributions to the Science of Creative Thinking* (pp. 155-173): Springer.
M007 (Marples, 1960)	. The decisions of engineering design Inst. of Eng. *Designers, London*. . The decisions of engineering design. *IRE Transactions on Engineering Management* (2), 55-71. . Stauffer, L. A. (1987). *An empirical study on the process of mechanical design*. Thesis, Department of Mechanical Engineering, Oregon State University, Corvalhs, OR.
M008 (Asimow, 1962)	. Asimow, M. (1962). *Introduction to design* (Vol. 394): Prentice-Hall Englewood Cliffs, NJ.
M009 (Rogers, 1962)	. Howard, T. J., et al. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies* 29(2): 160-180. . Rogers, E. M. (2010). *Diffusion of innovations:* Simon and Schuster.
M110 (Osborn, 1963; Parnes, 1967)	. Osborn, A. (1963). Applied imagination: Principles and procedures of creative problem solving, Charles Scribner's Son. *New York, NY*. . Osborne, S. M. (1993). *Product development cycle time characterization through modelling of process iteration*. Massachusetts Institute of Technology. . Giangreco, M. F., Cloninger, C. J., Dennis, R. E., & Edelman, S. W. (1994). Problem-solving methods to facilitate inclusive education. *Creativity and collaborative learning: A practical guide to empowering students and teachers*, 321-346. . Parnes, S. J. (1967). *Creative behavior guidebook:* Scribner. . Parnes, S. J. (1981). The magic of your mind Bearly Limited, *New York.*
M011 (Jones, 1963)	. Jones, J. C., & Thornley, D. G. (1963). Conference on design methods. Papers presented at the Conference on Systematic and intuitive methods in Engineering industrial design, architecture and communications (London, sept. 1962). . Jones, J. C. (1970). Design methods: seeds of human futures. L*ondon and New York: John Wiley (2nd edn, 1992, New York: Van Nostrand Reinhold).* . Johne, F. A., & Snelson, P. A. (1988). Success factors in product innovation: a selective review of the literature. *Journal of product innovation management* 5(2), 114-128. . Cross, N. (1984). *Developments in design methodology:* John Wiley & Sons. NY.
M012 (Watts, 1966)	. Watts, R. D. (1966). The elements of design. *The design method* (pp. 85-95): Springer. . McCrory, R. (1963). The design method—A scientific approach to valid design. *Contributions to a Philosophy of Technology* (pp. 158-173): Springer. . Gregory, S. A. (2013). *The design method*: Springer.
M013 (Matchett & Briggs, 1966)	. Matchett, E., & Briggs, A. (1966). Practical design based on method (fundamental design method) *The design method* (pp. 183-199): Springer. . Gregory, S. A. (2013). *The design method*: Springer.
M014 (Krick, 1965)	. Krick, E. V. (1965). *An introduction to engineering and engineering design.* John Wiley, New York
M015 (French, 1971)	. French, M. J. (1971). *Engineering Design, The Conceptual Stage*, Heinemann, London. . French, M (1985) *Conceptual design for engineers.* The Design Council, London . French, M. J., Gravdahl, J., & French, M. (1985). *Conceptual design for engineers:* Springer. . Cross, N., & Roy, R. (1989). *Engineering design methods* (Vol. 4): Wiley New York.
M016 (Utterback, 1971)	. Utterback, J. M. (1971). The process of technological innovation within the firm. *Academy of management Journal, 14*(1), 75-88. . Utterback, J. M. (1971). The process of innovation: A study of the origination and development of ideas for new scientific instruments. *IEEE Transactions on Engineering Management* (4) 124-131. . Utterback, J. M. (1994). *Mastering the Dynamics of Innovation*, Boston, MA: Harvard Business School Press.

M017 (Stein, 1974)	. Stein, M. I. (1974). *Stimulating creativity.* Academic Press, New York. . Stein, M. I. (2014). *Stimulating creativity: Individual procedures:* Academic Press, New York.
M018 (Harris, 1980)	. Harris, A. J. (1980). Can design be taught? Proc. Inst. *Civ. Engrs* 68(1), 409-416.
M019 (Wilson, 1980)	. Wilson, D. R. (1980). *An exploratory study of complexity in axiomatic design*, Massachusetts Institute of Technology.
M020 (Urban & Hauser, 1980)	. Urban, G. L., & Hauser, J. R. (1993). *Design and marketing of new products* (Vol. 2): Prentice hall Englewood Cliffs, NJ. . Hauser, J. R. (2008). *Note on Product Development*: Cambridge, MA: MIT Sloan Courseware.
M021 (Barron & Harrington, 1981)	. Barron, F., & Harrington, D. M. (1981). Creativity, intelligence, and personality. *Annual review of psychology, 32*(1), 439-476.
M022 (Steward, 1981)	. Steward, D. V. (1981). The design structure system: A method for managing the design of complex systems. *IEEE transactions on Engineering Management* (3) 71-74. . Eppinger, S. D., et al. (1994). A model-based method for organizing tasks in product development. *Research in engineering design* 6(1): 1-13. . Eppinger, S. D., Whitney, D. E., Smith, R. P., & Gebala, D. A. (1994). A model-based method for organizing tasks in product development. *Research in engineering design,* 6(1), 1-13. . Morelli, M. D., Eppinger, S. D., & Gulati, R. K. (1995). Predicting technical communication in product development organizations. *IEEE transactions on engineering management* 42(3), 215-222.
M023 (Ito & Shinno, 1982)	. Ito, Y., & Shinno, H. (1982). Structural description and similarity evaluation of the structural configuration in machine tools. *International Journal of Machine Tool Design and Research* 22(2), 97-110.
M024 (Booz & Company, 1982)	. From New Products Management for the 1980s by Booz & Company. Copyright © 1982 by Booz & Company. Reprinted by permission of Booz & Company.
M025 (Amabile, 1983)	. Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of personality and social psychology* 45(2): 357. . Amabile, T. (1996). *Creativity in context Westview.* Press, Boulder, CO. . Kuo, H. C. (2011). Toward a synthesis framework for the study of creativity in education: an initial attempt. *Education* 11(1), 65-75.
M026 (Pahl & Beitz, 1984)	. Paul, G. and W. Beitz (1984). *Engineering design*. London, UK: Design Council. . Pahl, G., et al. (2007). *Engineering Design*, 2007, Springer, London. . Jensen, T. E., & Andreasen, M. M. (2010). Design Methods in Practice-Beyond the Systematic Approach of Pahl & Beitz. In: *DS 60: Proceedings of DESIGN 2010, the 11th International Design Conference, Dubrovnik, Croatia*. . Weiss, M. P., & Hari, A. (2015). Extension of the Pahl & Beitz systematic method for conceptual design of a new product. *Procedia CIRP* 36, 254-260.
M027 (Archer, 1964)	. Archer, L. B. (1964). *Systematic method for designers:* Council of Industrial Design London. . Archer, L. B. (1968). *The structure of design processes.* Royal College of Art. . Archer, N. P., & Ghasemzadeh, F. (1999). An integrated framework for project portfolio selection. *International Journal of Project Management* 17(4), 207-216. . Council, D. (2007). Eleven lessons: Managing design in eleven global companies-desk research report. *Design Council*. . Boyd Davis, S., & Gristwood, S. (2016). The Structure of Design Processes: ideal and reality in Bruce Archer's 1968 doctoral thesis. *Proceedings of DRS 2016,* 7, 2593-2611.
M028 (March, 1984)	. March, L. (1984). *The logic of design*. Developments in Design Methodology, John Wiley & Sons, Chichester, 265-276. . Cross, N. (1984). *Developments in design methodology:* John Wiley & Sons. . Wynn, D., & Clarkson, J. (2005). Models of designing. *Design process improvement* (pp. 34-59): Springer.
M029 (Crawford, 1984)	. Crawford, C. M. (1984). Protocol: new tool for product innovation. *Journal of Product Innovation Management,* 1(2), 85-91.
M030 (Fledman & Page, 1984)	. Feldman, L. P., & Page, A. L. (1984). Principles vs. practice in new product planning. *Journal of Product innovation management* 1(1): 43-55.
M031 (Kline & Rosenberg, 1986)	. Kline, S. J., & Rosenberg, N. (1986). An overview of innovation. The positive sum strategy: *Harnessing technology for economic growth* 14, 640.
M032 (Taguchi, 1986)	. Taguchi, G. (1986). *Introduction to quality engineering: designing quality into products and processes*. Asian Productivity Organization, Tokyo. . Byrne, D. M. (1987). The Taguchi approach to parameter design. *Quality Progress* 20(12), 19-26. . Kackar, R. N. (1989). Off-line quality control, parameter design, and the Taguchi method. *Quality Control, Robust Design, and the Taguchi Method* (pp. 51-76): Springer.
M033 (Hubka & Erder, 1987)	. Hubka, V., & Eder, W. E. (1987). A scientific approach to engineering design. *Design studies* 8(3), 123-137. . Hubka, V. (1992). Design for quality and design methodology. *Journal of Engineering Design* 3(1), 5-15. . Hubka, V., & Eder, W. E. (1996). *Design science: introduction to needs, scope and organization of engineering design knowledge:* Springer Verlag. . Eder, W. E. (1990). *Engineering Design–A perspective on UK and Swiss Developments*. In: *ASME, DE*.

	. Eder, W. E., & Hosnedl, S. (2007). *Design engineering: a manual for enhanced creativity*: CRC Press. . Eder, W. E. (2012). Comparison of several design theories and methods with the legacy of Vladimir Hubka. *private publication (74 pages) available from eder-e@ kos. net, submitted for web-site of The Design Society,* www. designsociety. org.
M034 (Andreasen & Hein, 1987)	. Andreasen, M. M., & Hein, L. (1987). Integrated product development. IFS (Publications) Ltd. . Andreasen, M. M., & Hein, L. (2000). Integrated product development. IFS (Publications) Ltd. . Andreasen, M. M. (2011). 45 Years with design methodology. *Journal of Engineering Design* 22(5), 293-332. . Andreasen, M. M., & Mortensen, N. H. (1997). *Basic thinking patterns and working methods for multiple DFX.* In: *DFX 1997: Proceedings of the 8th Symposium on Design for Manufacturing, Schnaittach/Erlangen, Germany,* 16-17.10. 1997. . Ritzén, S. (2000). *Integration environmental aspects into product development: proactive measures*. KTH.
M035 (Ito & Shinno, 1987)	. Ito, Y. & Shinno, H. (1987). Computer aided concept design for structural configuration of machine tools: variant design using directed graph. *ASME Journal of Mechanisms, Transmissions, and Automation in Design* 109, 372–376.
M036 (Cooper, 1988)	. Cooper, R. G. (1988). Predevelopment activities determine new product success. *Industrial Marketing Management* 17(3), 237-247. . Cooper, R. G. (1994). Perspective third-generation new product processes. *Journal of product innovation management*, 11(1) 3-14. . Cooper, R. G. (2014). What's Next?: After Stage-Gate. *Research-Technology Management* 57(1), 20-31. . Cooper, R., Edgett, S., & Kleinschmidt, E. (2001). Portfolio management for new product development. *R&D Management* 31(4), 361-380. . Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. (2002). Optimizing the stage-gate process: what best-practice companies do—I. *Research-Technology Management* 45(5), 21-27. . Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. (2002). Optimizing the stage-gate process: what best-practice companies do–II. *Research-Technology Management* 45(6), 43-49.
M037 (Murphy & & Kumar, 1996)	. Murphy, S. A., & Kumar, V. (1996). The role of predevelopment activities and firm attributes in new product success. *Technovation* 16(8): 431448-441449. . Murphy, S. A., & Kumar, V. (1997). The front end of new product development: a Canadian survey. *R&D Management 27(1): 5-15.*
M038 (Langerak et al., 2004)	. Langerak, F., Jan Hultink, E., & Robben, H. S. (2004). The role of predevelopment activities in the relationship between market orientation and performance. *R&D Management* 34(3), 295-309.
M039 (NASA, 1988)	. Cooper, R. G. (1988). Predevelopment activities determine new product success. *Industrial Marketing Management* 17(3), 237-247. . Cooper, R. G. (1994). Perspective third-generation new product processes. *Journal of product innovation management* 11(1), 3-14. . Shenhar, A., Dvir, D., Milosevic, D., Mulenburg, J., Patanakul, P., Reilly, R., & Srivannaboon, S. (2005). Toward a NASA-specific project management framework. *Engineering Management Journal* 17(4), 8-16. . NASA. (2012). NASA Space Flight Program and Project Management Requirements w/Changes 1-15. *NASA Procedural Requirements (NPR)*, 7120.5E.
M040 (Leonard-Barton, 1988)	. Leonard-Barton, D. (1988). Implementation as mutual adaptation of technology and organization. *Research policy 17*(5), 251-267.
M041 (Jone & Snelson, 1988)	. Johne, F. A., & Snelson, P. A. (1988). Success factors in product innovation: a selective review of the literature. *Journal of product innovation management* 5(2), 114-128.
M042 (Boeham, 1988)	. Boehm, B. W. (1988). A spiral model of software development and enhancement. *Computer* 21(5): 61-72.
M043 (Ford, 1998)	. Ford, D. (1998). Sterman, JD. Dynamic modeling of product development processes. *System Dynamics Review 14*(1), 31-68.
M044 (Mahajan & Wind, 1988)	. Mahajan, V., & Wind, Y. (1988). New product forecasting models: Directions for research and implementation. *International Journal of Forecasting* 4(3), 341-358.
M045 (Shocker & Srinivasan, 1979)	. Shocker, A. D., & Srinivasan, V. (1979). Multiattribute approaches for product concept evaluation and generation: A critical review. *Journal of Marketing Research*: 159-180.
M046 (Ito et al., 1989)	. Ito, Y., Shinno, H., & Nakanishi, S. (1989). Designer's thinking pattern in the basic layout design procedure of machine tools—validity evaluation of thinking block. *CIRP Annals-Manufacturing Technology* 38(1), 141-144.
M047 (VDI, 1*989*)	. Cross, N., & Roy, R. (1989). *Engineering design methods* (Vol. 4): Wiley New York. . Jänsch, J., & Birkhofer, H. (2006). The development of the guideline VDI 2221-the change of direction. In: *DS 36: Proceedings DESIGN 2006, the 9th International Design Conference, Dubrovnik, Croatia*.
M048 (Cross, 1989)	. Cross, N., & Roy, R. (1989). *Engineering design methods* (Vol. 4): Wiley New York. . Cross, N. (1984). *Developments in design methodology:* John Wiley & Sons. . Roozenburg, N. F., & Cross, N. (1991). Models of the design process: integrating across the disciplines. *Design studies* 12(4), 215-220.

M049 (Zinger & Maidique, 1990)	. Zirger, B. J., & Maidique, M. A. (1990). A model of new product development: An empirical test. *Management science 36*(7), 867-883. . Maidique, M. A., & Zirger, B. J. (1985). *The new product learning cycle. Research policy* 14(6), 299-313. . Maidique, M. A., & Zirger, B. J. (1984). A study of success and failure in product innovation: the case of the US electronics industry. *IEEE Transactions on engineering management* (4), 192-203.
M050 (Dougherty, 1990)	. Dougherty, D. (1990). Understanding new markets for new products. *Strategic management journal*, 59-78. . Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization science, 3*(2), 179-202. . Dougherty, D., & Corse, S. M. (1995). When it comes to product innovation, what is so bad about bureaucracy? *The Journal of High Technology Management Research* 6(1), 55-76.
M051 (Sanvido & Khayyal, 1990)	. Sanvido, V. E., & Khayyal, S. A. (1990). *An integrated building process model: Computer Integrated.* Construction Research Program, Department of Architectural Engineering, the Pennsylvania State University. . Chung, E. K. (1989). A survey of process modelling tools. *CIC Research Lab, Penn State University, University Park, PA.*
M052 (Pugh, 1991)	. Pugh, S. (1991). *Total design: integrated methods for successful product engineering*: Addison-Wesley. . Pugh, S. (2009). The Systems Engineering Tool Box. http://www.burgehugheswalsh.co.uk/uploaded/documents/Pugh-Matrix-v1.1.pdf . Adams, K. (2015). *Non-functional Requirements in Systems Analysis and Design* (Vol. 28): Springer. . Villanueva, P. M., Lostado Lorza, R., & Corral Bobadilla, M. (2016). Pugh's Total Design: The design of an electromagnetic servo brake with ABS function–a case study. *Concurrent Engineering* 24(3), 227-239.
M053 (Suh, 1990)	. Suh, N. P. (1990). *The principles of design* (Vol. 990): Oxford university press New York. . Suh, N. P. (1998). Axiomatic design theory for systems. *Research in engineering design* 10(4), 189-209. . Suh, N. P. (2001). Axiomatic design: Oxford University Press, New York. . Farid, A. M., & Suh, N. P. (2016). *Axiomatic Design in Large Systems: Complex Products, Buildings and Manufacturing Systems*: Springer. . Foley, J. T., & Harðardóttir, S. (2016). Creative Axiomatic Design. *Procedia CIRP* 50, 240-245.
M054 (Rochford, 1991)	. Rochford, L. (1991). Generating and screening new products ideas. *Industrial Marketing Management 20*(4), 287-296.
M055 (Clark & Fujimoto, 1991)	. Clark, K. B., & Fujimoto, T. (1991). *Product development performance: Strategy, organization, and management in the world auto industry*: Harvard Business Press. . Clark, K. B., et al. (1987). Product development in the world auto industry. B*rookings Papers on Economic Activity* (3): 729-781. . Ellison, D. J., Clark, K. B., Takahiro, F., & Young-suk, H. (1995). *Product development performance in the auto industry: 1990s update*. Working Paper 95-066, Harvard Business School.
M056 (Huber, 1991)	. Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization science 2*(1), 88-115.
M057 (Salamatov, 1991)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Salamatov, Y. (1991). System of The Laws of Technical Systems Evolution. *Chance to Adventure* 7-174.
M058 (Zlotin, B., & Zusman, 2001)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Zlotin, B., & Zusman, A. (2001), Directed Evolution–philosophy, theory, and practice http://www. ideationtriz. com/new/materials. DirectedEvolutionBook. pdf. . Prushinskiy, V., Zainiev, G., & Gerasimov, V. (2005). *Hybridization: the new warfare in the battle for the market*. Ideation International Inc., Southfield, MI.
M059 (Cavallucci & Weill, 2001)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Cavallucci, D., & Weill, R. D. (2001). Integrating Altshuller's development laws for technical systems into the design process. *CIRP Annals-Manufacturing Technology 50*(1), 115-120. . Mann, D. L. (2003). Better technology forecasting using systematic innovation methods. *Technological Forecasting and Social Change* 70(8), 779-795.
M60 (Shpakovsky, 2006)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Shpakovsky, N. (2006). Evolution Trees. Analysis of technical information and generation of new ideas. ISBN: 5-9348.
M061 (Kucharavy, 2008)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Kucharavy, D. (2008). Technological forecasting. Prediction of technology change. Vinci. Retrieved from http://seecore.org/d/20080626-01.pdf.

	. Kucharavy, D., & De Guio, R. (2011). Logistic substitution model and technological forecasting. *Procedia Engineering* 9, 402-416.
M062 (2012)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science 16*(3), 29-63. . Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, Improve your problem solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).* . Cascini, G., Rotini, F., & Russo, D. (2009). Functional modeling for TRIZ-based evolutionary analyses. In: *DS 58-5: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 5, Design Methods and Tools (pt. 1)*, Palo Alto, CA, USA, 24-27. . Cascini, G., Rotini, F., & Russo, D. (2011). Networks of trends: systematic definition of evolutionary scenarios. *Procedia Engineering* 9, 355-367.
M063 (Anthony & McKay, 1992)	. Anthony, M. T., & McKay, J. (1992). From experience: balancing the product development process: achieving product and cycle-time excellence in high-technology industries. *Journal of Product Innovation Management* 9(2), 140-147.
M064 (Hybs & Gero, 1992)	. Hybs, I., & Gero, J. S. (1992). An evolutionary process model of design. *Design Studies* 13(3), 273-290. . Gero, J. S., & Kannengiesser, U. (2007). A function–behavior–structure ontology of processes. *AI EDAM: Artificial Intelligence for Engineering Design, Analysis, and Manufacturing* 21(04), 379-391.
M065 (Wheelwright & Clark, 1992)	. Wheelwright, S. C., & Clark, K. B. (1992). *Revolutionizing product development: quantum leaps in speed, efficiency, and quality*: Simon and Schuster. . Wheelwright, S. C., & Clark, K. B. (1992). *Creating project plans to focus product development:* Harvard Business School Pub.
M067 (Couger et al., 1993)	. Couger, J. D., Higgins, L. F., & McIntyre, S. C. (1993). (Un) structured creativity in information systems organizations. *Mis Quarterly* 375-397.
M068 (Hales, 1993)	. Hales, C. (1993). *Managing Engineering Design*. Longman Scientific & Technical, Harlow, UK. . Hales, C., & Gooch, S. (2011). *Managing engineering design*: Springer Science & Business Media. . Maffin, D. J. B. (1996). *Engineering design and product development in a company context.* Doctoral Dissertation. University of Newcastle, Newcastle upon Tyne.
M069 (Isaksen et al., 1994)	. Isaksen, S., Dorval, K., & Treffinger, D. (1994). *Creative Approaches to Problem Solving, Kendall*: Hunt Publishing, Dubuque, IA. . Isaksen, S. G., Dorval, K. B., & Treffinger, D. J. (2010). *Creative approaches to problem solving: A framework for innovation and change*: Sage Publications.
M070 (Shinno et al., 1994)	. Shinno, H., Ito, Y., & Tadano, H. (1994). Basic layout design with multiple-layered decision making and transit evaluation. *CIRP Annals-Manufacturing Technology* 43(1), 111-114.
M071 (Shinno et al., 1991)	. Shinno, H., Ito, Y., & Hashizume, H. (1991). A decision-making methodology for basic layout design of machine tools. JSME international journal. Ser. 3, Vibration, control engineering, *engineering for industry 34*(2), 290-294. . Shinno, H., Ito, Y., & Tadano, H. (1994). Basic layout design with multiple-layered decision making and transit evaluation. *CIRP Annals-Manufacturing Technology* 43(1), 111-114.
M072 (Bloch, 1995)	. Bloch, P. H. (1995). Seeking the ideal form: Product design and consumer response. *The Journal of Marketing,* 16-29.
M073 (Clausing, 1995)	. O'Connor, P. (1995). Total Quality Development: A Step-by-Step Guide to World Class Concurrent Engineering, Don Clausing, ASME Press, 1994. *Quality and Reliability Engineering International* 11(3), 224-224.
M074 (Reinertsen, 1994)	. Reinertsen, D. (1994). Streamlining the fuzzy front-end. *World Class Design to Manufacture 1*(5), 4-8.
M075 (Bacon et al., 1994)	. Bacon, G., Beckman, S., Mowery, D., & Wilson, E. (1994). Managing product definition in high-technology industries: A pilot study. *California Management Review* 36(3), 32-56.
M076 (Brown & Eisenhardt, 1995)	. Brown, S. L., & Eisenhardt, K. M. (1995). Product development: Past research, present findings, and future directions. *Academy of management review* 20(2), 343-378.
M077 (Moenaert et al., 1995)	. Moenaert, R. K., De Meyer, A., Souder, W. E., & Deschoolmeester, D. (1995). R&D/marketing communication during the fuzzy front-end. *IEEE Transactions on Engineering Management 42*(3), 243-258. . Moenaert, R. K., & Souder, W. E. (1990). An information transfer model for integrating marketing and R&D personnel in new product development projects. *Journal of product innovation management* 7(2), 91-107.
M078 (Ford, GM, Chrysler, 1995)	. Chrysler, F., & Motors, G. (1995). *Advanced Product Quality Planning and Control Plan: Reference Manual*: Southfield, MI: Automotive Industry Action Group.
M079 (Roozenburg & Eekels, 1995)	. Roozenburg, N. F., & Eekels, J. (1995). *Product design: fundamentals and methods* (Vol. 2): Wiley Chichester.
M080 (Baxter, 1995)	. Baxter, M. (1995). *Product design: a practical guide to systematic methods of development of new products*: Chapman & Hall, London.
M081 (Ulrich & Eppinger, 1995)	. Ulrich, K. T., & Eppinger, S. D. (1988). *Product design and development, 1995*. Singapore. McGraw. . Ulrich, K. (2011). *Design: Creation of artefacts in society*. University of Pennsylvania: ISBN 978-0-9836487-0-3.

M082 (Williams et al., 1995)	. Williams, T., Eden, C., Ackermann, F., & Tait, A. (1995). The effects of design changes and delays on project costs. *Journal of the Operational Research Society,* 46(7), 809-818.
M083 (Boisot, 1995)	. Boisot, M. H. (1995). Is your firm a creative destroyer? Competitive learning and knowledge flows in the technological strategies of firms. *Research policy* 24(4), 489-506.
M084 (Golenko-Ginzburg & Gonik, 1996)	. Golenko-Ginzburg, D., & Gonik, A. (1996). On-line control model for cost-simulation network projects. *Journal of the Operational Research Society* 47(2), 266-283.
M085 (Christensen et al., 1996)	. Christensen, L., et al. (1996). Modeling and simulation in enterprise integration—a framework and an application in the offshore oil industry. *Concurrent Engineering* 4(3): 247-259.
M086 (Hughes & Chafin, 1996)	. Hughes, G. D., & Chafin, D. C. (1996). Turning new product development into a continuous learning process. *Journal of Product Innovation Management* 13(2), 89-104.
M087 (Prasad, 1996)	. Prasad, B. (1996). *Concurrent engineering fundamentals* (Vol. 1): Prentice Hall Englewood Cliffs, NJ. . Prasad, B. (1998). Concurrent Function Deployment Process for Product Life-cycle Management. *Journal of Engineering Design* 9(2), 3. . Prasad, B. (2000). A concurrent function deployment technique for a workgroup-based engineering design process. *Journal of Engineering design* 11(2), 103-119.
M088 (Prasad, 2002)	. Prasad, B. (2002). Building blocks for a decision-based integrated product development and system realization process. *Systems engineering* 5(2), 123-144.
M089 (Cheng & Van de Ven, 1996)	. Cheng, Y. T., & Van de Ven, A. H. (1996). Learning the innovation journey: Order out of chaos? *Organization science* 7(6), 593-614.
M090 (Raelin, 1997)	. Raelin, J. A. (1997). A model of work-based learning. *Organization science 8*(6), 563-578.
M091 (1997)	. Verganti, R. (1997). Leveraging on systemic learning to manage the early phases of product innovation projects. *R&D Management* 27(4), 377-392.
M092 (Koput, 1997)	. Koput, K. W. (1997). A chaotic model of innovative search: some answers, many questions. *Organization Science* 8(5), 528-542.
M093 (Ottum & Moore, 1997)	. Ottum, B. D., & Moore, W. L. (1997). The role of market information in new product success/failure. *Journal of Product Innovation Management 14*(4), 258-273.
M094 (Verma & Fabrycky, 1997)	. Verma, D., & Fabrycky, W. J. (1997). Systematically identifying system engineering practices and methods. *IEEE transactions on aerospace and electronic systems* 33(2), 587-595.
M095 (Khurana & Rosenthal, 1997)	. Khurana, A., & Rosenthal, S. R. (1997). Integrating the fuzzy front end of new product development. *IEEE Engineering Management Review 25*(4), 35-49. . Khurana, A., & Rosenthal, S. R. (1998). Towards holistic "front ends" in new product development. *Journal of product innovation management* 15(1), 57-74.
M096 (Lee et al., 1997)	. Lee, H., Shinno, H., & Ito, Y. (1997). Market competitiveness evaluation of machining centers by multidimensional vectors. *JSME international journal. Ser. C, Dynamics, control, robotics, design and manufacturing* 40(1), 163-169.
M097 (Dimancescu & Dwenger, 1996)	. Dimancescu, D., & Dwenger, K. (1996). *World-class new product development: benchmarking best practices of agile manufacturers*: Amacom.
M098 (Ulman, 2002)	. Ullman, D. G. (2002). *The mechanical design process*, McGraw-Hill Science/Engineering/Math.
M099 (BS7000)	. BS7000 (1997). *Design management systems. Part 2. Guide to managing the design of manufactured products.* BSI, London. . BS, B. S. (1989). *Guide to Managing Product Design:* British Standards Institution, London, UK. . Megchun, B. I. C., et al. (2008). *An investigation into how small, medium sized enterprises in Mexico value and utilise design within organisational activity.* Design Thinking: New Challenges for Designers, Managers and Organizations. DMI Education Conference.
M100 (BS2000)	. BS, B. S. (1989). Guide to Managing Product Design: British Standards Institution, London, UK. . Newton, A. J. (1995). *The planning and management of detailed building design*. © Andrew John Newton.
M101 (Griffin, 1997)	. Griffin, A. (1997). PDMA research on new product development practices: Updating trends and benchmarking best practices. *Journal of product innovation management* 14(6), 429-458.
M102 (Thomke et al., 1998)	. Thomke, S., Von Hippel, E., & Franke, R. (1998). Modes of experimentation: an innovation process—and competitive—variable. *Research Policy* 27(3), 315-332.
M103 (Veryzer, 1998)	. Veryzer, R. W. (1998). Discontinuous innovation and the new product development process. *Journal of Product Innovation Management 15*(4), 304-321.
M104 (Bhattacharya et al., 1998)	. Bhattacharya, S., Krishnan, V., & Mahajan, V. (1998). Managing new product definition in highly dynamic environments. *Management Science 44*(11-part-2), S50-S64.
M105 (Song & Montoya, 1998)	. Song, X. M., & Montoya-Weiss, M. M. (1998). Critical development activities for really new versus incremental products. *Journal of Product innovation management* 15(2): 124-135.
M106 (Goldenberg et al., 1999)	. Goldenberg, J., Mazursky, D., & Solomon, S. (1999). Toward Identifying the Inventive Templates of New Products: A Channeled Ideation. *Journal of Marketing Research* 36(2), 200-210.
M107 (Van der Ven et al., 1999)	. Van de Ven, A. H., Polley, D. E., Garud, R., & Venkataraman, S. (1999). *The innovation journey.* New York: Oxford University Press.

	. Zhou, J. (2015). *The Oxford handbook of creativity, innovation, and entrepreneurship*: Oxford University Press. . Kuhlmann, S. (2012). *Innovation Journey:* Navigating Unknown Waters. . Arnason, T. O. (2014). *Innovation management in the Massively Multiplayer Online game industry.* Mater Dissertation. Copenhagen Business School. . Martinez, L. (2014). *Theoretical considerations about Innovation in the Public Sector.* In: *RUC Sunrise Conference 2012*.
M108 (Lynn et al., 1999)	. Lynn, G. S., Schnaars, S. P., & Skov, R. B. (1999). A survey of new product forecasting practices in industrial high technology and low technology businesses. *Industrial Marketing Management 28*(6), 565-571.
M109 (Ozer, 1999)	. Ozer, M. (1999). A Survey of New Product Evaluation Models. *Journal of Product Innovation Management* 16(1), 77-94.
M110 (Shneiderman, 2000)	. Shneiderman, B. (2000). Creating creativity: user interfaces for supporting innovation. *ACM Transactions on Computer-Human Interaction (TOCHI)* 7(1), 114-138.
M111 (Basadur et al., 2000)	. Basadur, M., Pringle, P., Speranzini, G., & Bacot, M. (2000). Collaborative problem solving through creativity in problem definition: Expanding the pie. *Creativity and Innovation Management* 9(1), 54-76.
M112 (Thomke & Fujimoto, 2000)	. Thomke, S., & Fujimoto, T. (2000). The Effect of "Front-Loading" Problem-Solving on Product Development Performance. *Journal of product innovation management* 17(2), 128-142.
M113 (Montoya-Weiss & O'Driscoll, 2000)	. Montoya-Weiss, M. M., & O'Driscoll, T. M. (2000). From experience: applying performance support technology in the fuzzy front end. *Journal of Product Innovation Management* 17(2), 143-161. . Massey, A. P., Montoya-Weiss, M. M., & O'Driscoll, T. M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *Mis Quarterly,* 269-289.
M114 (Sheremata, 2000)	. Sheremata, W. A. (2000). Centrifugal and centripetal forces in radical new product development under time pressure. *Academy of management review* 25(2), 389-408.
M115 (Kagioglou et al., 2000)	. Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2000). Rethinking construction: the generic design and construction process protocol. Engineering, *Construction and Architectural Management* 7(2), 141-153.
M116 (Kagioglou et al., 2003)	. KAGIOGLOU, M., COOPER, R., AOUAD, G., & HINKS, J. (2003). THE PROCESS PROTOCOL: IMPROVING THE FRONT END OF THE DESIGN AND CONSTRUCTION PROCESS FOR THE UK INDUSTRY. *Profitable Partnering in Construction Procurement*, 226.
M117 (Al Hakim et al., 2000)	. Al-Hakim, L., Kusiak, A., & Mathew, J. (2000). A graph-theoretic approach to conceptual design with functional perspectives. *Computer-Aided Design* 32(14), 867-875.
M118 (Presley et al., 2000)	. Presley, A., Sarkis, J., & Liles, D. H. (2000). A soft-systems methodology approach for product and process innovation. *IEEE Transactions on Engineering Management* 47(3), 379-392.
M119 (Genc et al., 2000)	. Genc, S., Messler, R. W., & Gabriele, G. A. (2000). A method for attachment design concept development in integral snap-fit assemblies. *Journal of mechanical design* 122(3), 257-264. . Genc, S., Messler Jr, R. W., & Gabriele, G. A. (1997). Generating alternative attachment concepts in integral snap-fit assemblies. In: *International Conference on Engineering Design*.
M120 (Kryssanov et al., 2000)	. Kryssanov, V. V., Tamaki, H., & Kitamura, S. (2001). Understanding design fundamentals: how synthesis and analysis drive creativity, resulting in emergence. *Artificial Intelligence in engineering* 15(4), 329-342.
M121 (Dahan & Mendelson, 2001)	. Dahan, E., & Mendelson, H. (2001). An extreme-value model of concept testing. *Management science* 47(1), 102-116.
M122 (Loch et al., 2001)	. Loch, C. H., Terwiesch, C., & Thomke, S. (2001). Parallel and sequential testing of design alternatives. *Management Science* 47(5), 663-678.
M123 (Rice et al., 2001)	. Rice, M. P., Kelleyz, D., & Peters, L. (2001). Radical innovation: triggering initiation of opportunity recognition. *R & D Management* 31(4), 409-420.
M124 (Koen et al., 2001)	. Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., . . . Johnson, A. (2001). Providing clarity and a common language to the "fuzzy front end*". Research-Technology Management* 44(2), 46-55. . Koen, P. A., Ajamian, G., Boyce, S., Clamen, A., Fisher, E., Fountoulakis, S., . . . Davidson, J. (2002). Fuzzy front end: effective methods, tools, and techniques. *The PDMA Tool Book, 1*, 5-35. . Koen, P. A. (2004). The fuzzy front end for incremental, platform and breakthrough products and services. *The PDMA Handbook of New Product Development*, 2nd ed., by KB Khan.
M125 (Herstatt & Verworn, 2001)	. Herstatt, C., & Verworn, B. (2001). *The fuzzy front end of innovation:* Working Papers/Technologie-und Innovationsmanagement, Technische Universität Hamburg-Harburg. . Verworn, B. (2002). *The fuzzy front end of product development: An exploratory study:* Working Papers/Technologie-und Innovationsmanagement, Technische Universität Hamburg-Harburg. . Verworn, B., & Herstatt, C. (1999). *Approaches to the fuzzy front end of innovation:* Working Papers/Technologie-und Innovationsmanagement, Technische Universität Hamburg-Harburg.

M126 (Zhang & Doll, 2001)	. Zhang, Q., & Doll, W. J. (2001). The fuzzy front end and success of new product development: a causal model. *European Journal of Innovation Management* 4(2), 95-112. . Doll, W. J., & Zhang, Q. (2001). *Clarifying the fuzziness in the concept of front end fuzziness: a dual theoretical rationale*. The University of Toledo.
M127 (McKay et al., 2001)	. McKay, A., de Pennington, A., & Baxter, J. (2001). Requirements management: a representation scheme for product specifications. *Computer-Aided Design* 33(7), 511-520.
M128 (Reymen, 2001)	. Reymen, I. (2001). *Improving design processes through structured reflection: A domain-independent approach:* Eindhoven University of Technology Eindhoven.
M129 (Nooteboom, 2001)	. NOOTEBOOM, B. (2001). PROBLEMS AND SOLUTIONS IN KNOWLEDGE TRANSFER. *Management* 85, 85.08. . Nooteboom, B. (2002). A Balanced Theory of Sourcing, Collaboration and Networks. *ERIM Report Series Research in Management* (ERS-2002-24-ORG).
M130 (Nobelius & Trygg, 2002)	. Nobelius, D., & Trygg, L. (2002). Stop chasing the front-end process—management of the early phases in product development projects. *International Journal of Project Management* 20(5), 331-340. . Nobelius, D. (2002). *Managing R&D Processes-Focusing on Technology Development, Product Development, and their Interplay:* Chalmers University of Technology. . Nobelius, D. (2004). Linking product development to applied research: transfer experiences from an automotive company. *Technovation* 24(4), 321-334.
M131 (Mozota, 2002)	. Mozota, B. B. (2002). Design and competitive edge: A model for design management excellence in European SMEs. *Design Management Journal* 2(1), 88-103. . Mozota, B. B. (2006). The four powers of design: A value model in design management. *Design Management Review* 17(2), 44-53.
M132 (Flint, 2002)	. Flint, D. J. (2002). Compressing new product success-to-success cycle time: Deep customer value understanding and idea generation. *Industrial marketing management* 31(4), 305-315.
M133 (Dahl & Moreau, 2002)	. Dahl, D. W., & Moreau, P. (2002). The influence and value of analogical thinking during new product ideation. *Journal of Marketing Research* 39(1), 47-60. . DAHL, D. W., & MOREAU, C. P. (2007). Thinking Inside the Box: Why Consumers Enjoy Constrained Creative Experiences. *Journal of Marketing Research*.
M134 (Kim & Wilemon, 2002)	. Kim, J., & Wilemon, D. (2002). Focusing the fuzzy front-end in new product development. *R&D Management* 32, 269-279. . Kim, J., & Wilemon, D. (2010). Accelerating the fuzzy front-end of NPD projects: methods and management. *International Journal of Engineering Management and Economics* 1(1), 80-101.
M135 (Lawson & Finkelstein, 2002)	. Lawson, K., & Finkelstein, A. (2002). Integration of product and technology development process with R&D portfolio management using efficient frontier analysis. In: *Engineering Management Conference, 2002. IEMC'02. 2002 IEEE International*.
M136 (Jetter, 2003)	. Jetter, A. J. (2003). Educating the guess: strategies, concepts and tools for the fuzzy front end of product development. In: *Management of Engineering and Technology, 2003. PICMET'03. Technology Management for Reshaping the World. Portland International Conference on*.
M137 (Husing & Kohn, 2003)	. Hüsig, S., & Kohn, S. (2003). Factors influencing the front end of the innovation process: A comprehensive review of selected empirical NPD and explorative FFE studies. *Proceedings of the 10th IPDMC*, 14. . Song, X. M., & Parry, M. E. (1996). What separates Japanese new product winners from losers. *Journal of Product Innovation Management* 13(5), 422-439. . Ernst, H. (2002). Success factors of new product development: a review of the empirical literature. *International Journal of Management Reviews* 4(1), 1-40.
M138 (Russell & Tippett, 2008)	. Russell, R. K., & Tippett, D. D. (2008). Critical success factors for the fuzzy front end of innovation in the medical device industry. *Engineering Management Journal* 20(3), 36-43. . Bullen, C. V., & Rockart, J. F. (1981). *A primer on critical success factors*: Massachusetts Institute of Technology (MIT), Sloan School of Management. . Ernst, H. (2002). Success factors of new product development: a review of the empirical literature. *International Journal of Management Reviews* 4(1), 1-40.
M139 (Bucher et al., 2003)	. Bucher, P., Birkenmeier, B., Brodbeck, H., & Escher, J. P. (2003). Management principles for evaluating and introducing disruptive technologies: the case of nanotechnology in Switzerland. *R&D Management* 33(2), 149-163.
M140 (Mulgan & Albury, 2003)	. Martinez, L. (2014). *Theoretical considerations about Innovation in the Public Sector.* In: *RUC Sunrise Conference 2012.*
M141 (Fairlie & Muller, 2003)	. Fairlie-Clarke, T., & Muller, M. (2003). An activity model of the product development process. *Journal of Engineering Design* 14(3), 247-272.
M142 (Yang, 2003)	. Yang, B. (2003). Toward a holistic theory of knowledge and adult learning. *Human Resource Development Review* 2(2), 106-129.
M 143(Flynn et al., 2003)	. Flynn, M., Dooley, L., O'sullivan, D., & Cormican, K. (2003). Idea management for organisational innovation. *International Journal of Innovation Management* 7(4), 417–442.
M144 (Carlile, 2004)	. Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization science* 15(5), 555-568.

M145 (Phaal et al., 2004)	. Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). Technology road mapping—a planning framework for evolution and revolution. *Technological forecasting and social change* 71(1), 5-26. . Probert, D., Farrukh, C., & Phaal, R. (2004). Structuring a systematic approach to technology management: processes and framework *Bringing Technology and Innovation into the Boardroom* (pp. 76-91): Springer.
M146 (Sandmeier et al., 2004)	. Sandmeier, P., Jamali, N., Kobe, C., Enkel, E., Gassmann, O., & Meier, M. (2004). *Towards a Structured and Integrative Front-End of Product Innovation.* In: *Proceedings of The R & D Management Conference (RADMA). Saunders, M. N. (2011). Research methods for business students*: Pearson Education India.
M147 (van Aken & Nigel, 2004)	. van Aken, J. E., & Nagel, A. P. (2004). Organising and managing the fuzzy front end of new product development. *Eindhoven Center of Innovation Studies, Working paper, 4.*
M 148(Boeddrich, 2004)	. Boeddrich, H. (2004). Ideas in the workplace: a new approach towards organizing the fuzzy front end of the innovation process. *Creativity and Innovation Management* 13(4), 274-285.
M149 (Tidd et al., 2005)	. Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and Organizational Change*. John Wiley.
M150 (Sommer & Loch, 2004)	. Sommer, S. C., & Loch, C. H. (2004). Selectionism and learning in projects with complexity and unforeseeable uncertainty. *Management science* 50(10), 1334-1347. . Sommer, S. C., & Loch, C. H. (2003). Selectionism and learning in complex and ambiguous projects. *Management science* 50(10), 1334-1347.
M151 (Beers et al., 2005)	. Beers, P. J., Boshuizen, H. P. E., Kirschner, P. A., & Gijselaers, W. H. (2005). Computer support for knowledge construction in collaborative learning environments. *Computers in Human Behaviour* 21(4), 623-643.
M152 (Ziv Av & Reich, 2005)	. Ziv-Av, A., & Reich, Y. (2005). SOS–Subjective objective system for generating optimal product concepts. *Design Studies* 26(5), 509-533.
M153 (Williams et al., 2007)	. Williams, M. A., K.ochhar, A., & Tennant, C. (2007). An object-oriented reference model of the fuzzy front end of the new product introduction process. *The International Journal of Advanced Manufacturing Technology* 34(7), 826-841.
M154 (Shino et al., 2006)	. Shinno, H., Yoshioka, H., & Marpaung, S. (2006). A structured method for analysing product specification in product planning for machine tools. *Journal of Engineering Design* 17(4), 347-356. . Shinno, H., & Hashizume, H. (2002). Structured method for identifying success factors in new product development of machine tools. *CIRP Annals-Manufacturing Technology* 51(1), 281-284.
M155 (Li et al., 2006)	. Li, G., Tan, R., Liu, Z., & Zhang, H. (2006). Idea generation for fuzzy front end using TRIZ and TOC. In: *2006 IEEE International Conference on Management of Innovation and Technology*. . Savransky, S. D. (2000). *Engineering of creativity: Introduction to TRIZ methodology of inventive problem solving:* CRC Press.
M156 (Talke, K., et al., 2006)	. Talke, K., Salomo, S., & Mensel, N. (2006). A Competence-Based Model of Initiatives for Innovations. *Creativity and Innovation Management* 15(4), 373-384.
M157 (McCarthy et al, 2006)	. McCarthy, I. P., Tsinopoulos, C., Allen, P., & Rose-Anderssen, C. (2006). New product development as a complex adaptive system of decisions. *Journal of product innovation management* 23(5), 437-456.
M158 (Griffith & Grover, 2006)	. Griffiths-Hemans, J., & Grover, R. (2006). Setting the stage for creative new products: investigating the idea fruition process. *Journal of the Academy of Marketing Science* 34(1), 27-39.
M159 (Toubia, 2006)	. Toubia, O. (2006). Idea generation, creativity, and incentives. *Marketing Science* 25(5), 411-425.
M160 (Brassington & Pettitt, 2006)	. Brassington, F., & Pettitt, S. (2006). *Principles of marketing*: Pearson Education.
M161 (Osteras et al., 2006)	. Osteras, T., Murthy, D., & Rausand, M. (2006). Product performance and specification in new product development. *Journal of engineering design* 17(2), 177-192.
M162 (Andrew & Sirkin, 2006)	. Andrew, J. P., & Sirkin, H. L. (2007). Using the cash curve to discuss and discipline innovation investments. *Strategy & Leadership* 35(4), 11-17. . Andrew, J., Butman, J., Sirkin, H., Chessa, M., & Monti, R. (2007). *Payback:* Sperling & Kupfer Editori.
M163 (Lawrence et al., 2006)	. Lawrence, M., Goodwin, P., O'Connor, M., & Önkal, D. (2006). Judgmental forecasting: A review of progress over the last 25years. *International Journal of Forecasting* 22(3), 493-518.
M164 (Meade & Islam, 2006)	. Meade, N., & Islam, T. (2006). Modelling and forecasting the diffusion of innovation–A 25-year review. *International Journal of Forecasting* 22(3), 519-545.
M165 (Hansen & Birkins, 2007)	. Hansen, M. T. & Birkinshaw, J. (2007). The innovation value chain. *Harvard business review* 85(6): 121.
M166 (Seidel, 2007)	. Seidel, V. P. (2007). Concept shifting and the radical product development process. *Journal of product innovation management* 24(6), 522-533.
M167 (Backman et al., 2007)	. Backman, M., Börjesson, S., & Setterberg, S. (2007). Working with concepts in the fuzzy front end: exploring the context for innovation for different types of concepts at Volvo Cars. *R&D Management* 37(1), 17-28.
M168 (Ester & Daniel, 2007)	. Ester, V. J., & Daniel, J. (2007). Use of Tools, Methods and Techniques During the Fuzzy Front End of Innovation: Their Impact on Innovation Performance-An Exploratory Study

	of Companies in the Basque Country. *Guidelines for a Decision Support Method Adapted to NPD Processes*.
M169 (Salomo et al., 2007)	. Salomo, S., Weise, J., & Gemünden, H. G. (2007). NPD planning activities and innovation performance: the mediating role of process management and the moderating effect of product innovativeness. *Journal of product innovation management* 24(4), 285-302.
M170 (Chang et al., 2007)	. Chang, S. L., Chen, C. Y., & Wey, S. C. (2007). Conceptualizing, assessing, and managing front-end fuzziness in innovation/NPD projects. *R&D Management* 37(5), 469-478.
M171 (Tzortzopoulos et al., 2006)	. Tzortzopoulos, P., Cooper, R., Chan, P., & Kagioglou, M. (2006). Clients' activities at the design front-end. *Design Studies* 27(6), 657-683.
M172 (Lynes & Ford, 2007)	. Lyneis, J. M., & Ford, D. N. (2007). System dynamics applied to project management: a survey, assessment, and directions for future research. *System Dynamics Review* 23(2-3), 157-189.
M 173(Whitney, 2007)	. Assemble a technology development toolkit. *Research-Technology Management* 50(5), 52-58.
M174 (Trott, 2008)	. Trott, P. (2008). *Innovation management and new product development:* Pearson education.
M175 (Crawford & Di Benedetto, 2008)	. Crawford, C. M., & Di Benedetto, C. A. (2008). *New products management:* Tata McGraw-Hill Education.
M176 (Michael, 2008)	. Michael, B. (2008). *Product strategy and management*, Pearson Education India.
M177 (El-Sayed, 2008)	. El-Sayed, M. E. (2008). *Rethinking the Automotive Design and Development Processes for Product Realization:* SAE Technical Paper.
M178 (Agouridas et al., 2008)	. Agouridas, V., McKay, A., Winand, H., & de Pennington, A. (2008). Advanced product planning: a comprehensive process for systemic definition of new product requirements. *Requirements Engineering* 13(1), 19-48.
M179 (Birkhofer, 2008)	. Birkhofer, H. (2008). Tidying up design methods–an approach using elementary design methods. *In: DS 48: Proceedings DESIGN 2008, the 10th International Design Conference, Dubrovnik, Croatia*.
M180 (Barczak et al., 2009)	. Barczak, G., Griffin, A., & Kahn, K. B. (2009). Perspective: trends and drivers of success in NPD practices: results of the 2003 PDMA best practices study. *Journal of product innovation management* 26(1), 3-23.
M181 (Verworn, 2009)	. Verworn, B. (2009). A structural equation model of the impact of the "fuzzy front end" on the success of new product development. *Research Policy* 38(10): 1571-1581. . Verworn, B., Herstatt, C., Nagahira, A. (2008). The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects. *R&D Management* 38 (1), 1–19. . Verworn, B., & Herstatt, C. (2003). A causal model of the impact of the "fuzzy front end" on the success of new product development. In: *Proceedings of the 10th International Product Development Management Conference, Brussels.*
M182 (Mulder & Stappers, 2009)	. Mulder, I., & Stappers, P. J. (2009). Co-creating in practice: results and challenges. In: *Collaborative Innovation: Emerging Technologies, Environments and Communities (Proceedings of the 15th International Conference on Concurrent Enterprising: ICE 2009, Leiden, The Netherlands*, 22–24 June 2009). Centre for Concurrent Enterprise: Nottingham, UK.
M183 (Qian et al., 2009)	. Qian, Y., Liang, J., & Dang, C. (2009). Knowledge structure, knowledge granulation and knowledge distance in a knowledge base. *International Journal of Approximate Reasoning* 50(1), 174-188.
M184 (Poskela, 2009)	. Poskela, J. (2009). *Management control in the front end of innovation.* Doctoral Dissertation in Department of Industrial Engineering and Management, Helsinki University of Technology.
M185 (Brun & Saetre, 2009)	. Brun, E., & Sætre, A. S. (2009). Managing ambiguity in new product development projects. *Creativity and Innovation Management* 18(1), 24-34. . Brun, E., Steinar Saetre, A., & Gjelsvik, M. (2009). Classification of ambiguity in new product development projects. *European Journal of Innovation Management* 12(1), 62-85.
M186 (Brun & Saetre, 2008)	. Brun, E., & Saetre, A. S. (2008). Ambiguity reduction in new product development projects. *International Journal of Innovation Management* 12(04), 573-596. . Brun, E., Sætre, A. S., & Gjelsvik, M. (2008). Benefits of ambiguity in new product development. *International Journal of Innovation and Technology Management* 5(03), 303-319.
M187 (Berg et al., 2009)	. Berg, P., Pihlajamaa, J., Poskela, J., Lempiala, T., Haner, U., & Mabogunje, A. (2009). Balanced innovation front end measurement: Discontinuous innovation approach. In: *Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference on*. . Berg, P., Pihlajamaa, J., Poskela, J., Lempiala, T., Haner, U., & Mabogunje, A. (2008). Measurement of the innovation front end: Viewpoint of process, social environment and physical environment. In: *Management of Engineering & Technology, 2008. PICMET 2008. Portland International Conference on*.
M188 (Kutvonen & Torkkeli, 2009)	. Kutvonen, A., & Torkkeli, M. T. (2009). Opening the fuzzy front end: A synthesis of two theories. In: *Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference on*. . Chesbrough, H. (2006). *Open business models: How to thrive in the new innovation landscape:* Harvard Business Press.

M189 (Zhang et al., 2009)	. Zhang, Q., Vonderembse, M. A., & Cao, M. (2009). Product concept and prototype flexibility in manufacturing: Implications for customer satisfaction. *European Journal of Operational Research, 194*(1), 143-154.
M190 (Gausemeier et al., 2009)	. Gausemeier, J., Brink, V., Ihmels, S., Kokoschka, M., & Reymann, F. (2009). Strategic product-and technology-planning with the innovation-database: A field-proven approach from the market-oriented product idea up to an operational development roadmap. In: *Industrial Technology, 2009. ICIT 2009. IEEE International Conference on*.
M191 (Marion, 2009)	. Marion, T. J. (2009). A framework for balancing efficiency and effectiveness in innovative product design*. In: DS 58-1: Proceedings of ICED 09, the 17th International Conference on Engineering Design*, Vol. 1, Design Processes, Palo Alto, CA, USA, 24.-27.08. 2009.
M192 (Moder et al., 1983)	. Moder, J., Phillips, C., & Davis, E. (1983). *Project management with CPM, PERT and project diagramming*: Van Nostrand Reinhold Publishers. . Antill, J. M., & Woodhead, R. W. (1990). *Critical path methods in construction practice*: John Wiley & Sons.
M193 (Du Chatenier et al., 2009)	. Du Chatenier, E., Verstegen, J. A., Biemans, H. J., Mulder, M., & Omta, O. (2009). The challenges of collaborative knowledge creation in open innovation teams. *Human Resource Development Review* 8(3), 350-381.
M194 (Kolb et al., 2009)	. Kolb, A. Y., & Kolb, D. A. (2009) *Experiential learning theory*: A dynamic, holistic approach to management learning, education and development. Armstrong, S., & C. Fukami (Eds.). *The SAGE handbook of management learning, education and development* (pp. 42–68). Los Angeles: SAGE.
M195 (Hill Model)	. Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).* . Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63.
M196 (Tong Model)	. Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).* . Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63.
M197 (Funnel Model)	. Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).* . Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63.
M198 (Brem & Voigt, 2009)	. Brem, A., & Voigt, K.-I. (2009). Integration of market pull and technology push in the corporate front end and innovation management—Insights from the German software industry. *Technovation* 29(5): 351-367.
M199 (Halpin, 2010)	. Halpin, D. W. (2010). *Construction management:* John Wiley & Sons.
M200 (Kolter & Armstrong, 2010)	. Kotler, P., & Armstrong, G. (2010). *Principles of marketing:* Pearson education.
M201 (Slack et al., 2010)	. Slack, N., Chambers, S., & Johnston, R. (2010). *Operations management:* Pearson education.
M202 (Dewulf, 2010)	. Dewulf, K. (2010). Play it forward: a game-based tool for sustainable product and business model innovation in the fuzzy front end. In: *Knowledge Collaboration & Learning for Sustainable Innovation: ERSCP-EMSU Conference*, 25-29 October 2010, Delft, The Netherlands.
M203 (Oliveira & Rozenfeld, 2010)	. Oliveira, M. G., & Rozenfeld, H. (2010). Integrating technology road mapping and portfolio management at the front-end of new product development. *Technological Forecasting and Social Change* 77(8), 1339-1354. . Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). Technology road mapping—a planning framework for evolution and revolution. *Technological Forecasting and Social Change* 71(1), 5-26. . Cooper, R., Edgett, S., & Kleinschmidt, E. (2001). Portfolio management for new product development. *R&D Management* 31(4), 361-380. . Archer, N. P., & Ghasemzadeh, F. (1999). An integrated framework for project portfolio selection. *International Journal of Project Management* 17(4), 207-216. . Crawford, C. M., & Di Benedetto, C. A. (2008). *New products management:* Tata McGraw-Hill Education.
M204 (Lidwell et al., 2010)	. Lidwell, W., Holden, K., & Butler, J. (2010). *Universal principles of design revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design:* Rockport Pub. . Hanington, B., & Martin, B. (2012). *Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions:* Rockport Publishers.
M205 (Kumar, 2012)	. Kumar, V. (2012). *101 design methods: A structured approach for driving innovation in your organization*, John Wiley & Sons.
M206 (Clarkson et al., 2013)	. Clarkson, P., Coleman, R., Hosking, I., & Waller, S. (2007). *Inclusive design toolkit:* Engineering Design Centre, University of Cambridge, UK. . Clarkson, P. J., Coleman, R., Keates, S., & Lebbon, C. (2013). *Inclusive design: Design for the whole population:* Springer Science & Business Media.
M207 (van Boeijen et al., 2014)	. *van Boeijen, A., et al. (2014).* Delft design guide: Design methods*, BIS publishers.*

M208 (Unger et al., 2011)	. Unger, D., & Eppinger, S. (2011). Improving product development process design: a method for managing information flows, risks, and iterations. *Journal of Engineering Design* ***22*****(10), 689-699.** . Unger, D. W., & Eppinger, S. D. (2009). Comparing product development processes and managing risk. *International Journal of Product Development* 8(4), 3. . Unger, D. W., & Eppinger, S. D. (2006). *Improving product development processes to manage development risk.* MIT Sloan Working Paper 4568-06, 2006. . Unger, D. W., & Eppinger, S. D. (2002). Planning design iterations. Innovation in Manufacturing Systems and Technology (IMST) (2002) Available from: http://hdl.handle.net/ 1721.1/4037.
M209 (Luchs & Swan, 2011)	. Luchs, M., & Swan, K. S. (2011). Perspective: The emergence of product design as a field of marketing inquiry. *Journal of Product Innovation Management* 28(3), 327-345.
M210 (Zhang et al., 2011)	. Zhang, D., Hu, P., & Kotabe, M. (2011). Marketing–industrial design integration in new product development: The case of China. *Journal of Product Innovation Management* 28(3), 360-373.
M211 (Kurkkio, 2011)	. Kurkkio, M. (2011). Managing the fuzzy front-end: insights from process firms. *European Journal of Innovation Management* 14(2), 252-269. . Frishammar, J., Lichtenthaler, U., & Kurkkio, M. (2012). The front end in non-assembled product development: A multiple case study of mineral-and metal firms. *Journal of Engineering and Technology Management* 29(4), 468-488.
M212 (Lin et al., 2011)	. Lin, R.-J., Wei, C.-C., Chang, H.-W., & Wei, C.-S. (2011). A model for selecting a new product development project portfolio. *Journal of Information and Optimization Sciences* 32(4), 909-927. . Wei, C. C., & Chang, H.-W. (2011). A new approach for selecting portfolio of new product development projects. *Expert Systems with Applications* 38(1), 429-434.
M213 (Kim & Yoon, 2011)	. Kim, K., & Yoon, H. (2011). R&D Plan's Influence for the Management Performance-Focus on Fuzzy front end model. *Productivity Review (Korea)* 25(4), 317-344.
M214 (Wormald, 2011)	. Wormald, P. W. (2011). Positioning industrial design students to operate at the 'fuzzy front end': investigating a new arena of university design education. *International Journal of Technology and Design Education* 21(4), 425-447. . Veryzer, R. W. (2005). The roles of marketing and industrial design in discontinuous new product development. *Journal of Product Innovation Management* 22(1), 22-41. . Steen, M., Kuijt-Evers, L., & Klok, J. (2007). Early user involvement in research and design projects–A review of methods and practices. In: *The 23rd EGOS Colloquium (European Group for Organizational Studies)*.
M215 (Montagna, 2011)	. Montagna, F. (2011). Decision-aiding tools in innovative product development contexts. *Research in Engineering Design* 22(2), 63-86.
M216 ((Mootee, 2011)	. Mootee, I. (2011). Strategic innovation and the fuzzy front end. *Ivey Business Journal* 75(2), 3.
M217 (Kim & Kim, 2011)	. Kim, K. Y., & Kim, Y. S. (2011). Causal design knowledge: Alternative representation method for product development knowledge management. *Computer-Aided Design* 43(9), 1137-1153.
M218 (ENV model)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63.
M219 (Substance-Field model)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).*
M220 (Contradiction model)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Yan, B., & Zeng, Y. (2011). Design conflict: conceptual structure and mathematical representation. *Journal of Integrated Design and Process Science* 15(1), 75-89.
M221 (ARIZ model)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).* . Rousseau, P. R., & Khomenko, N. (2011). Improving Problem Solving and Solution Design Skills Using Problem Flow Coaches in Capstone Projects. *Proceedings of the Canadian Engineering Education Association.*
M222 (Thinking model)	. . Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Cascini, G., Frillici, F., Jangtschi, J., Kaikov, I., & Khomenko, N. (2009). TRIZ, Theory of Inventive Problem Solving, improve your problem-solving skills. *Education and Culture DG, Lifelong Learning Programme, TETRIS (Teaching TRIZ at School).*
M223 (System Design model)	. Cascini, G. (2012). TRIZ-based anticipatory design of future products and processes. *Journal of Integrated Design and Process Science* 16(3), 29-63. . Song, M. J., Lee, J.-G., Park, J.-M., & Lee, S. (2012). Triggering navigators for innovative system design: The case of lab-on-a-chip technology. *Expert Systems with Applications, 39*(16), 12451-12459.

M224 (Brentani & Reid, 2012)	. Brentani, U., & Reid, S. E. (2012). The Fuzzy Front-End of Discontinuous Innovation: Insights for Research and Management. *Journal of Product Innovation Management* 29(1): 70-87. . Reid, S. E., & De Brentani, U. (2004). The fuzzy front end of new product development for discontinuous innovations: a theoretical model. *Journal of product innovation management* 21(3), 170-184.
M225 (Jacoby & Scheelen, 2012)	. Jacoby, A., & Scheelen, L. (2012). How to Prepare Students for the Real Front-End of Innovation Challenges: A Methodological Perspective. In: *DS 74: Proceedings of the 14th International Conference on Engineering & Product Design Education (E&PDE12) Design Education for Future Wellbeing*, Antwerp, Belguim, 06-07.9. 2012.
M226 (Zhai et al., 2012)	. Zhai, L., Hong, Z., Zhang, R., & Nagahira, A. (2012). The internal mechanism of FFE affecting NPD performance: A theoretical model. In: *Management of Technology (ISMOT), 2012 International Symposium on*.
M227 (Heising, 2012)	. Heising, W. (2012). The integration of ideation and project portfolio management—A key factor for sustainable success. *International Journal of Project Management* 30(5), 582-595.
M228 (Soukhoroukova et al., 2012)	. Soukhoroukova, A., Spann, M., & Skiera, B. (2012). Sourcing, filtering, and evaluating new product ideas: An empirical exploration of the performance of idea markets. *Journal of Product Innovation Management* 29(1), 100-112.
M229 (Wang & Gan, 2012)	. Wang, Z., & Gan, L. (2012). *Lean Front-End Framework Development*. Master of Science in Management, Economics and Industrial Engineering. Polo Terrioriale Di Como.
M230 (Dornberger & Suvelza, 2012)	. Dornberger, U., & Suvelza, A. (2012). Managing the fuzzy front-end of innovation. *International SEPT Program of the Leipzig University: Leipzig, Germany.*
M 231(Florén & Frishammar, 2012)	. Florén, H., & Frishammar, J. (2012). From preliminary ideas to corroborated product definitions: Managing the front end of new product development. *California Management Review* 54(4), 20-43.
M232 (Achiche et al., 2013)	. Achiche, S., Appio, F. P., McAloone, T. C., & Di Minin, A. (2013). Fuzzy decision support for tools selection in the core front end activities of new product development. *Research in engineering design* 24(1), 1-18.
M233 (Defossez & Serhan, 2013)	. Défossez, H. J., & Serhan, H. (2013). Managing design excellence tools during the development of new orthopaedic implants. *Journal of Biomechanical Engineering* 135(11), 114506.
M234 (Riel et al., 2013)	. Riel, A., Neumann, M., & Tichkiewitch, S. (2013). Structuring the early fuzzy front-end to manage ideation for new product development. *CIRP Annals-Manufacturing Technology* 62(1), 107-110.
M235 (Akbar & Tzokas, 2013)	. Akbar, H., & Tzokas, N. (2013). An Exploration of New Product Development's Front-end Knowledge Conceptualization Process in Discontinuous Innovations. *British Journal of Management* 24(2), 245-263. . Akbar, H., & Tzokas. N. (2013). Charting the organisational knowledge-creation process: an innovation-process perspective. *Journal of Marketing Management* 29(13-14): 1592-1608.
M236 (Eling et al., 2014)	. Eling, K., Griffin, A., & Langerak, F. (2014). Using Intuition in Fuzzy Front-End Decision-Making: A Conceptual Framework. *Journal of Product Innovation Management* 31(5), 956-972.
M237 (Goto et al., 2014)	. Goto, S., Ishida, S., Gemba, K., & Yaegashi, K. (2014). The Interaction between Design Research and Technological Research in Manufacturing Firm. *Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence*, 226.
M238 (Verganti, 2011)	. Verganti, R. (2011). Radical design and technology epiphanies: a new focus for research on design management. *Journal of Product Innovation Management* 28(3), 384-388. . Verganti, R. (2009). *Design driven innovation: changing the rules of competition by radically innovating what things mean:* Harvard Business Press. . Dell'Era, C., & Verganti, R. (2009). Design-driven laboratories: organization and strategy of laboratories specialized in the development of radical design-driven innovations. *R&D Management* 39(1), 1-20.
M239 (Verganti, 2008)	. Verganti, R. (2008). Design, meanings, and radical innovation: A metamodel and a research agenda. *Journal of Product Innovation Management* 25(5), 436-456.
M240 (Yoon et al., 2015)	. Yoon, B. S., & Jetter, A. J. (2015). Connecting customers with engineers for the successful fuzzy front end: Requirements of tools. In: *Management of Engineering and Technology (PICMET), 2015 Portland International Conference on*.
M241 (Castilho et al., 2015)	. Castilho, J., Dias, J., Bagno, R. B., Freitas, J. S., & Cheng, L. C. (2015). A methodology to build an initial R&D portfolio for industry-university cooperation. In: *Management of Engineering and Technology (PICMET), 2015 Portland International Conference on*.
M242 (Akman et al., 2015)	. Akman, G., Özcan, B., & Hatipoğlu, T. (2015). Fuzzy multi criteria decision making approach to innovative strategies based on Miles and Snow typology. *Journal of Intelligent Manufacturing* 26(3), 609-628.
M243 (Kock et al., 2015)	. Kock, A., Heising, W., & Gemünden, H. G. (2015). How Ideation Portfolio Management Influences Front-End Success. *Journal of Product Innovation Management* 32(4), 539-555.
M244 (Gurtner et al., 2016)	. Gurtner, S., & Reinhardt, R. (2016). Ambidextrous Idea Generation—Antecedents and Outcomes. *Journal of Product Innovation Management* 33(S1), 34-54.
M245 (Kock et al., 2016)	. Kock, A., Heising, W., & Gemünden, H. G. (2016). A Contingency Approach on the Impact of Front-End Success on Project Portfolio Success. *Project Management Journal*.

M246 (Salerno et al., 2015)	. Salerno, M. S., de Vasconcelos Gomes, L. A., da Silva, D. O., Bagno, R. B., & Freitas, S. L. T. U. (2015). Innovation processes: Which process for which project? *Technovation* 35, 59-70.
M247 (Alexandersdottir, 2015)	. Alexandersdóttir, A. (2015). *Managing the front end of innovation. The positive impact of the organizational attributes to the front end of innovation performance*. Master of Science in Marketing and International Business. University of Iceland.
M248 (Kaitlin et al., 2016)	. Wowak, K. D., Craighead, C. W., Ketchen, D. J., & Hult, G. T. M. (2016). Toward a "Theoretical Toolbox" for the Supplier-Enabled Fuzzy Front End of the New Product Development Process. *Journal of Supply Chain Management* 52(1), 66-81.
M249 (Buede & Miller, 2016)	. Buede, D. M., & Miller, W. D. (2016). *The engineering design of systems: models and methods:* John Wiley & Sons.
M250 (Thanasopon et al., 2016)	. Thanasopon, B., Papadopoulos, T., & Vidgen, R. (2016). The role of openness in the fuzzy front-end of service innovation. *Technovation* 47, 32-46.
M251 (Bacciotti et al., 2016)	. Bacciotti, D., Borgianni, Y., Cascini, G., & Rotini, F. (2016). Product Planning techniques: investigating the differences between research trajectories and industry expectations. *Research in Engineering Design* 27(4), 367-389.
M252 (Hamidian, 2017)	. Hamidian, E. (2017). *The front-end evaluation process in the new product development process: towards a more effective selection procedure of NPD projects*. Thesis, Master of Science in Innovation Management, Eindhoven University of Technology.
M253 (Moretti & Junior, 2017)	. Moretti, I. C., & Junior, A. B. (2017). Reference model for apparel product development. *Independent Journal of Management & Production* 8(1), 232-262.
M254 (Andriopoulos et al., 2017)	. Andriopoulos, C., Gotsi, M., Lewis, M. W., & Ingram, A. E. (2017). Turning the Sword: How NPD Teams Cope with Front-End Tensions. *Journal of Product Innovation Management* 35(3), 427-445.
M255 (Parida et al., 2017)	. Parida, V., Patel, P. C., Frishammar, J., & Wincent, J. (2017). Managing the front-end phase of process innovation under conditions of high uncertainty. *Quality & Quantity* 51(5), 1983-2000.
M256 (Rodrigues et al., 2017)	. Rodrigues, T., Braghini Junior, A., & Sola, A. V. H. (2017). Structuring front-end innovation activities throughout strategic product planning. *Production*, 27.
M257 (Yong, 2017)	. Yong, C., Islam, M. S., Sun Hilen, M., & Nizam, E. H. (2017). *Front-End Activities Promote Front-End Performance? —The Moderating Effect of Front-End Uncertainty*: Global Journal of Management and Business Research.
M258 (Tate et al., 2018)	. Tate, M., Bongiovanni, I., Kowalkiewicz, M., & Townson, P. (2018). Managing the "Fuzzy front end" of open digital service innovation in the public sector: A methodology. *International Journal of Information Management* 39, 186-198.
M259 (Khastehdel et al., 2018)	. Khastehdel, M., & Mansour, S. (2018). Developing a Dynamic Model for Idea Selection during Fuzzy Front End of Innovation. World Academy of Science, Engineering and Technology, *International Journal of Economics and Management Engineering* 5(3).
M260 (Cho et al., 2018)	. Cho, Y., Kirkewoog, S., & Daim, T. U. (2018). Managing strategic intellectual property assets in the fuzzy front end of new product development process. *R&D Management* 48(3), 354-374.
M261 (Marshall, 2018)	. Marshall, J. K. (2018). *Front-End Innovation and Craft Beer Breweries: Exploring Problem Framing and the Customer Experience through Design Thinking*. Doctoral Dissertation in School of Business and Technology, Capella University.
M262 (Borgianni et al., 2018)	. Borgianni, Y., Cascini, G., & Rontini, F. (2018). Investigating the future of the fuzzy front end: towards a change of paradigm in the very early design phases?. *Journal of Engineering Design* 29(11), 644–664.
M263 (Röth et al., 2019)	. Röth, T., Spieth, P., & Lange, D. (2019). Managerial Political Behavior in Innovation Portfolio Management: A Sensegiving and Sensebreaking Process. *Product Innovation Management* 36(5), 534-559.
M264 (Schweitzer et al., 2019)	. Schweitzer, F., Van den Hende, E. A. and Hultink, E.-J. (2019). There's more than one perspective to take into account for successful customer integration into radical new product innovation: A framework and research agenda. *IEEE Transactions on Engineering Management* 67(3), 813–829.
M265 (Roach, 2020)	. Is It Time to Reassess the Front-End Innovation Approach?. *IEEE Engineering Management Review* 48(1), 10–13.
M266 (Joachim & Spieth, 2020)	. Joachim, V., & Spieth, P. (2020). What does front-end research build on? A cocitation analysis of the intellectual background and potential future research avenues. *IEEE Transactions on Engineering Management* 67(1): 105–121.

The following papers, which examine representative models, were also referenced:

- Evbuomwan, N., Sivaloganathan, S., & Jebb, A. (1996). A survey of design philosophies, models, methods and systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 210(4), 301-320.
- Eveleens, C. (2010). Innovation management; a literature review of innovation process models and their implications. *Science 800*(2010), 900.

- Howard, T. J., et al. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies* 29(2), 160-180.
- McAdam, R., & McClelland, J. (2002). Individual and Team-based Idea Generation Within Innovation Management: Organisational and Research Agendas. *European Journal of Innovation Management* 5(2), 86-97.
- Meredith, J. R., & Shafer S. M. (2009). *Operations management for MBAs,* John Wiley & Sons.
- Simms, C. D. (2012). *An analysis of the management of packaging within new product development: an investigation in the UK food and drinks sectors.* University of Portsmouth. UK.
- Wynn, D., & Clarkson, J. (2005). *Models of designing. Design process improvement* (pp. 34-59): Springer.
- van Aken, J. E. (2005). Valid knowledge for the professional design of large and complex design processes. *Design Studies* 26(4), 379-404.
- Costa, M. A. B., & Toledo, J. C. (2016). Analysis of predevelopment models and activities: a systematic bibliographic review. *G & P* 23(4), 704-717.
- Takey SM and Carvalho MM (2016) Fuzzy front end of systemic innovations: A conceptual framework based on a systematic literature review. *Technological Forecasting and Social Change* 111: 97–109.

In the table above, some papers which have similar features and affect other models; these are not arranged in chronological order. Instead, they are grouped. However, when the historical trend analysis was conducted with SPSS, those models were arranged in chronological order.