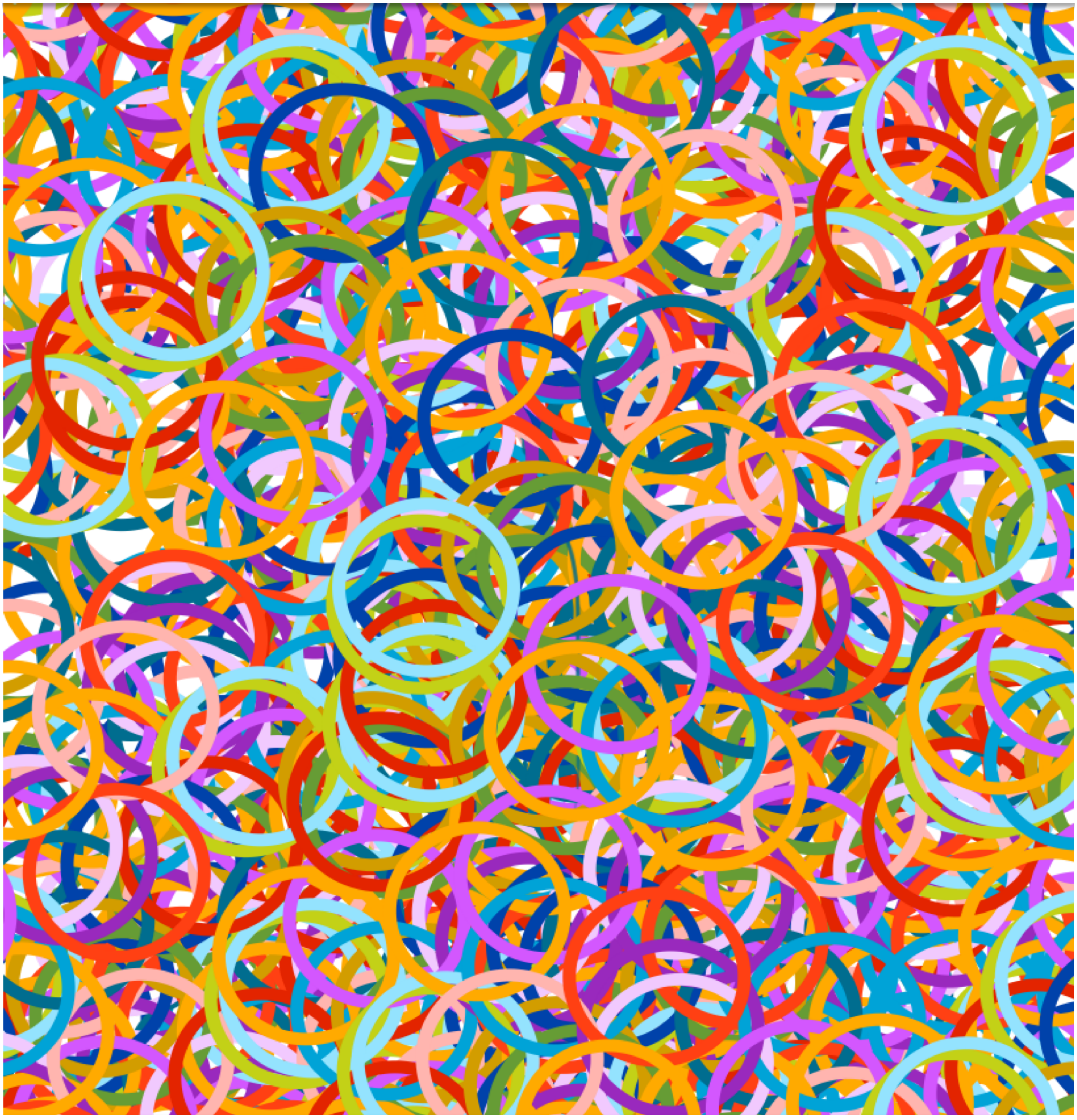
JIM
Journal of Innovation Management
The International Journal on Multidisciplinary Approaches on Innovation
Volume 8 Issue 1 | 2020 | open-jim.org



ISSN 2183-0606
FEUP Edições

Volume 8 - Issue 1

Table of Contents

ISSN 2183-0606
http://www.open-jim.org

Editorial Team

ISSN 2183-0606
http://www.open-jim.org

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 8, 1 (2020) 1-5
HANDLE: https://hdl.handle.net/10216/126987
DOI:https://doi.org/10.24840/2183-0606_008.001_0001

Coronavirus: a catalyst for change and innovation

Anne-Laure Mention
anne-laure.mention@rmit.edu.au | RMIT University, Australia
João José Pinto Ferreira
jjpf@fe.up.pt | INESC Technology and Science, Faculty of Engineering, University of Porto, Portugal
Marko Torkkeli
marko.torkkeli@lut.fi | Lappeenranta University of Technology, Finland

Man's existence lies in his integrity. A man without integrity can exist merely through his luck.

- Analects of Confucius, VI: 19

As we write this editorial, people around the world are apprehensive about their future; some are at home; some are thinking about the loved ones they cannot visit; some, unfortunately, are dying. We watch the graphs and listen to the daily news of new coronavirus cases, but be it just one or one thousand, for the those close of the ones affected, the impact is catastrophic.

The impact of coronavirus, named COVID-19, was rapid in most industries, affecting both supply and demand. Airport Council International (ACI) reported that global air traffic declined at the rate of 2% - 5% in January 2020 compared to previous month. Significantly larger drops are to follow as airlines ground nearly 75% of their fleet due to domestic and international travel restrictions as governments try to contain the spread of coronavirus (Kotoky, Stringer and Saxena, 2020). Similar stories are reported on ground with TomTom live traffic index suggesting that road mobility is down by 75% in some of the world's busiest cities like Milan, Paris, Manchester and Boston (Marchant, 2020).

The world is a different place. Recent studies in psychology post COVID-19 found that people are experiencing higher levels of anxiety, depression and indignation compared to period before the pandemic (Li et al., 2020). What we have come to believe through our previous experiences is being challenged. Dissonance as we struggle to maintain cognitive consistency between what we believe out to be and what the situation demands of our actions (Festinger, 1957). World leaders are facing difficult decisions, trying to reduce cognitive inconsistencies between actions required in their role as heads of state and their own beliefs on the value of human life. Some have argued

ISSN 2183-0606
http://www.open-jim.org

that this is no simple economic trade-off (Cohen, 2020; Mahoney, 2020), and that controlling coronavirus and maintaining economic prosperity are indeed intertwined. Mahoney (2020) goes on to claim that the mere debate of trade-offs in the coronavirus situation is disingenuous. Every event creates new opportunities, besides the challenges. Coronavirus has created unprecedented demand for several products and services from face masks, to ventilators to online and home-delivery. When efforts are put towards these new demands, it not only helps to cope with the health catastrophe but also helps the economy but redirect flow of funds, creating new markets and new job opportunities. Even the government relief incentives to boost economies and support now jobless employees are not a trade-off against productivity. The difference in this situation as compared to other economic events (e.g. the Global Financial Crisis) is that right now we do want people to stay home, which diminishes the value of argument that providing job seeker payments to individuals will affect future productivity. Indeed, our assumption is that a lesson from current coronavirus situations would be that people will become more vigilant of their finances and more appreciative of opportunities that come their way. Perhaps this is just our optimism in an effort to stay positive or perhaps it is a way we are reducing dissonance, MK Gandhi's quote: "It is health that is real wealth and not pieces of gold and silver".

No matter what the personal situation, as a witness of these overwhelming events, one cannot ignore the importance of 'being human'- a notion that involves purposeful actions that conform to the principles of fairness, wellness and integrity. While fairness (being impartial or non-discriminatory) is relative and guided by societal values (Franke, Keinz and Klausberger, 2013), wellness (state of being in good health) and integrity (quality of being honest) are rooted in the inside-out or intrinsic intention-behaviour (Rutter & Quine, 2002).

Our readers who familiarise with Fédération Internationale de Football Association's (n.d.) version of fairness, would know that Winning is not fun if achieved unfairly". This notion of fairness is relatively simple to understand – it is about idea of being true to oneself in this world. The fairness value concept is ingrained in our societies, the feeling of unfairness is something we feel from a very young age. Just think of a case when a kid gets one candy and the other gets two. The one who did not receive two candies may feel it to be unfair in normal circumstances. But what if you told them that the kid who got two candies is sick. Would the kid who felt unfair initially suddenly feel that their dissonance is reduced? Perhaps, since now they have additional information which helps them to reframe the action (Festinger, 1957). The belief of what action is fair gets reframed when survival is at stake, such as in the current world-wide pandemic. Greed emerges as fears of some are recognised as opportunities by others.

The hierarchy of needs proposed by Abraham Maslow and discussed in a Letter from Academia published in the Journal of Innovation Management (Venter, 2016) explains how individuals and even societies can close as greed and self-preservation takes over considerations of fairness. We have recently been witnessing richer bidders getting key medical materials, which were already bought and promised, diverted to higher bidders. However, there is still hope in humanity as examples of innovations that embrace the principles of being human continue to rise. It is clearly a wake-up call for individuals and nations alike. The innovation climate which has been unbalanced before coronavirus with short-sighted willingness to pursue profits against long-term humanistic approach to sustainability is being reshaped. Bureaucracy and closed mindset are being challenged. Open innovation is being promoted to embed trust amongst wide and varied stakeholders, under the premise that ‘trust is the *conditio sine qua non* of any kind of social, business-oriented interaction and cooperation (Salampasis, Mention and Torkkeli, 2015, p. 52). Trust in others being fair drives willingness to contribute by encouraging learning, experimentation and investment in long-term value creation efforts (Dahlander and Gann, 2010). An example of this is the exchange of information and anti-malaria drugs between Indian and US governments in a combined effort to combat COVID-19 pandemic. Open government communities have also been looking at ways to apply principles of transparency, accountability and participation to build trust and promote fairness innovation efforts. Several countries have initiated open platforms to engage world audience through hackathons, whatsapp groups, social media campaigns, social contact tracing technologies and online education, amongst others (see full list by country at: https://www.opengovpartnership.org/collecting-open-government-approaches-to-covid-19/)

Innovation in the COVID-19 times is happening at a rapid pace and in the most inspiring ways. Universities, industry and governments are working together in rapid testing and rollout of innovations, with best available evidence translated into practice within days or even hours. Digital-diagnosing is becoming a routine as medical associations relax the status quo and provide guidance to practitioners on use of online diagnostic technologies (Downey, 2020). The academic community has also been quick to chip in by turning around collaborative initiatives, experiments with emerging technologies and publishing studies at a rapid pace. For example, Australian RMIT University's Health Transformation Lab has partnered with social enterprise MediStays to launch path-breaking accommodation service, connecting patients, families and health workers in times of social isolation. The same university has also begun trials of new type of face mask that can be worn for longer durations by health workers. Likewise, Oxford University's Centre for Evidence-based Medicine has established a COVID-19 evidence service to provide rapid response to primary care questions (see https://www.cebm.net/oxford-covid-19-evidence-service/). European Pharmaceutical industry has banded together as part of the Innovative Medicines Initiative (an EU-wide H2020 Research and Innovation Action, Call 21) to search for vaccines, supply medicines to patients and support government and health systems on the ground. GM, Ford, and Tesla have joint forces and transformed some of their manufacturing capacity to assemble much needed ventilators. Likewise, British Formula 1 team and Dyson are collaborating to redesign the ventilator by reframing the design challenge as one that captures need and speed. Besides these, every day now there are numerous stories of entrepreneurial efforts and innovations emerging, from virtual stylists, apps to encourage good neighbours, to hilarious was of raising money for COVID-19 relief efforts (see full list by industry sector at: https://www.covidinnovations.com/).

Coronavirus COVID-19 is clearly a catalyst of change. But, amidst such rapid change, there lies risks and lessons for future. Foremost risk is that while for most young people engaging online may not be unusual, it perpetuates inequalities in absence of choice for our most vulnerable population - the elderly, disabled and those experiencing poverty or social exclusion. The lesson for innovating firms is that no matter where it is in the digital maturity spectrum, the focus now needs to be on finding new ways to embrace affordance-effectivity fit and creating new products and services by reframing the innovation challenge. Our central message for the innovation community is that traditional ways of framing an innovation problem based on business benefits are no longer sufficient and a humanistic approach is needed. Such an approach has the user at its kernel and is based on the principles of fairness and wellness.

Finally, it seems clear that, for the benefit of all, the pandemic is no excuse to relax core principles of integrity & fair play, for that reason, and in the context of this Journal, we would like to ask our readers and authors of papers under review to give us and reviewers' time. At this point in time, we are not putting pressure on the reviewers, it is likely that many are working from home, with kids around and loaded not only with the usual work, but also having to cope with the home chores. Integrity & fair Play are deeply entwined in JIM's DNA.

Wish you all well. Thank you for your trust and commitment to JIM.

Innovatively yours,

Anne-Laure Mention, João José Pinto Ferreira, Marko Torkkeli

Founding Editors

References

Cohen, J., 2020. 'There's no trade-off between targeting coronavirus and restarting the economy – they're intertwined', Forbes, 26 March, viewed 20 April 2020, https://www.forbes.com/sites/joshuacohen/2020/03/26/tradeoff-between-public-health-measures-targeting-covid-19-and-the-economy-is-a-fa #3f4ec01260d2

Downey, A., 2020. 'GPs urged to go digital to prevent spread of coronavirus', *Digital Health*, 10 March, viewed 20 April 2020, https://www.digitalhealth.net/2020/03/gps-urged-to-go-digital-to-prevent-spread-of-coronavirus/

Dahlander, L. and Gann, D.M., 2010. How open is innovation? *Research policy*, 39(6), pp.699-709.

Fédération Internationale de Football Association's (n.d.). Fair Play. FIFA, viewed 20 April 2020, https://grassroots.fifa.com/en/for-kids/11-for-health/fifa-fair-play.html

Festinger, 1957. *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Franke, N., Keinz, P. and Klausberger, K., 2013. "Does this sound like a fair deal?": Antecedents and consequences of fairness expectations in the individual's decision to participate in firm innovation. *Organization science*, 24(5), pp.1495-1516.

Kotoky,A., Stringer D., and Saxena, R., 2020. 'Two-thirds of the world's passenger jets are grounded amid COVID-19 pandemic: here's what that means', Time, 9 April, viewed 20 April 2020, https://time.com/5823395/grounded-planes-coronavirus-storage/

Li, S., Wang, Y., Xue, J., Zhao, N. and Zhu, T., 2020. The impact of COVID-19 epidemic declaration on psychological consequences: a study on active Weibo users. *International journal of environmental research and public health*, 17(6), p.2032.

Mahoney, N., 2020. 'Don't fall for the false trade-offs of COVID-19 policy', Chicago Booth Review, 26 March, viewed 20 April 2020, https://review.chicagobooth.edu/economics/2020/article/don-t-fall-false-trade-offs-covid-19-policy

Marchant, A., 2020. ‘What can traffic data tell us about the impact of coronavirus?’, TomTom, 17 April, viewed 20 April 2020, https://www.tomtom.com/blog/moving-world/covid-19-traffic/

Rutter, D., & Quine, L. (2002). Social cognition models and changing health behaviours. In D. Rutter & L. Quine (Eds.), *Changing health behaviour: Intervention and research with social cognition models* (p. 1–27). Open University Press.

Salampasis, D.G., Mention, A.L. and Torkkeli, M., 2015. Trust embeddedness within an open innovation mindset. *International Journal of Business and Globalisation*, 14(1), pp.32-57.

Venter, H.J., 2016. Self-transcendence: Maslow’s answer to cultural closeness. *Journal of Innovation Management*, 4(4), pp.3-7.

FIFA: https://grassroots.fifa.com/en/for-kids/11-for-health/fifa-fair-play.html.

Journal of Innovation Management
JIM 8, 1 (2020) 6-12
HANDLE: https://hdl.handle.net/10216/126987
DOI: https://doi.org/10.24840/2183-0606_008.001_0002

Tribal Ethos Favours Self-Transcendence, Within the Tribe

Alfredo Behrens
behrens@usal.es | Global MBA, Universidad de Salamanca, Spain and FIA Business School, São Paulo, Brazil

Letter from Academia

Abstract. Where there is little trust, can there be self-transcendence? Can one strive for openness as well as closeness between tribes? Preference to trust own clan members is much higher among Mediterranean peoples than among Germanic ones. In both Germanic and Mediterranean clusters, trusting behaviours follow culturally determined kinship patterns that are slow to change, so much so that the different Mediterranean and Germanic trust patterns still show between Latin America and the USA. Germanic managerial techniques rest on Germanic trusting behaviours that are relatively lacking in the Mediterranean cluster, among whom Germanic managerial techniques lose efficacy and self-transcendence might be a riskier path to take. Clan-friendly management among Mediterranean peoples, including rewards more readily focused on needs, teamwork and citizenship behaviour, require less controls, bringing about faster alignment and more agile organizations. These reflections are relevant to manage North African migrants into Europe, as they are to manage Latin Americans into the USA.

Keywords. Clans; Trust; Openness; Closeness; Christians; Muslims.

Cite paper as: Behrens, A., (2020). Tribal Ethos Favours Self-Transcendence, Within the Tribe - Letter from Academia, *Journal of Innovation Management*, www.open-jim.org, 8(1), 6-12.

1 Introduction

This article follows an interesting editorial conversation (Mention et al, 2016) and a follow-up by Venter (2017), on the subject of openness and closeness, and variations on the Maslow model extended to self-transcendence, as also appears in the work of Barrett (2014).

The focus here is on the determinants of the workings of generalized trust among European countries and their cultural heirs in the New World (Behrens, 2009) and among Muslims (Majeed, 2017).

The aim towards closeness during the international expansion of corporations leads to the marked preference for hiring in the host country among those whose mindset is closest to those of headquarters, such as English-speaking professionals. However, this strategy amounts to hiring within the "Chinese comprador class" (Behrens, Singh & Bhandarker, 2016). Those professionals are in short supply, pricier and are generally less attuned to the majority in the local market

Openness, on the other hand, would lead managers to favor diversity when building management teams, if lack of trust does not get in the way. However, among the many values that shape attitudes to collaborative work in host emerging markets and southern European ones, generalized trust falls short (Inglehart et al, 2014).

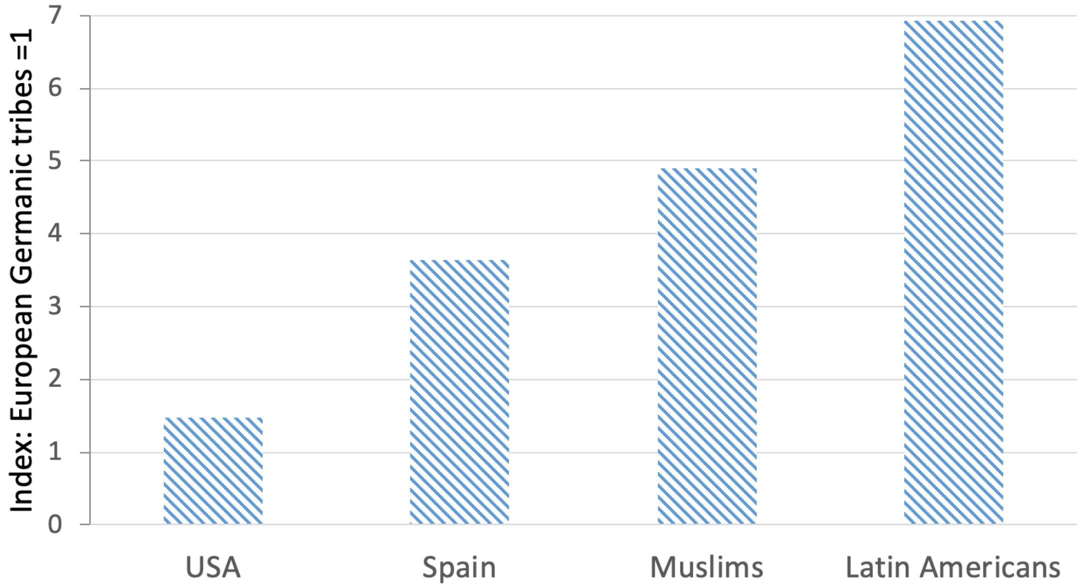
It is safe to say that everywhere collaborative work follows local accepted patterns regarding authority, trust and rewards. The same for companies born in the Mediterranean and Latin American countries: when small they are all managed in tune with local culture in ways that shape their organizational behaviour (Reay, Jaskiewicz & Hinings, 2015). However, as they mature and grow, family firms in these countries face difficulties in the scalability of their organizational forms.

In developing countries, as well as in many countries bathed by the Mediterranean Sea, business lacks a strong base of autochthonous managerial research. The growing firms there are confronted with a relative managerial void other than the predominant one, which originated in Germanic countries and propagated through most business schools, particularly in America, after Talcott Parson´s translation of Max Weber´s work (1927).

The trouble is that among Mediterranean countries, and their cultural heirs in Latin America, traditional authority and ways of doing business does not seem to be a phase but a way of being; not a trait to be superseded, but one that fits the way society is organized. Yet, intellectually colonized, these societies have not come up with a managerial template fitting them. However, Germanic organizational forms and behaviours match poorly the Mediterranean culture, North and southern shores, and result in weak engagement on the part of the workforce, with the consequent waste of their productivity potential.

2 Differences in trusting levels

In particular, clan-based societies have specific forms of socialization that are expressed in the low level of trust given to people outside the clan. On the contrary, in cultures of more indi-



Graph 1. How many more times is trust granted to family members than to outsiders, compared to European Germanic tribes
Source: Author´s own on Wave 6 of World Values Survey data. Graph 1 expresses the result of dividing the shares of replies to V102 "Completely trust the family" by V24 "Most people can be trusted". Latam reflects the average replies of peoples in Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Uruguay. Muslim reflects the average replies of peoples in Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, Palestine, Tunisia and Turkey. Germanic reflects the average replies of peoples in Germany, Netherlands and Sweden. Because of the salience of the USA in producing management techniques, for purposes of illustration, respondents from that country were detached from the Germanic cluster.

vidualistic regions of northern Europe and America, people develop more extended high levels of trust, with important expressions in organizational behaviour, as openness, with the faster integration of outsiders into work teams allowing for greater specialization and mobility, both greatly contributing to high productivity among Germanic cultures. However, the nature of the trust, which underpins Germanic organizational preference, is relatively lacking in Mediterranean cultures, which emphasizes closeness.

In Southern Europe, in much of Latin America, as well as in Muslim countries, widespread trust is lower than in Germanic countries and the USA (Olivera, 2015; Inglehart et al, 2014).

Comparing how much greater is the level of trust in the family vis-à-vis the trust granted to the general public offers an indication of how much more inward-looking, more clan-oriented, a people are when it comes to making themselves vulnerable to the other, i.e. trusting. I illustrate this in Graph 1.

Indeed, Graph 1 points out how much more inclined to trust clan members than outsiders are Muslims, Latin Americans, and the Spanish. The figures suggest that, on average, the inclination

ISSN 2183-0606
http://www.open-jim.org

to trust clan members over the rest is about two to five times higher among Mediterranean peoples than among USA-Americans or those of Germanic cultures.

This is particularly relevant to European countries with strong Muslim residents. Among the latter, there is an important orientation towards trusting clan members over the rest (Mertzanis, 2017). This undermines national social cohesion at host countries (Majeed, 2017) where it also promotes discrimination of Muslims at work (Pierné, 2018). The Muslim challenge to effective management in Europe is likely to increase because of the high influx of Muslim migrants and their initial higher fertility over time (Westoff & Fretja, 2007).

3 Clans, self-transcendence and management

The continued resolution of the conflict between openness and closeness requires that clans be managed in congruence with their culture. Self-transcendence, with its optimism and altruism, is riskier where trust is low, as when one is outside of one´s own culture. The European religious wars of the 17th century offer a pointed illustration of the risk of self-transcendence if one were a Catholic in a Protestant land, or vice versa. Yet, one need not go as far back. It was risky to be a Jew or a Roma in continental Europe under Hitlerism. Referring to Catholic countries by the unsavory acronym, PIIGS (BBC, 2010), or the workings which led to Brexit, or even the lack of a European Union-wide quick response to the Covid1-19 pandemic threat, are more recent expressions of the same difficulty of conceiving self-transcendence across clans when a tribal ethos predominates. The drive towards standardization, so prevalent in the mainstream business community, gives place to nit-picking regulations like determining the sugar content of jam in the European Union (Grice, 2013).

Self-transcendence, as a desirable endeavor, thrives more easily with openness and is more likely within clans. Inside clans, the acceptance of managerial ambiguity regarding goals, rewards and procedures, is possible because of the strong sense of community around which the clans are built - as well as by the intense exchange of information within the clan. Both tolerance and internal cohesion inhibit opportunistic behavior and facilitate cooperation with few objective control mechanisms. The arrangement excludes the need to formalize performance assessments, which, in any case, could hardly be managed in the absence of contractual standards. This is why the organizational forms of the clan generate less incongruity, favoring cooperation (Ouchi, 1980). This is what one sees in large and effective clan organizations in such disparate countries like Brazil and India. There, whether samba schools or dabbawalas, deliver to a high degree of exactness within clan structures, where trust and self-transcendence is high, and granted by recruitment practices based on affinities, such as provided by clans (Behrens, Singh & Bhandarker, 2016).

Where clan attitudes prevail, clan-appropriate management styles may be the shortest, least-cost path to high performance. This would involve recruiting by internal referrals and allowing natural leaders to emerge. These are likely to be more paternalistic than would be acceptable in Germanic or Anglo-Saxon cultures (Behrens, 2010, 2018). Besides, clan-appropriate management is more likely to foster protagonism, altruism, to tolerate non-rational expressions such as religion or idealism in the workplace, and is also more likely to reward for needs as well for behaviours that reinforce cohesion rather than individual contribution to goals. Without trust, self-transcendence might not go very far.

In the eyes of the management advocated in non-clan cultures, with its pragmatic emphasis on procedures over relationships, and on logical and professional individualism, the clan's management will seem irrational and subjective, therefore inadequate and non-functional. However, in clan-oriented societies, where trust towards out-groups is lower, the clan's organizational form, which builds along trust clan lines, should facilitate the alignment of subordinates to their leaders and the faster integration of work teams, generating higher productivity with more joy, building on self-transcendence.

4 Concluding remarks

Germanic business practices might suffocate self-transcendence where it is more likely to appear: in clannish societies. There are two ways to favour the appearance to self-transcendence aims: to improve the match of management to culture and to diminish distrust between clans. I have suggested an Ouchi-based approach to management of clans, as spontaneously practiced in Brazilian samba schools or among Mumbai dabbawalas. To diminish distrust it will take greater advocacy, like the obvious stamping out of insults, i.e. PIIGS, but also finer grained attentiveness, like withholding from attempts to standardization where it might unnecessarily stifle diversity, like regulating on the sugar content of jams across Europe. Still on the issue of advocacy, one could start building less on our differences and more on what we have in common, like love of peace, generosity, fairness, and fulfillment. For instance, children stories have collected the peoples' expectations of good kings, queens and sheikhs; what made them so noble? What can we learn from those stories to put into business practice today? After all, stories shape mindsets and we might not be making the best use of them in a management style that reflects Mediterranean mindsets (Behrens and Medeiros, 2020).

5 References

Barrett, R. (2014) The Values-Driven Organization: Unleashing Human Potential for Performance and Profit. New York: Routledge

BBC (2010). Europe's PIGS: Country by country. http://news.bbc.co.uk/2/hi/8510603.stm. Accessed on February 6, 2020.

Behrens, A. (2009). Culture and Management in the Americas. Palo Alto: Stanford University Press.

Behrens, A. (2010). Charisma, Paternalism, and Business Leadership in Latin America. Thunderbird International Business Review. 52 (1) 21-28.

Behrens, A., Singh, P., Bhandarker, A. (2016). View from Practice: Managing Effectively in Collectivist Societies: Lessons from Samba Schools and Dabbawalas. Thunderbird International Business Review. 60(2) 137-145

Behrens, A. (2018). Gaucho Dialogues on Leadership and Management. London: Anthem Press.

Behrens, A. and Medeiros, I. (2020). A Pig in a Poke Management. Thunderbird International Business Review. https://doi.org/10.1002/tie.22117

Grice, A. (2013) When is jam not a jam? When the EU says is should be a fruit spread. https://www.independent.co.uk/news/uk/politics/when-is-jam-not-a-jam-when-the-eu-says-it-should-be-a-fruit-spread-8536956.html Accessed on February 6, 2020.

Inglehart, R., C. Haerpfer, A. Moreno, C. Welzel, K. Kizilova, J. Diez-Medrano, M. Lagos, P. Norris, E. Ponarin & B. Puranen et al. (eds.). (2014). World Values Survey: Round Six - Country-Pooled Datafile 2010-2014. Madrid: JD Systems Institute.

Majeed, M. T. (2017). Economic growth and social cohesion: Evidence from the organization of Islamic conference countries. Social Indicators Research, 132(3), 1131-1144. doi:http://dx.doi.org.lbs.idm.oclc.org/10.1007/s11205-016-1332-3

Mention, Anne-Laure & Pinto Ferreira, João José & Torkkeli, Marko. (2016). Revisiting Openness: A must for Society. Journal of Innovation Management. 4. 1. 10.24840/2183-0606_004.003_0001.

Mertzanis, C. (2017). Family ties and access to finance in an Islamic environment. Journal of International Financial Markets, Institutions and Money. Volume 48, May 2017, Pages 1-24

Olivera, J. (2015). Changes in inequality and generalized trust in Europe. Social Indicators Research, 124(1), 21-41. doi:http://dx.doi.org.lbs.idm.oclc.org/10.1007/s11205-014-0777-5

Ouchi, W. G. (1980). Markets, Bureaucracies, and Clans. Administrative Science Quarterly, 25(1) 129-141.

Pierné, G. (2018) Hiring discrimination, ethnic origin and employment status", International Journal of Manpower, 39(1) 152-165, https://doi.org/10.1108/IJM-05-2016-0104.

Reay, T., Jaskiewicz, P., & Hinings, C. R. (Bob). (2015). How Family, Business, and Community Logics Shape Family Firm Behavior and "Rules of the Game" in an Organizational Field. Family Business Review, 28(4), 292-311. https://doi.org/10.1177/0894486515577513

Venter, H.G. (2017). Self-Transcendence: Maslow's Answer to Cultural Closeness. Journal of Innovation Management. Journal or Innovation and Management. 4 (2016): 3-7

Weber, M. (1927). General Economic History. Glencoe, IL: Free Press, 1950.

Westoff, C.F. Frejka, T. (2007). Religiousness and Fertility among European Muslims. Population and Development Review. (33)4 785-809. https://doi.org/10.1111/j.1728-4457.2007.00197.x

Biographies

Alfredo Behrens. Behrens, A. Montevideo, Uruguay, 1951. He is also a Brazilian national and holds a Ph.D. granted by the University of Cambridge, U.K. in 1983. He worked on economic development until 2000, having lectured on economic integration at Princeton University (1986-1989) and at Florida State University until 1992, when he joined the World Bank to work on economies in transition. In 2000 he was visiting research fellow at the London Business School, transitioning then to working on cross-cultural management issues. On extended sabbatical from FIA Business School, São Paulo, Brazil, Dr. Behrens currently lectures on Cross-cultural Leadership at the Global MBA with IME Business School, at the Universidad de Salamanca, Spain, where his also coordinates the Soft Skills area at the said MBA and is a member of the advisory council of the Global Studies Think Tank. He published Culture and Management in the Americas at Stanford University Press (2009) and Gaucho Dialogues, with Anthem Press (2018) when, by ILBA (CA) the book was selected to be taken to TV Series. His most recent article is A Pig in a Poke Management, published by Thunderbird International Review (2020) and his most recent book is one for children, entitled Teresa Voa, published by Edições Esgotadas, Porto, 2020. http://www.alfredobehrens.com

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 8, 1 (2020) 13-19
HANDLE: https://hdl.handle.net/10216/126987
DOI: https://doi.org/10.24840/2183-0606_008.001_0003

Analysing the Sentiments towards Work-From-Home Experience during COVID-19 Pandemic

Akash D Dubey
drakashddubey@gmail.com | Jaipuria Institute of Management, Jaipur, Rajasthan, India
Shreya Tripathi
shreyatripathi13@gmail.com | Amity University, India

Letter from Academia

Abstract. With almost one third of the world on a lockdown, the corporates and the offices have now rapidly shifted to working from home. Since no specific treatment has been suggested by any medical institution so far, World Health Organization has recommended that the only possible solution to be safe is to self-isolate and stay home. Due to this, the world has come to a screeching halt and the businesses have to be shifted to remote work. Work-from-Home is a very new experience for most of us and hence the perception of the people ranges from being very excited to very hopeless. This study aims to examine the sentiments of the people regarding Work-from-Home concept by analysing twitter activities posted on social media. Total 100,000 tweets were analysed for this study. Results indicate that Work-from-Home concept was taken positively by the people. The emotions associated with most of the tweets were of trust and anticipation indicating that this concept is being welcomed by the people.

Keywords. Work From Home (WFH);COVID-19; Pandemic; Remote Working; Twitter; Sentiment Analysis.

Cite paper as: Dubey, A., Tripathi, S., (2020). Analysing the Sentiments towards Work-From-Home Experience during COVID-19 Pandemic - Letter from Academia, *Journal of Innovation Management*, www.open-jim.org, 8(1), 13-19.

ISSN 2183-0606
http://www.open-jim.org

1 Introduction

Sars-CoV-2 or 2019-nCoV was firstly detected in the city of Wuhan, China in December 2019 (Chaolin et al, 2020) and since then this disease has been spreading exponentially. While there were 86,604 patients of COVID-19 on 28th February and 858,361 on 31st March, the number has increased to 2,086,477 on 15th April 2020. COVID-19 has affected 210 countries and 2 international conveyance till now.

As suggested by World Health Organization, in the absence of any specific treatment, one of the ways to stop the spread of COVID-19 is self-quarantine and isolation. This procedure was followed by China in the city of Wuhan and 15 other provinces with positive results.

As per the recommendation of WHO, many countries have opted for complete lockdown of the country. India, France, Italy, New Zealand, Poland and UK opted for one of the largest and restrictive lockdowns that world has witnessed. India, a home to 1.3 billion people locked down the country on 25th April 2020 for three weeks which was later extended till 3rd May 2020. Similarly, one of the worst hit country, Italy, has decided to extend the lockdown till 13th May 2020. On the contrary, the worst hit country till now, USA has gone against the complete lockdown.

Since the lockdown has made people stay at home, most of the businesses have been trying to go for Work-from-Home (WFH) concept. To implement WFH concept, several technical platforms are being used to make sure that the efficiency of the employees remain intact. Several IT companies, academic institutions and other industries have gone completely online and the employees are now expected to work-from-home with a different set of rules and regulations that would suit the organizations.

In these changing times, the employees have to shift their modus operandi completely and that may be a reason of concern considering their perception and eagerness to adapt to the situation. To evaluate the sentiments of Work-from-Home concept among the people worldwide, we have collected 100,000 tweets across the world which ranges between 15th March and 15th April 2020. Twitter has been one of the most important social platforms when it comes to information dissemination and self-documentation (Liu, Cheung, Lee, 2010). It has been a medium for millions to express their views on any issues or topics. During previous events of natural disasters, people have used this platform for expressing their feelings (Soriano et al, 2016; Lent et al, 2017; Nair et al, 2017; Fu et al, 2016).

2 Methodology

With a total number of 330 million daily active users, Twitter has found a huge following throughout the world. For this research, we have used the Twitter API for the collection of the tweets over a regular interval of time. In total, we have collected 100,000 tweets worldwide. These tweets either contained the term #WorkFromHome or #WFH.

For the collection of the tweets, RTweet package was used in R. To avoid the duplication of the tweets, retweets were not included in the collection. After the collection of the tweets, the data cleaning was done. During the data cleaning, the white spaces, punctuations and stop words were removed, while covering the whole tweet to lower case. After the data cleaning, NRC Emotion Lexicon (Mohammad SM, Turney PD, 2013) was used for the sentiment analysis to analyse the tweets. For this analysis, Syuzhet package version 1.0.1 (Jockers M, 2017) was used in R. The Syuzhet package classifies the tweets on the basis of sentiments (positive and negative) and also categorizes them into 8 emotions (fear, joy, anticipation, anger, disgust, sadness, surprise, trust). After the scoring process was over, the word cloud was created to analyse the most tweeted words in relation to work-from-home.

3 Results and Discussion

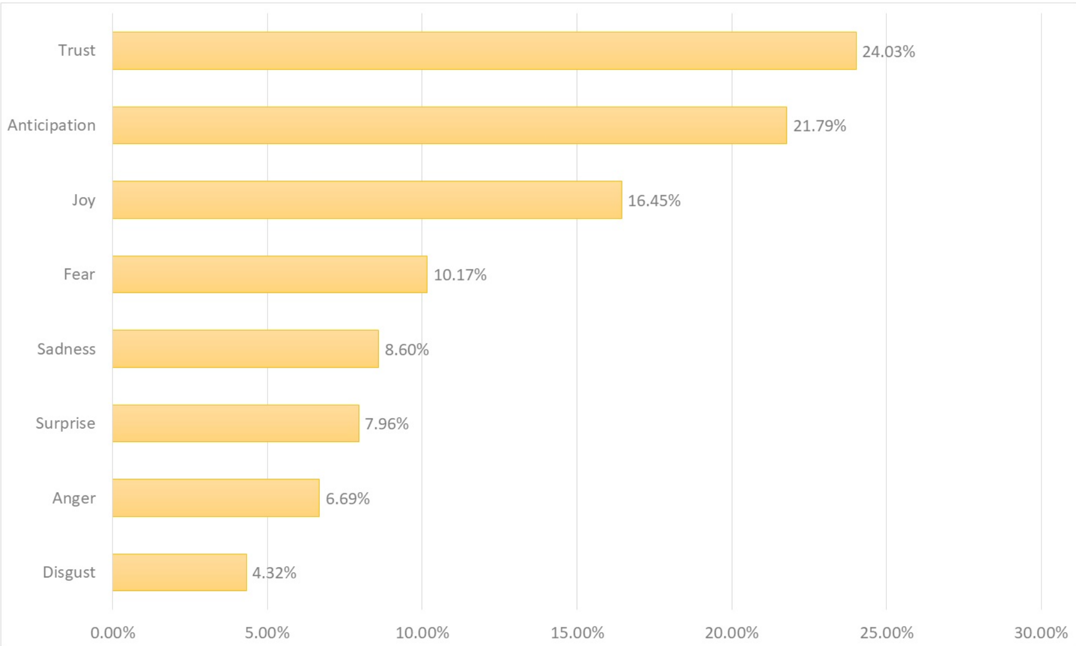


Fig. 1. Sentiment Analysis of Tweets for Work from Home

From the analysis of the sentiments regarding Work-from-Home, it was found that 73.10 % of the tweets had positive sentiments as compared to 26.10% negative sentiments. This signifies that the people had a positive outlook towards the concept of work-from-home. For a more detailed analysis of the tweets, the emotion quotient associated with tweets were analysed. There were total 8 emotions which were evaluated in this analysis which included fear, joy, anticipation, anger, disgust, sadness, surprise and trust.

During the analysis of the emotional quotient of the tweets, it was found that the majority of the tweets across the globe were done with three emotions, Trust, Anticipation and Joy. Figure 1 shows that the tweets with trust emotion were almost one fourth of the total tweets analysed (24.03%). Following the trust emotion was the anticipation emotion which signified that people were looking forward to experiencing Work-from-Home concept. Similarly, the joy emotion was associated with almost 16.45% of the tweets which again strengthens the positive sentiments of the people. Emotions like fear, sadness, anger and disgust had relatively smaller portion of tweets with a share of 10.17%, 8.60%, 6.69% and 4.32% respectively. These results prove that the people had a positive outlook and were looking forward to work-from-home.

For the second phase of analysis, a word cloud was created using the most used words and the emotions that were associated with them. It was found that the word GOOD was tweeted most in context of WFH. As illustrated in figure 2, words GOOD, BREAK and HOPE were used most of the times and related with emotion of surprise. Words like LOVE, SHARE, HAPPY, SAFE and HOME were tweeted frequently with the emotion of joy. Words like TEAM, MANAGE, REMOTEWORK were tweeted frequently with emotions of trust. Words like TIME and START were frequently tweeted with the emotion of anticipation. People also tweeted words like FEEL, BAD and ILL with the emotion of disgust while words like PANDEMIC, ISOLATE and LATE were regularly used with emotions of sadness.

These results signify that majority of the people have a positive outlook towards the work-from-

Fig. 2. Word Cloud of the Tweets related to Work from Home

home experience. These results become more important especially when a report from Gartner stated that 74% CFOs and Finance leaders are willing to shift least 5% of on-site employees to remote work permanently (Lavelle, 2020).

4 Summary

This research work aimed at analysing the sentiments and emotions of the people towards work-from-home concept during COVID-19. During the study, it was revealed that more than 73% people had a positive sentiment towards work-from-home while almost 27% people had a negative perception towards WFH experience. Also, more than 60% of the people tweeted with emotions of trust, anticipation and joy for work-from-home culture while a few tweeted with fear, sadness, anger and disgust. From the obtained results, it can be concluded the work-from-home experience had a positive perception worldwide. Since the tweets collected were in English, it might be a limitation of the study.

For future works, this study can be used to analyse the changing emotions and sentiments of people and check whether there are major shifts in them over a period of time.

5 References

Coronavirus Update. Accessed 20th April 2020. https://www.worldometers.info/coronavirus/.

Fu, K. W., Liang, H., Saroha, N., Tse, Z. T. H., Ip, P., & Fung, I. C. H. (2016). How people react to Zika virus outbreaks on Twitter? A computational content analysis. *American journal of infection control*, 44(12), 1700-1702.

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., & Cheng, Z. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet, 395(10223), 497-506.

Jockers, M. (2017). Introduction to the Syuzhet package. Accessed 15th April 2020. https://cran.r-project.org/web/packages/syuzhet/vignettes/syuzhet-vignette.html

Lavelle, J., (2020) CFO Survey Reveals 74% Intend to Shift Some Employees to Remote Work Permanently. Gartner. Accessed 20th April 2020. https://www.gartner.com/en/newsroom/press-releases/2020-04-03-gartner-cfo-surey-reveals-74-percent-of-organizations-to-shift-some-employees-to-ren

Liu, I. L., Cheung, C. M., & Lee, M. K. (2010). Understanding Twitter Usage: What Drive People Continue to Tweet. *Pacis*, 92, 928-939.

Mohammad, S. M., & Turney, P. D. (2013). Crowdsourcing a word–emotion association lexicon. *Computational Intelligence*, 29(3), 436-465.

Mohammad, S. M., & Turney, P. D. (2013). Nrc emotion lexicon. *National Research Council*, Canada.

Nair, M. R., Ramya, G. R., & Sivakumar, P. B. (2017). Usage and analysis of Twitter during 2015 Chennai flood towards disaster management. *Procedia computer science*, 115, 350-358.

Soriano, C. R., Roldan, M. D. G., Cheng, C., & Oco, N. (2016). Social media and civic engagement during calamities: the case of Twitter use during typhoon Yolanda. *Philippine Political Science Journal*, 37(1), 6-25.

Van Lent, L. G., Sungur, H., Kunneman, F. A., Van De Velde, B., & Das, E. (2017). Too far to care? Measuring public attention and fear for Ebola using Twitter. *Journal of medical Internet research*, 19(6), e193.

Biographies

Akash D Dubey. Dr Akash D Dubey has completed his PhD from Indian Institute of Technology, BHU, India in Artificial Intelligence and Robotics. He is currently working as an Assistant Professor at Jaipuria Institute of Management, Jaipur, Rajasthan, India. Prior to Jaipuria, he has worked as Assistant Professor at Fiji National University in Fiji for four years. He has written several reputed international research articles and international conferences. Dr. Dubey has conducted many workshops and seminars in Fiji and India. His research interest area includes Artificial Intelligence, ICT in education, Social Media and Computational Intelligence.

Shreya Tripathi. Ms Shreya Tripathi is currently pursuing Master in Business Administration from Amity University, India. Her specialization for MBA is Human Resources. Ms Tripathi has completed her Bachelor in Commerce from Allahabad University, Allahabad, India. Her research area includes Talent Acquisition, Training and Development, Business Law, Entrepreneurship, Economics, Commercial Studies and Performance appraisals.

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 8, 1 (2020) 20-38
HANDLE: https://hdl.handle.net/10216/126987
DOI: https://doi.org/10.24840/2183-0606_008.001_0004
SM: Oct/2019 AM: Jan/2020

Fostering Soft and Hard Skills for Innovation Among Informatics Engineering Students – an Emancipatory Approach

Manuel F. Torres
mfirmino@fe.up.pt | Department of Informatics Engineering, Faculty of Engineering University of Porto. INESC TEC - Institute for Systems and Computer Engineering, Technology and Science. Rua Dr. Roberto Frias 4200-465 Porto, Portugal
Nuno Flores
nflores@fe.up.pt | University of Porto - Faculty of Engineering & INESC-TEC
Raquel T. Torres
raquelttorres@gmail.com | Manuel Firmino & Associados, Lda.

Abstract. Informatics engineers are currently in the spotlight of innovation. It is, therefore, relevant to analyse and reflect on how higher education can, and should, prepare future engineers to innovate as expected in this ever-changing world. This paper aims to further research and foster scholarly debate regarding the requirements and implications of teaching innovation. For that purpose, we examine an exploratory case study on interdisciplinary cooperation between two higher education courses, designed to promote students' active learning of innovation through the progressive development of their soft and hard skills. Both courses engaged in an emancipatory pedagogical approach, mostly grounded in project-based work, active learning, and formative assessment. To obtain feedback on this interdisciplinary cooperation, questionnaires were devised to ascertain the students' perceptions about this pedagogical approach. Individual responses were collected from both courses and data was analysed through simple statistical procedures. Articulating *a priori* soft skills development with *a posteriori* hard skills learning process is perceived by students as beneficial in gradually, yet successfully, understanding the subject of innovation. Also, there were even some external success indicators which showed the recognition of successful innovation skills development in informatics engineering students. Thus, according to students' perceptions of their experience with an emancipatory pedagogy that connected soft with hard skills development, we conclude that such approach encouraged students to create new knowledge and allowed them to develop the necessary skills to innovate.

Keywords. Informatics Engineering; Innovation, Soft and Hard Skills; Emancipatory Pedagogy.

Cite paper as: Torres, M., Flores, N., Torres, R., (2020). Fostering Soft and Hard Skills for Innovation Among Informatics Engineering Students – an Emancipatory Approach, *Journal of Innovation Management*, www.open-jim.org, 8(1), 20-38.

1 Introduction

Over the past decades, technological advancements have been shaping the world and changing our lives, allowing innovation to develop at an increasingly fast pace and creating countless opportunities. Currently, technology is widely recognized as a major driver of innovation and, in turn, innovation is considered crucial for professional success.

Many of these technological advances are being made by engineers, putting them into the spotlight of innovation. Informatics engineering, as a domain of knowledge, is at the core of most, every day, technological software applications, ranging from web browsers to very large-scale banking systems. Software is omnipresent in our lives, and we carry it with us everywhere. Specialists and expert professionals are, and have been, in high demand by the industry (EuroStat, 2017), with procurement rates showing no signs of diminishing in the years to come (EuroStat, 2016).

In addition, "the requirements of twenty-first century engineers are considerable: engineers must be technically competent, globally sophisticated, culturally aware, innovative and entrepreneurial, and life-long learners" (Liebenberg & Mathews, 2012, p. 93). Today, the EUR-ACE[1] standards and guidelines for accreditation of engineering university degrees define programmes outcomes according to eight learning areas – knowledge and understanding; engineering analysis; engineering design; investigations; engineering practice; making judgements; communication and team-working; and lifelong learning. This recognizes their professional competence as a complex array of knowledge and skills, reaching far beyond technical (also known as hard) skills.

Within this context, and because "educators are further challenged to teach "soft" (social) skills within computing courses" (Exter & Turnage, 2012, p. 3), Faculty of Engineering University of Porto created Personal and Interpersonal Proficiency course (PIP), addressed at fostering the development of soft skills among undergraduates on a Masters' Degree in Informatics and Computing Engineering[2]. Additionally, this Masters' curriculum includes Software Development Laboratory course (SDL), focused on the improvement of hard technical skills, where students learn to define and apply a software engineering process. In conjunction, both courses are designed, respectively, to promote the development of the soft and hard skills required for academic and professional activity in informatics engineering.

The importance of combining both hard and soft skills together has, for some time now, been demonstrated as a vital component for professional competence (Kauffeld, Grote & Frieling, 2003). This entails an indissociable interdependence of these competences for the successful performance of future informatics engineers.

Specifically, the need for soft skills is quite evident, considering that, for more than 40 years, the German Engineering Association has recommended that 20% of all courses in the engineering

[1] EUR-ACE accreditation system for quality standards in engineering programmes, which belongs to the European Network for Accreditation of Engineering Education.

[2] This is an Integrated Masters' degree program, which results from combining a graduate degree, done in the first three years of university enrollment, and a masters' degree, achieved in the next two years. Thus, these students are called "undergraduates" throughout their enrollment in the Masters' Degree in Informatics and Computing Engineering.

curricula should be about soft skills. Moreover, "soft skills are behaviours that must be internalized as a natural aspect of a person's repertory of social skills and character attributes" (ODEP 2010, p. 1), and they are increasingly critical in today's complex business environment. This has led employers to shift their focus towards greater coordination and communication needs from their collaborators, thus giving a greater relevance to soft skills when hiring (Firth, 2011). Hence, to maximize the chances of success for these future informatics engineers, the authors believe that "while professional skills may open the door of opportunity, soft skills keep them in the driver's seat" (Kaipa, Milus, Chowdary & Jagadeesh, 2005, p. 1).

Interacting with and observing students, the authors discovered that students usually took advantage of a certain continuity between the two mentioned courses, namely in the elaboration of innovation projects. Informally and through their own initiative, several students started using PIP course output as SDL course input, achieving very good results, as they were able to produce more structured and relevant innovation projects but with a lower academic workload. These informal observations encouraged the teachers/authors to: (1) set up a collaboration protocol, focused on boosting students' active learning of innovation, and (2) launch an interdisciplinary supervision based on an emancipatory pedagogical approach, providing stronger on-going support to students. This interdisciplinary cooperation increased the relevance, feasibility, and quality of the innovation projects and, foremost, allowed for students to autonomously develop their knowledge and skills relating to innovation.

The uniqueness of this interdisciplinary cooperation justified an exploratory and descriptive case study to better understand how and why students were so motivated to link soft with hard skills to successfully learn about innovation. The present article introduces and discusses this case study, which sought to systematically ascertain students' perceptions about the impact of this interdisciplinary cooperation on the development of their innovation projects. It serves to help further analyse and reflect about how higher education can, and should, prepare future engineers to innovate, as expected in the professional world. In the following sections, a literature review on innovation and skills is presented, and then a description of the interdisciplinary cooperation protocol, along with the pedagogical approach used. A small-scale study on students' perceptions is presented, and its findings are discussed in order to identify the specific contributions for the research and practice of teaching innovation in informatics engineering higher education programmes. As the aforementioned Master course is, foremost, based on the scientific and technological education of undergraduates, the authors believe that the affordances of this case study will be useful as an example of successful teaching of innovation in a science and technological educational context.

2 Innovation and skills

Innovation happens when someone successfully identifies and exploits a new idea (Tether, Mina, Consoli & Gagliardi, 2005) and "depends on people who are able to generate and apply knowledge and ideas in the workplace and in society at large" (OECD, 2011, p. 9). Today, innovation is a well-known and widely recognized concept. However, it still remains rather complex and controversial, namely when it is linked with entrepreneurship, the latter defined as the generation of value by exploiting new products, processes, or markets (Ahmad & Seymour, 2008). More precisely, "entrepreneurship is a way of thinking, reasoning, and acting that is opportunity obsessed, holistic in approach, and leadership balanced for the purpose of value creation and capture" (Timmons & Spinelli, 2009, p. 101).

Consequently, over the past decades, many authors have attempted to understand the connection between entrepreneurship and innovation. Some have even referred to these concepts as inextricable, describing entrepreneurs as innovators "who take advantage of change", or entrepreneurship as an "act of innovation". In this context, Zhao (2005) suggested that entrepreneurship and innovation overlapped. Both were positively related, complementary, and equally necessary to succeed. He proposed that innovation is a tool for entrepreneurship to exploit change and that entrepreneurship is the organizational behaviour related to change and innovation. The present paper adopts this approach, perceiving innovation as one of the main drivers of entrepreneurship.

It is also important to highlight that innovation is not automatically produced by scientific and technical knowledge since "some of the crucial elements that 'translate' knowledge into innovation are the ways in which skills and expertise are developed and used by individuals" (Borrás & Edquist, 2015, p. 215). This perspective is strengthened by the growing emergence of new models of innovation. As explained in the Centre for Research on Innovation and Competition report:

"In the older models of (technological) innovation, such as the 'science push' model of Vannevar Bush, the skills to 'produce' innovation are the degree and higher-level science and engineering skills of a small head or elite in the organisational hierarchy. More recent models of innovation, such as the 'systemic integration' model, allow for more democratic, distributed sources of innovation, involving the skills of the whole workforce. In particular, this model says all workers should have basic 'platform' skills that allow them to be adaptable to changing circumstances and more open to new ideas to be innovative." (Tether et al., 2005, p. 6)

This posed a challenge to the educational system because there is no specific skill set that can ensure innovative performance. Instead, the demand for skills is defined by innovation type and context (OECD, 2011; Tether et al., 2005). This challenge has been increasing alongside the growing concern with the existing "skills mismatch" between education and work (Cinque, 2016; Cobo, 2013; Coll & Zegwaard, 2006; Quintini, 2011). Innovation is, inevitably, added to the agenda of many prompting political endeavours and international initiatives, focused on aligning the educational supply of skills with labour market demand. Among these initiatives, and together with scientific research, there is a shared perspective of the importance and shortage of soft skills in employability in general, and especially in innovation and entrepreneurship. As stated by Passig and Cohen (2014), "for an organization to realize and execute innovative ideas it needs communication, networking and teamwork skills, as well as motivation" (p. 63), which many organizations find they are lacking.

Soft skills are frequently associated with social, transversal, or generic skills, and, although it is difficult to achieve a clear and simple definition (Cimatti, 2016), they are referred to as "twenty-first century skills", "key competences" or "skills for social progress" (Cinque, 2016). Additionally, our literature review has shown that it is common (and more helpful) to define soft skills in comparison to hard skills. Thus, according to Chell and Athayde (2011), hard skills are based on high levels of expertise relating to specific knowledge and technical content, whereas soft skills are composed of behaviours and attitudes that are acquired through experience. Likewise, Cimatti (2016) describes hard skills as the necessary capacities to perform a particular job and soft skills as the interpersonal skills required at performing all jobs. As such, soft skills can be transversal, and thus, transferable (or applicable) to all contexts and types of innovation, while "give[ing] hard skills the required plasticity to develop and keep up-to-date in changing circumstances" (Cimatti, 2016, p. 99).

Hence, it is not easy to draw a line between soft and hard skills. Even though they are complementary (Borrás & Edquist, 2015) and both are required to perform a task, its development in an individual is only effective when they are integrated (Cimatti, 2016). Therefore, "it is now common to view cognitive and behavioural skills as complementary with successful individual performance requiring both types of skills" (Coll & Zegwaard, 2006, p. 32). When addressing innovation and entrepreneurship, these are no exception, as they engage and depend upon both hard and soft skills. Moreover, "successful software development today is therefore as much about the social and team aspect as it is about the process and technology" (Gotel, Scharff & Kulkarni, 2012, p. 199).

Given the stated commitment to gathering evidence for the aforementioned relationships between soft and hard skills, the authors designed a case study to ascertain these findings in an academic, technological, educational context. This case study relied on a pedagogical methodology focused on promoting the active learning of innovation among informatics engineering students. Through a progressive development of their soft and hard skills, students were able to gradually explore and learn about the complexities of innovation and entrepreneurship, while successfully developing a software product. Aimed at providing an effective engineering education process for innovation, this case study is detailed and analysed in the next section.

3 Description of the case study

The case study focused on the establishment of a cooperative protocol between two distinct academic courses. Thus, a single case study is reported here, which is "appropriate when the case is special (in relation to established theory) for some reason. This might arise when the case provides a critical test to a well-established theory, or where the case is extreme, unique, or has something special to reveal" (Rowley, 2002, p. 21). This was an exploratory and holistic case study that "examine[s] the case as one unit" (*idem*, p. 22) allowing the authors to research a phenomenon that is implicitly indissociable from its specific context (Teegavarapu, Summers & Mocko, 2008).

This section begins by explaining the details of this protocol, along with the description of the contents and learning objectives of both courses. To support the active learning of innovation, the students were engaged in a common emancipatory pedagogical approach, the framework of which will also be detailed.

3.1 Connecting soft and hard skills to boost students' innovation

As previously stated, innovation is, now more than ever, paramount in informatics engineering. Entrepreneurship and innovation should, thus, play a crucial role in the curriculum of higher education course programmes. As a result, as part of the Master's degree in Informatics Engineering from Faculty of Engineering University of Porto, the promotion of entrepreneurship and innovation is identified as a general goal that should be fostered across course units.As collaboration among course units is encouraged, the Master's programme enabled the required cooperation between PIP and SDL. Enrolled students could, thus, progressively develop the necessary soft and hard skills, towards a successful outcome of their innovation projects.

This cooperation allowed the authors to overcome the traditional division (supported by the literature) between stand-alone approaches (implying the creation of a specific course for the development of innovation skills) and embedded approaches (which entails that these skills should be developed across the curriculum) (MacVaugh, Jones & Auty 2014; Robley, Whittle & Murdoch 2005; Simatele 2015). Accordingly, these skills are successfully taught, if integrated and contextualized. This

"means that learners are taught skills in an overt and transparent way that arises out of and is integrated with disciplinary knowledge. Thus, learners are given the opportunity first to understand the skills, and then to enact them in real and meaningful tasks" (MacVaugh, Jones & Auty, 2014, pp. 768-769).

Likewise, the Accreditation Board for Engineering and Technology (ABET)[3], endorses in Criterion 5, that the curriculum must culminate in a "major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work" (ABET, s/d), promoting thus embedded approaches to curriculum.

The two courses involved in this study are detailed next, followed by a clarification about the pedagogical approach which was adopted to foster the active learning of innovation among informatics engineering students.

3.2 Personal and Interpersonal Proficiency

This course aims to prepare students to successfully use their personal and interpersonal skills in informal situations, as well as in academic/professional contexts. The knowledge and skills acquired during this course were organized according to three main areas: personal and professional attitudes (including e.g., micromarketing, time management, creativity); interpersonal attitudes (involving e.g., communication, assertiveness, teamwork); and understanding organizational and societal contexts (entailing e.g., customer service, meetings, team management). The main objectives of this course are:

- To identify and acquire the basic knowledge on how to progressively maximize the successful conditions of the personal and interpersonal performance.

[3] ABET is an accreditation system that defines quality standards to uphold within university programs in science, technology, engineering and mathematics (STEM) in the United States and abroad.

ISSN 2183-0606
http://www.open-jim.org

- To apply self-control techniques and strategies of interpersonal relationships, as to allow a skilful management of (1) the efficient implementation of work processes within an organization and (2) the effectiveness of its outcomes.
- To be aware of the importance of knowing how to use soft skills, and to perform personal growing changes in order to develop a professional profile, thus enhancing the future performance of the informatics engineer.

Teaching soft skills requires the use of several pedagogical methods (expositive, interrogative, demonstrative, and active) and practical activities (case analysis, training exercises, and so on). In these classes, students are grouped into teams and invited to develop an innovation project. The project theme must be constrained to the Master's scope, but should address the student's personal interests, and be applicable in their professional future.

These team projects give students the opportunity to explore some basic principles about innovation and entrepreneurship, ranging from creating innovative hypotheses with added value to organizations, to analysing the relevance/feasibility of the project design/implementation. Such matters are thoroughly debated in class, involving, not only the team members, but all the students and teachers. Discussion focuses on, for example, conditions to generate technologically innovative hypotheses, conceptual aspects and practical procedures on projects development, or possible impact of the projects' application in the social context. This project-base work intends to give, to a heterogeneous group of students, an opportunity to manage a tailored, self-paced development of the set of skills which are required of an innovative engineer. These include, among others, creativity, communication, gathering and analysis of data, information organization and processing, business pragmatism, collaboration/teamwork, time management, and critical thinking.

The development of these projects is also followed-up through team meetings with the course teachers, who "acted as facilitators of the process, and encouraged students to be creative and innovative" (Chang, Benamraoui & Rieple, 2014, p. 461), thus engaging them in active learning. For this pedagogical approach to be successful, it was necessary to align project-based work and active learning strategies with the adequate formative assessment procedures. This required surpassing "assessment of learning" to invoke also assessment "for and as learning" (Torres & Leite, 2014). Hence, a strong formative assessment component supported students' elaboration of the innovation projects based not only on teacher assessment, but mostly on peer and self-assessment. Teams were subject to weekly briefings where, together with the rest of the class, they debated and questioned the innovativeness, feasibility and relevance of their projects. This approach creates a favourable environment for continuous peer and self-assessment, and the means to promote feedback, coaching, and critical thinking. Additionally, these briefings served to promote cooperative learning, encouraging students to learn from/with each other and to reach further in solving complex life problems (Cinque, 2016).

It was also a requirement that students must produce two deliverables on their innovation project: (1) a written report and, (2) an oral presentation, supported with audio-visual materials, as a means to enhance students' communication skills (written, oral, and graphical) of complex ideas. Grades were established by combining individual in-class performance with teamwork effort in the development of the project and its deliverables. Both deliverables and feedback on the developed innovation projects were later used by students as input for SDL.

3.3 Software Development Laboratory

This course unit implies that after completing the three first years of the Master's programme, students have acquired sufficient technological knowledge and theoretical background to cope with the challenge of developing a full-fledged, real life software project. Hence, SDL goal is to allow students to apply a software engineering process that enforces the complete development of a real software system. As an outcome, students should become capable of defining and applying a development process, using agile practices and typical software development tools, while working as a team.

In software engineering, agile practices are a set of lightweight techniques that improve the software process by embracing the relative changing nature of software (Martin, 2013). Nowadays, software changes very rapidly, even during development. Time-to-market is ever decreasing and what stands today may not tomorrow. Therefore, the learned software process must be ready to cope with change, which may come when least expected.

Consequently, software engineers have evolved from adopting a more traditional, waterfall-like, sequential phased process of developing software, towards a more agile, sprint-like, iterative process (Davis, 2012). Software development goes through a series of phases, namely requirements elicitation, design, implementation, testing, and delivery. In a waterfall process, these phases are sequentially executed to completion, where one phase must finish before the next one starts (thus the waterfall analogy). If something changes (e.g., the scope of product changes, errors in the software are found, and so on), it likely forces going back to a previous phase of development. The further back the developer needs to go, the more costly it becomes (Sommerville, 2015).

Due to the increasing volatility of software, the development paradigm has shifted to a more agile process. Instead of handling the full scope of the software product in one single run, the developer divides the scope into smaller minimum viable product partitions, asking the customer to sort them in a most-valuable-sooner fashion. The most valuable scope is then developed first, going through all the phases in a small, fast iteration, where it becomes less costly to incorporate changes that might occur. The final product is, thus, iteratively and incrementally developed to full scope. This partitioning into smaller iterations, and release of a fully functional, partial software product, enables customer feedback sooner and allows for a cost-effective introduction of changes to the software product specifications (Shore, 2007).

Being a course with a strong laboratorial component, its few theoretical classes are used to briefly introduce specific tools or practices that will be used throughout the course and present the overall coordinative structure and role distribution between students and teachers. Most of the laboratory classes, besides project development, are used to monitor progress, review, and improve process quality and to overcome technological obstacles.

The students establish autonomous, self-manageable, self-sustainable working teams that will be responsible for the project development. The teacher, to some extent, supervises the team,

ISSN 2183-0606
http://www.open-jim.org

but they have a considerable degree of liberty to make their own decisions, manage risks, and handle accountability. The team is responsible for planning iterations, setting product goals, distributing member roles, assigning tasks, choosing technologies and tailoring the development process to cope with the project specifics. The iterative nature of the development process allows for a periodic self-assessment of progress. This is done by retrospectively evaluating how the team fared during the previous iteration and on this basis, proposing improvements to uphold in the next iteration. Overall, the project development is divided into five iterations:

- Iteration 0, week 1 to 5 – this first iteration is termed kick-off. The longer duration comes from bootstrapping the project. Here, existing projects that (eventually) migrate from PIP are matured and converted into software development projects. Activities range from refining requirements with real life customers and stakeholders, to choosing suitable technologies and producing a functional vertical prototype of the final product.
- Iterations 1–4, week 6 to 13 – after week 5, product development starts, divided into two-week iterations, where the teams are expected to incrementally produce the defined final software product. Process maturity is self-assessed by the teams and monitored by the teachers, as well as project tracking and management.
- Finale, week 14 – by week 14, the final product is released, and all process related deliverables (source-code, documentation, technical reports, video pitch, and so on) are completed. A public event is held for demonstration of the products, in order to evaluate the idea, concept, and solution from a client's perspective.

These iterations, together with individual assessment and the website of the project/product, are the final graded components. Assessment is conducted throughout the course unit, by presenting the students with a set of specific goals and metrics they should achieve, and upon which they can make self-assessment. In addition, the technological platform for producing and managing the project deliverables allows for continuous feedback in terms of quality and content assessment.

3.4 An emancipatory approach to innovation in engineering

Although recognizing the strong interdependency between soft and hard skills, PIP and SDL are very divergent in content, with each mainly focusing on one type of skill. However, these two courses share a common pedagogical approach strongly established upon team project-based work, and sustained on the assumption that "for learning [how] to solve large engineering problems, project work seems to be more suited, because the time-scale and the range of activities of project work more adequately map reality" (Perrenet, Bouhuijs, & Smits 2000, p. 351). This teaching methodology requires students to learn by doing (Dewey, 1956) and, consequently, to actively engage with innovation, as stated by the literature (Balan & Metcalfe, 2012; Chang, Benamraoui & Rieple, 2014; Chang & Rieple, 2013; Karim, 2016; Pittaway, Hannon, Gibb & Thompson, 2009; Rasmussen & Sørheim, 2006).

Additionally, the cooperation between the two courses is driven by a strong concern for the constructive alignment of teaching methods and learning strategies, together with the selected assessment procedures (Biggs, 1999; Torres, 2013), to pursue the intended pedagogical aim of guiding students to evolve into knowledge production (via project-based work, active learning, and formative assessment). The authors believe that adopting an emancipatory pedagogical approach may have facilitated students to transpose the produced knowledge and the developed skills from PIP to SDL.

Feedback from students in both classes steered the research towards a more rigorous analysis of the importance of the connection between soft and hard skills in improving the active learning of innovation. It appeared that students enjoyed the soft skills preparation for hard skills development, which, in turn, allowed them to innovate more effectively, and sequentially evolve from idea to project and from project to business (product/service). Encouraged by these findings, a small-scale study was designed to ascertain students' perspectives about this possible advantage of connecting prior soft skills development with hard skills learning, in gradually promoting an innovative competence among engineering students.

4 Study Design

This exploratory case study was initially based on the direct observation of students', complemented by documentation analysis. Having insufficient data sources for a more thorough analysis, there was the need for more systematic data collection. Hence, to more rigorously capture students' awareness on the benefits of combining skills from both PIP and SDL courses, a questionnaire survey was developed (based on informally obtained feedback from students), with the intent to present these ideas to all the enrolled students' population. Thus, the devised questionnaire addressed issues regarding the course cooperation, innovative product development, and success metrics. The expected outcome was to ascertain students' perceptions about the benefits brought by the cooperation established between both courses, mainly in terms of innovation and entrepreneurship active learning. This section now details the study and presents the attained results.

4.1 Participants

The 2016 population of enrolled students in both courses was approximately 250 students. All students were invited to voluntarily participate in the study, from which a convenience sample of 70 individual responses was obtained.

4.2 Procedures

All enrolled students were asked, by email, to answer a short online questionnaire and were informed that all data would remain confidential. Collected responses were analysed through the generation of means and standard deviations.

4.3 Instrument

The questionnaire consisted of three Likert scale items (ranging from 1 – "I completely disagree" to 5 – "I completely agree"), a success metrics question, and a final, free text question. As noted above, these questions were inspired by informal feedback from students, and provided a more rigorous and systematic verification of student perceptions.

5 Results

This section presents the results from student answers to the questionnaire. The results are briefly presented and discussed in order to gather evidence for the validation of the initial propositions.

5.1 Question #1

The cooperation between PIP and SDL courses fosters the development of "soft skills" (personal and interpersonal competences) and "hard skills" (software development technical competences) essential to the development of innovation projects.

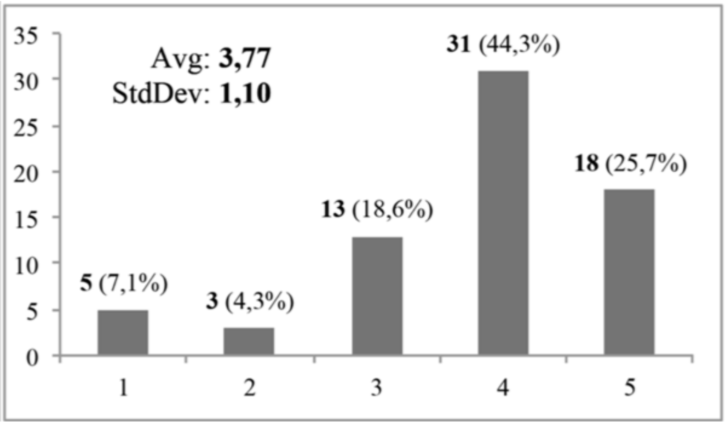


Fig. 1. Question #1 results.

Question #1 is quite straightforward, directly asking if the cooperation between PIP and SDL courses is perceived as valuable for the development of innovation projects. As seen in Figure 1, an average rating of 3.77 corroborates the assumption that it is indeed so, as most respondents (70%) agreed with the presented statement, whereas only a minority (11.4%) disagreed.

5.2 Question #2

These "soft skills" and "hard skills" are predecessors of innovation and entrepreneurship, in the sense that they promote the ability to evolve an idea towards a project, and a project towards a product.

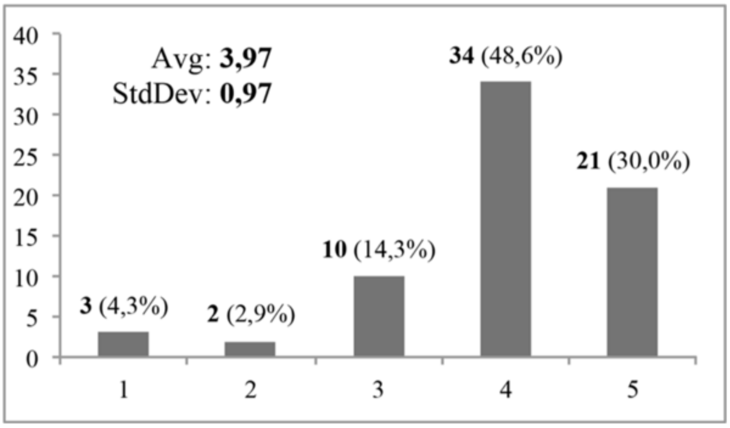


Fig. 2. Question #2 results.

Question #2 tried to ascertain if the conjunction of both soft and hard skills is perceived as means to make an innovation project feasible by providing tools to make an idea evolve towards a final product or service. Again, as seen in Figure 2, a meaningful majority of the respondents (78,6%) agreed with this statement, whereas a slight minority (7.2%) disagreed. The average score of 3.97 substantiates the conclusion that most students perceived this skill combination as valuable for the development of innovation projects.

5.3 Question #3

The sequence of PIP and SDL courses stimulates, first, the improvement of (inter)personal competences – like team work, presentation techniques, critical thinking, and so on – and, second, the application of technologies together with agile software development methodologies, thus assuring the production of quality software. This pedagogical sequence proves indispensable to the materialization of the several innovation projects.

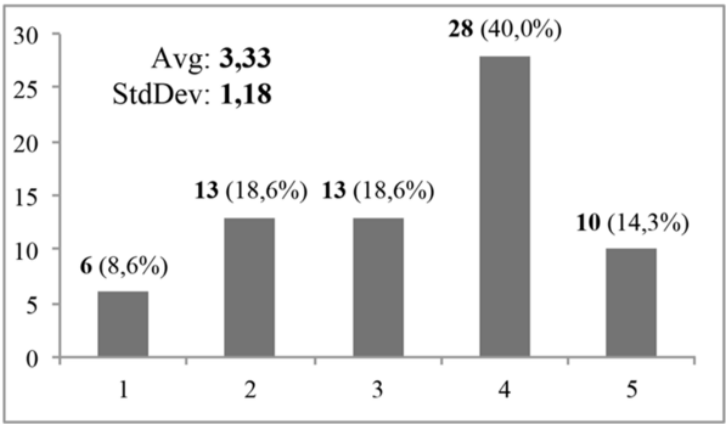


Fig. 3. Question #3 results.

Question #3 intended to emphasize the pedagogical sequence between the PIP and SDL courses, addressing the development of soft skills first and hard skills next. It is important to ascertain if, beyond the cooperation between the two courses, the sequencing is perceived as appropriate. Figure 3 shows that, although more balanced than the previous questions, most respondents (54.3%) agreed that the existing sequencing was appropriate and relevant to the effective and sustainable development of innovation projects, while only a minority (27.2%) disagreed. The average score of 3.33 supports the premise that students perceived tackling soft skills prior to hard skills as beneficial in coping with the development of innovation projects.

5.4 Question #4

Considering the innovation project(s) in which you have participated, please indicate which success indicators it achieved:

- Commercial interest (CI): buying/acquisition proposal
- Spin-off feasibility (SO): self-investment, third-party investors, incubators, and so *on.*
- Scientific publication (SP): journal, conference, workshop
- Public recognition (PR): award, merit distinction, media coverage, contests, and so on.
- Release of product/service (RP): incorporation/integration/cooperation with other products/services, donation to institutions, and so on.
- Other success indicators (OS)

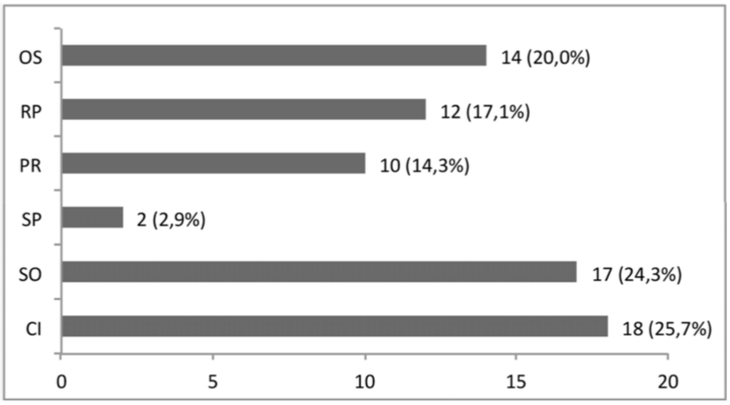


Fig. 4. Question #4 results.

Question #4's purpose was to gather data on the level of success achieved by the innovation projects that students were engaged in while attending PIP and SDL courses. Success metrics were divided into six categories, ranging from commercial or investment interest on the product, to public or scientific recognition on the value of the product. As seen in Figure 4, for those projects that had any measure of success, it mostly involved that of commercial interest (25.7%) or establishing a business or company to promote/market/evolve the product (24.3%). With slightly less predominance but still of relevance, some projects became an integrant part of other larger products or the rights released for public use (17.1%), while others were awarded for the innovative features or attraction of media attention (14.3%). These indicators show that the success achieved by our students in their innovation projects represent the external recognition of their creative and effective solutions, as well as their authorship.

5.5 Question #5

After concluding both PIP and SDL courses, have you any knowledge of any other innovation project (in either industry or academia) that might have benefited from the skills acquired from these courses? If so, describe it briefly.

Question #5 intended to sample to what extent the competences acquired during PIP and SDL courses went beyond the context of both courses, and what perceived impact the students had of their value in other projects. Although the number of affirmative responses was low (i.e., ten), most referred to projects developed within another course which was part of the Master's program. In this course, real industry companies and stakeholders "hire" small virtual tech companies, composed only of students, for development of real projects. According to students, this entrepreneurial context benefits greatly from the competences acquired during both PIP and SDL courses, and here, it all combines into, not only a project with real value, but also a full-working start-up company with specific goals and constraints. There were also testimonials which recognized the intrinsic value of these competences, not only in innovation projects, but also throughout the respondents' entire professional careers.

6 Discussion and conclusions

Innovation and entrepreneurship are now, indisputably, high-demand competences across most jobs, but particularly informatics engineers are required to "have an entrepreneurial mindset" (Karim, 2016, p. 380). Thus, the challenge of how to teach future engineers to become innovative entrepreneurs seems to rely on how to provide the necessary technical skills without strangling the creativity of students (Mayhew, Simonoff, Baumol, Wiesenfeld & Klein, 2012). In this case study, the challenge was addressed by creating an interdisciplinary cooperation, inspired by our students' feedback and achievements that focused on the active learning of innovation through a progressive development of soft and hard skills. Throughout the analysis of this exploratory case study, it is possible to outline three main ideas that can enrich the practice of teaching innovation in a science and technological educational context:

(1) It is necessary to recognize that soft skills are essential skills for students' active learning of innovation, namely by allowing them to develop their creativity, autonomy, communication, teamwork and cooperation, self-assessment, critical thinking, and so on. In fact, according to the literature it is imperative to acknowledge that the importance of these transversal skills goes far beyond learning about innovation once that they can even "predict success in life" (Heckman & Kautz, 2012, p. 452).

(2) This experience showed that, although soft and hard skills can be theoretically taught separately, they are always integrated in practice. So, a cooperative and complementary approach between the development of soft and hard skills was perceived to be most ef-

fective method to foster innovation among informatics engineering Master's students. As acknowledged by this case study, many students agreed that they enjoyed the soft skill preparation for hard skill development. According to the students, it allowed them to innovate more successfully and sequentially evolve from the idea to project and from the project to business (product/service). The survey data confirmed that connecting prior soft skills development with hard skills learning is perceived by students to be beneficial to their learning process, as they gradually engage in innovation. Also, data analysis produced important indicators (question #4), showing that, even beyond the context of the courses, some students were recognized as successful innovators. Furthermore, and of importance in future research, these data show that students who benefit from these developed skills continue to apply them in other innovation projects among the Master's curriculum (question #5).

(3) This interdisciplinary cooperation, aiming "to meet some of the contemporary demands for knowledge and skills that equip students for addressing the most challenging problems of our time" (Millar, 2016, p. 472), was based on a common pedagogical approach that focused on stimulating students' active learning through project-based work. This allowed students to evolve from a regulatory to a more emancipatory pedagogy. They progressively assumed responsibilities, became more autonomous and learned by doing, which appeared to be crucial in promoting the active learning of innovation among informatics engineering undergraduates.

In conclusion, the complexity of innovating may further benefit from integrative approaches that complement soft with hard skills. There is a pedagogical advantage, as found with this case study, in connecting prior soft skills development with hard skills learning to foster students' active learning of innovation.

Despite the limitations derived from the specificity of the case study design, which is bounded to its own particular context and exploratory procedure, the chosen methodology sought to collect both qualitative and quantitative data so that the resulting findings could inspire other educators to improve their practices by listening to their students and, most importantly, by progressively adopting an emancipatory pedagogical approach. Taking into consideration the students' perceptions and practices was fundamental in further connecting soft with hard skills development. This bond supports students to develop new knowledge and to support them in progressively learning the necessary skills to become capable of innovating in this ever-changing world.

The authors strongly agree that "there is a need to design an educational experience that is timely and engaging for students, yet instrumental in preparing them to be productive members in both the current and future workforce" (Gotel, Scharff & Kulkarni, 2012, p. 199). This gains even more prominence when considering the existing need in informatics engineering to engage students with innovation and entrepreneurship. We will deeper explore these findings, as it is hoped that the present study will be motivational for further research and trigger more scholarly debate in this area. These debates should address the challenge of educating future science and technological professionals in developing innovation, but, foremost, to emancipate them into becoming responsible, autonomous, and active learners throughout life.

7 References

ABET (n.d.). *Criteria for Accrediting Engineering Programs, 2019 – 2020.* Accessed 30th October 2019.

https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2
#GC5

Ahmad, N., & Seymour, R. (2008). *Defining Entrepreneurial Activity: Definitions Supporting Frameworks for Data Collection* (OECD Working Papers). Accessed 12th March 2018: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=std/doc(2008)1

Balan, P. & Metcalfe, M. (2012). Identifying teaching methods that engage entrepreneurship students. *Education + Training* 54(5), 368-384.

Barkas, L. (2011). 'Teaching' or 'support'? The poisoned chalice of the role of Students' Skills Centres. *Journal of Further and Higher Education* 35(2), 265-286.

Biggs, J. (1999). *Teaching for quality learning at university.* Buckingham: SRHE and Open University Press.

Borrás, S. & Edquist, C. (2015). Education, training and skills in innovation policy. *Science and Public Policy* 42, 215-227.

Chang, J., Benamraoui, A. & Rieple, A. (2014). Learning-by-doing as an approach to teaching social entrepreneurship. *Innovations in Education and Teaching International*, 51(5), 459-471.

Chang, J. & Rieple, A. (2013). Assessing students' entrepreneurial skills development in live projects. *Journal of Small Business and Enterprise Development*, 20(1), 225-241.

Chell, E. & Athayde, R. (2011). Planning for uncertainty: soft skills, hard skills and innovation. *Reflective Practice*, 12(5), 615-628.

Cimatti, B. (2016). Definition, development, assessment of soft skills and their role for the quality of organizations and enterprises. *International Journal for Quality Research*, 10(1), 97-130.

Cinque, M. (2016). Lost in translation. Soft skills development in European countries. *Tuning Journal for Higher Education*, 3(2), 389-427.

Cobo, C. (2013). Mechanisms to identify and study the demand for innovation skills in world-renowned organizations. *On the Horizon,* 21(2), 96-106.

Coll, R. & Zegwaard, K. (2006). Perceptions of desirable graduate competencies for science and technology new graduates. *Research in Science & Technological Education,* 24(1), 29-58. http://dx.doi:10.1080/02635140500485340

Davis, B. (2012). *Agile Practices for Waterfall Projects: Shifting Processes for Competitive Advantage.* Florida: J. Ross Publishing.

Dewey, J. (1916). *Philosophy of education (Problems of men).* California: Littlefield, Adams.

Eurostat (2016). ICT specialists - statistics on hard-to-fill vacancies in enterprises. Retrieved from EuroStat Statistics. Accessed 13th September 2018: http://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_-_statistics_on_hard-to-fill_vacancies_in_enterprises

Eurostat (2017). ICT specialists in employment. Retrieved from EuroStat Statistics. Accessed 13th September 2018: http://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment#Further_Eurostat_information

Exter, M. & Turnage, N. (2012). Exploring experienced professional's reflections on computing education. ACM Transactions on Computing Education 12(3), Article 12, 1-23.

Firth, M. (2011) What job skills are employers looking for today? Suite101.com. Accessed 16th January 2018.
http://www.suite101.com/content/what-job-skillsare-employers-looking-for-today-a282039#ixzz1CWcHpHQy

Gotel, O., Scharff, C. & Kulkarni, V. (2012). Mixing continents, competences and roles: five years. *IET Software*, 6(3) 199-213.

Heckman, J. & Kautz, T. (2012). Hard evidence on soft skills. *Labour Economics*, 19(4) 451-464. http//dx.doi:10.1016/j.labeco.2012.05.014

Kaipa, P., Milus, T., Chowdary, S. & Jagadeesh, B. (2005). Soft Skills are Smart Skills. Kaipa Group. Accessed 22th February 2018: http://kaipagroup.com/articles/softskills.pdf

Karim, M. (2016). Entrepreneurship education in an engineering curriculum. *Procedia Economics and Finance*, 35, 379-387.

Kauffeld, S., Grote, S., & Frieling, E. (2003). The Kassel Competence Grid (KKR) [The Cassel Competence Grid]. In L. Rosenstiel and J. Erpenbeck (Ed.), *Competence Measurement*, (pp. 261-281). Stuttgart: Schäffer-Poeschel.

Liebenberg, L. & Mathews, E. (2012). Integrating innovation skills in an introductory engineering design-build course. *International Journal of Technology and Design Education*, 22(1), 93-113.

MacVaugh, J., Jones, A., & Auty, S. (2014) Implicit, stand-alone or integrated skills education for undergraduates: a longitudinal analysis of programme outcomes. *Journal of Further and Higher Education*, 38(6), 755-772.

Martin, R. (2013). *Agile Software Development, Principles, Patterns, and Practices.* London: Pearson Education Limited.

Mayhew, M., Simonoff, J., Baumol, W., Wiesenfeld, B., & Klein, M. (2012). Exploring innovative entrepreneurship and its ties to higher educational experiences. *Research in Higher Education*, 53(8), 831-859.

Millar, V. (2016). Interdisciplinary curriculum reform in the changing university. *Teaching in Higher Education,* 21(4), 471-483.

OECD (2011). Skills for Innovation and Research: Skills for Innovation and Research. Organisation for Economic Co-operation and Development - OECD - Publishing

Passig, D. & Cohen, L. (2014). Measuring the style of innovative thinking among engineering students. *Research in Science & Technological Education*, 32(1), 56-77.

Perrenet, J., Bouhuijs, P. & Smits, J. (2000). The Suitability of Problem-based Learning for Engineering Education: Theory and practice. *Teaching in Higher Education* 5(3), 345-358.

Pittaway, L., Hannon, P., Gibb, A. & Thompson, J. (2009). Assessment practice in enterprise education. *International Journal of Entrepreneurial Behavior & Research* 15(1), 71-93.

Quintini, G. (2011). *Right for the Job: Over-qualified or under-skilled?* Paris: OECD Working Paper. Accessed 22th March 2018: http://www.oecd.org/els/48650012.pdf

Rasmussen, E. & Sørheim, R. (2006). Action-based entrepreneurship education. *Technovation*, 26, 185–194.

Robley, W., Whittle, S. & Murdoch-Eaton, D. (2005). Mapping generic skills curricula: a recommended methodology. *Journal of Further and Higher Education*, 29(3), 221-231.

Rowley, J. (2002). Using case studies in research. *Management Research News*, 25(1), 16-27.

Shore, J., & Warden, S. (2007). *The Art of Agile Development: Pragmatic Guide to Agile Software Development*. California: O'Reilly Media, Sebastopol.

Simatele, M. (2015). Enhancing the portability of employability skills using e-portfolios. *Journal of Further and Higher Education*, 39(6): 862-874.

Sommerville, I. (2015). Software Engineering (10th Edition). London: Pearson Education Limited.

Teegavarapu, S., Summers, J. & Mocko, G. (2008). Case study method for design research: a justification. In *Proceedings of the ASME 2008 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, edited by American Society of Mechanical Engineers, 1-9.

Tether, B., Mina, A., Consoli, D. & Gagliardi, D. (2005). A Literature Review on Skills and Innovation. How Does Successful Innovation Impact on the Demand of Skills and How Do Skills Drive Innovation. Manchester: ESRC Centre for Research on Innovation and Competition. Accessed 12th March 2018: https://www.researchgate.net/publication/268212425

Torres, M. (2013). *Modos de trabalho pedagógico e de avaliação da aprendizagem no ensino superior – um estudo na Universidade do Porto* (PhD Thesis). Faculdade de Psicologia e de Ciências da Educação, Universidade do Porto, Porto, Portugal. http://repositorio-aberto.up.pt/handle/10216/67683

Torres, M. & Leite, C. (2014). Assessment of and for learning in higher education. *Transnational Curriculum Inquiry*, 11(1), 14–29. http://ojs.library.ubc.ca/index.php/tci/article/view/184316

Zhao, F. (2005). Exploring the synergy between entrepreneurship and innovation. *International Journal of Entrepreneurial Behavior & Research*, 11(1), 25-41.

Biographies

Manuel F. Torres. Manuel Torres is graduated in Psychology and obtained his PhD in Educational Sciences at the University of Porto (UP) with a thesis about Higher Education, one of his main research interests. He was a Professor in higher education since 1983 in several institutions. Currently, he is a Professor at the Faculty of Engineering, UP (FEUP) on Personal and Interpersonal Proficiency, Organizational Behaviour and Project FEUP. He also received several pedagogical recognition awards from FEUP and the pedagogical excellence award from the University of Porto. Additionally, he is Partner Manager of a Consulting Company and Senior Consultant in Psychology, Education and Training at over 150 public and private organizations, with extensive experience in professional and pedagogical training, soft skills development, coaching and counselling.

Nuno Flores. Nuno Flores is an Assistant Professor at Faculty of Engineering of University of Porto (FEUP), lecturing courses on Software Engineering, Agile Software Development and Software Architecture. He's a researcher at the Software Engineering Research Group at FEUP, conducting work aimed at collaborative software knowledge management and software engineering education. He's also a research collaborator at INESC TEC and member of the international Hillside Group. His PhD thesis is about Software Engineering and his most recent research interests are applying game-like techniques to improve software engineering education.

Raquel T. Torres. Raquel Torres is graduated in Educational Sciences and has a European master degree in Social and Educational Sciences. She has also been enrolled in an interdisciplinary Ph.D. (comprising areas such as sociology, law, economics and politics). Furthermore, she was an education specialist in social and educational institutions and an independent researcher in some universities and research centers, within several study areas. Her research interests include also the development of transdisciplinary approaches to human (inter)actions. Presently, she is a researcher and consultant in a private company, where she is conducting studies about transversal skills in academic and professional contexts.

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 8, 1 (2020) 39-50
HANDLE: https://hdl.handle.net/10216/126987
DOI: https://doi.org/10.24840/2183-0606_008.001_0005
SM: Dec/2019 AM: Feb/2020

Five Maturity Levels of Managing AI: From Isolated Ignorance to Integrated Intelligence

Ulrich Lichtenthaler
lichtenthaler@web.de | ISM - International School of Management, Im MediaPark 5c, 50670 Cologne, Germany

Abstract. To guide future discussions about managing artificial intelligence (AI), this article suggests an AI management framework with five maturity levels, which are comparable to the five levels of the autonomous driving framework from no automation to complete automation. If companies move beyond Isolated Ignorance (Level 0), they are characterized by an Initial Intent (Level 1), which typically evolves towards an Independent Initiative (Level 2). A more advanced management leads to Interactive Implementation (Level 3) and Interdependent Innovation (Level 4). On this basis, a close combination of AI and human knowledge enables a sustainable competitive advantage with Integrated Intelligence (Level 5). This framework draws on the intelligence-based approach to company performance, and it provides the basis for an AI maturity assessment in organizations. It further helps to identify many firms' managerial challenges as well as major organizational limitations even in those firms that are often considered as AI leaders.

Keywords. Artificial Intelligence; Conceptual Framework; Digitalization; Digital Transformation; Integrated Intelligence; Intelligence-based View.

Cite paper as: Lichtenthaler, U., (2020). Five Maturity Levels of Managing AI: From Isolated Ignorance to Integrated Intelligence, *Journal of Innovation Management*, www.open-jim.org, 8(1), 39-50.

1 Introduction

"If you invent a breakthrough in artificial intelligence, so machines can learn, that is worth 10 Microsofts" (Lohr, 2004). Bill Gates made this statement already in 2004, and the evolution of artificial intelligence (AI) has progressed substantially since then (Daugherty & Wilson, 2018; Davenport, 2018). Beyond the firms that focus on developing and commercializing new AI technology, many established manufacturing and service companies have started strategic initiatives to apply AI solutions, such as advanced analytics and smart algorithms. This massive attention to AI may be observed in nearly all sectors, including consumer products, machinery, automotive, financial services, electronics, and many others (Agrawal, Gans, & Goldfarb, 2018; Apanesevic, Arvidsson, & Markendahl, 2018; Brock & Wangenheim, 2019). Despite the broad application of AI, the knowledge about managing such initiatives is surprisingly limited. This is particularly noteworthy because many firms' AI initiatives do not live up to the initial expectations, whereas only a few firms and organizations achieve major competitive benefits from leveraging the recent progress in different AI fields, such as natural language processing, machine learning, and speech synthesis (Brito, 2018; Haenlein & Kaplan, 2019; Tambe, Cappelli, & Yabukovich, 2019).

While some firms still ignore AI, many others pursue strategic AI programs, but the management of these programs has often remained a black box, and our knowledge about managing AI has remained incomplete so far beyond some initial insights (Garbuio & Lin, 2019; Lichtenthaler, 2020b; Shrestha, Ben-Menahem, & Krogh, 2019). This insufficient understanding of managing AI is similar to the limited insights into the results of some machine learning algorithms based on big data (Plastino & Purdy, 2018; Rometty, 2016). To guide a deeper understanding of AI management, this article builds on prior research in the *Journal of Innovation Management* about the intelligence-based view (Lichtenthaler, 2019) and suggests a framework with five maturity levels of managing AI. These five levels are comparable to the five well-known levels of autonomous driving from no automation to complete automation (SAE International, 2019).

This AI management framework offers several contributions. First, it provides the basis for an AI maturity assessment in companies, and it illustrates the relevance of an intelligence-based view of firm performance (Kumar, Rajan, Venkatesan, & Lecinski, 2019; Lichtenthaler, 2019). Second, the different maturity levels help to explain many companies' challenges in managing AI initiatives and in profiting from these initiatives by strengthening their competitive position (Datta, 2018; Overgoor, Chica, Rand, & Weishampel, 2019). Third, the framework allows for identifying the limitations of many firms that are considered to be successfully managing AI (Metcalf, Askay, & Rosenberg, 2019; Swift, 2018). These companies are often in the paradoxical situation that they only believe to leverage AI, but a more detailed analysis points to many unrealized opportunities that could be achieved with an integrated intelligence architecture (Bühring & Moore, 2018; Wilbert, Durst, Ferenhof, & Selig, 2018).

2 Managing artificial intelligence

Many previous articles and studies about AI focus on specific topics, and this varying emphasis has contributed to a relatively broad understanding of what AI actually is, for example with regard to advanced data analytics and smart algorithms (Lichtenthaler, 2020b). In particular, some previous studies have focused on technological opportunities and solutions, whereas others have primarily concentrated on market applications and use cases of AI (Davenport, 2018; Tegmark, 2018). In addition, the understanding of AI is often dynamic, which leads to a different scope of AI as technologies and markets evolve over time (Lichtenthaler, 2020b). In the management context, AI may be defined as "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (Kaplan & Haenlein, 2019, p. 15).

In a similar vein, the glossary of the research and advisory firm Gartner provides the following definition of AI. "Artificial intelligence (AI) applies advanced analysis and logic-based techniques, including machine learning, to interpret events, support and automate decisions, and take actions" (Gartner, 2019a). On this basis, there are various systematizations of specific fields of AI, and some of these categorizations focus on different fields of technology, whereas others describe distinct market aspects (Lichtenthaler, 2020b). In this regard, machine learning has probably been discussed most prominently in recent years in light of the substantial technological improvements in this field (Finlay, 2017). Other important types of AI include natural language processing, speech synthesis, machines and robotics, expert systems, computer vision as well as optimization and planning solutions. Different overviews may be found in several prior works (Haenlein & Kaplan, 2019; Lichtenthaler, 2020b; Mueller & Massaron, 2018; Wein, 2018).

On this basis, the management of AI rather than AI generally comprises the following activities, and this understanding of AI management as the coordination of a firm's AI activities follows the understanding of data management by the research and advisory firm Gartner, which focuses on the coordination of data in an enterprise (Gartner, 2019b). Consistent with this underlying logic, AI management consists of the strategies, processes, practices, activities, tools, and organizational mechanisms for achieving consistent access and utilization of artificial intelligence in response to the intelligence requirements across an organization. As such, the AI activities are part of a company's intelligence architecture, which comprises various types of AI, various types of human intelligence, and a meta-intelligence for renewing and recombining the intelligence types and their interfaces (Lichtenthaler, 2020b). This understanding of intelligence architecture draws on the concept of *Integrated Intelligence* and the intelligence-based view of company performance (Lichtenthaler, 2019, 2020b).

In particular, this notion of an intelligence architecture is consistent with the concept of information architecture in information technology management. In this regard, the research and advisory firm Gartner defines information architecture as follows: "All the sources of information – including paper, graphics, video, speech and thought – that define the enterprise are represented by this layer of applications architecture. It also defines the sources and destinations of information, its flow through the enterprise, as well as the rules for persistence, security and ownership" (Gartner, 2019d). As such, the enterprise information architecture "describes – through a set of requirements, principles and models – the current state, future state and guidance necessary to flexibly share and exchange information assets to achieve effective enterprise change" (Gartner, 2019c). In this respect, an integrated intelligence architecture involves a comprehensive perspective on the different types of AI, the different types of human intelligence and the meta-intelligence to ensure that the overall architecture is more the sum of the individual intelligence types (Lichtenthaler, 2020b).

3 Five maturity levels

Based on the detailed coverage of the recent progress in AI across all media channels, most companies are well aware of the growing competitive relevance of AI (Agrawal, Gans, & Goldfarb, 2017; Plastino & Purdy, 2018). Nonetheless, many businesses still largely ignore the increasing importance of AI. In some firms, this reluctant approach derives from a limited openness to new technology and a limited willingness to innovate (Huang & Rust, 2018; Ili & Lichtenthaler, 2017). In contrast, some other companies have taken the deliberate strategic decision to focus on other value drivers for their customers. Consequently, they may take major steps to apply AI solutions in the future. Currently, however, they continue to concentrate on other topics and are largely inactive with respect to AI (Kavadias, Ladas, & Loch, 2016; Tegmark, 2018).

Therefore, this reluctant approach has been termed *Isolated Ignorance* (Lichtenthaler, 2020b), and it may be considered Level 0 in managing AI based on an intelligence-based perspective on firm performance. If companies leave this stage of inactivity and start some initial steps of experimenting with selected AI solutions, they enter Level 1 of managing AI. This level of *Initial Intent* is often characterized by exploring the technical feasibility as well as the business viability of specific AI applications (Figure 1). However, many of these experimental activities are discontinued after some time, and they are not rolled out in the organization because of major uncertainties whether the implementation of these particular AI solutions will actually pay off or not in the long run.

Level 2 of managing AI is termed *Independent Initiative*. Here, companies typically have several ongoing AI activities, whose extent is still relatively limited. In large businesses, these activities have often been started in various organizational units, and there is hardly any coordination among these activities. For example, large insurance companies like American International Group and Zurich started multiple AI programs in different business and functional units several years ago (Lloyd-Jones, 2016). Usually, these AI programs focus on advanced automation solutions to improve the efficiency of established business processes by automating jobs (Agrawal et al., 2018). If companies start to exploit diverse business opportunities deriving from AI, they enter Level 3, which is called *Interactive Implementation*. These companies pursue multiple AI solutions, whose implementation is aligned with one another. On this basis, the executives coordinate the activities across multiple units of large organizations. In addition, there may be pooled interdependencies between AI and human intelligence, which provide distinct contributions to a firm's overall intelligence architecture (Lichtenthaler, 2018).

Many companies that are regarded as AI leaders have achieved Level 3. However, many of these firms still focus on utilizing AI for optimization purposes rather than for developing novel solutions for their existing and new customers (Lichtenthaler, 2020b). This is the core difference between those firms and the small minority of businesses that have arrived at Level 4 of *Interdependent Innovation*. These companies put a much stronger emphasis on growth and innovation due to combining AI solutions with additional innovation types, for example new services and

Level	Name	Icon	Description	Impact
+	Intuitive Ingenuity		Shared management of human intelligence and AI; self-awareness systems with some consciousness, emotional intelligence, and ingenuity (only in the future)	Very High
5	**Integrated Intelligence**		Renewal and recombination of human intelligence and AI; leveraging pooled, sequential, and reciprocal interdependencies for completely novel solutions	
4	**Interdependent Innovation**		Emphasis on AI for innovation beyond efficiency; sometimes pooled and sequential interdependencies of human intelligence and AI; often corporate orchestration for synergies	
3	**Interactive Implementation**		Exploitation of multiple AI solutions; sometimes pooled interdependencies of human intelligence and AI; often coordination of activities in multiple organizational units	
2	**Independent Initiative**		Ongoing AI initiatives; typical emphasis on advanced automation and enhancing efficiency of established processes; often started in selected organizational units	
1	**Initial Intent**		Initial steps of experimenting with selected AI technologies; exploration of feasibility and viability; limited implementation in uncertain context	
0	Isolated Ignorance		Ignorance of the growing relevance of AI; strategic emphasis on other topics and value drivers at least in the short term; present inactivity with regard to AI	Very Low

Fig. 1. AI management framework with five maturity levels.

new business models (Davenport, 2018). In addition to pooled interdependencies between AI and human intelligence, there may be sequential interdependencies in situations when the output of one intelligence constitutes the input to the other intelligence (Lichtenthaler, 2018). For instance, Autodesk's AI solution Dreamcatcher enables designers to ease the identification of suitable solutions based on particular features that are considered as fixed (Wilson & Daugherty, 2018; Wilson, Daugherty, & Bianzino, 2017). This approach facilitates the design process, and it involves close interactions with multiple other experts and solutions in distinct organizational units. Accordingly, Level 4 also calls for a systematic orchestration of AI programs and additional initiatives to achieve synergies and strategic alignment. For example, General Electric specifically regards its AI activities as a multidisciplinary program, which considers efficiency as well as innovation benefits, including advanced analytics and edge computing for strengthening its industrial IoT solutions (General Electric, 2019).

Finally, Level 5 refers to *Integrated Intelligence*. To date, hardly any company has arrived at this level of managing AI, which would involve a meta-intelligence for systematically renewing and recombining AI and human intelligence (Lichtenthaler, 2020a). Thus, companies at this level fully go beyond viewing AI applications as stand-alone solutions. Instead, firms try to achieve an integrated intelligence architecture by leveraging all types of interdependencies between AI and human intelligence – pooled, sequential, and reciprocal interdependencies (Lichtenthaler, 2018). In the case of reciprocal interdependencies, there are cyclical interactions between AI and human intelligence (Lichtenthaler, 2018). Based on an integrated intelligence architecture, companies may arrive at completely novel solutions along a development funnel with close collaborations of

AI and human experts. For example, the startup Tawny.ai develops tailored algorithms drawing on its key technology for AI-powered emotion analytics (Lichtenthaler, 2020b). On this basis, it aims at easing the interaction between AI and human intelligence to enable integrated intelligence architectures on a scalable basis.

Even if some businesses are considered AI leaders – or if they consider themselves as AI leaders – they usually have not achieved Level 5, at least not in large parts of their organizations. Consequently, they still do not leverage the full strategy space of AI. Many of these companies are already very successful in terms of optimizing and streamlining their internal processes to achieve cost reductions (Agrawal et al., 2018; Daugherty & Wilson, 2018). However, the executives typically do not consider the variety of effects that AI will have on the value chain in their industry. In addition, the opportunities for business model innovations, potentially together with external partners in a future intelligence-based ecosystem, are often left unconsidered. Thus, even the most advanced companies in managing AI are only able to gain an intelligence-based competitive advantage (Lichtenthaler, 2020b). However, they will have a difficult time in sustaining this competitive advantage over a longer period, especially as many AI applications will become relatively standardized solutions in the near future, which are further commoditized in the long run. Figure 1 indicates that the competitive consequences of AI are strong in the most advanced companies because they have often achieved Level 4 of managing AI. Nonetheless, there is still significant unrealized potential for further strengthening their competitive positions based on an integrated intelligence architecture.

Level 5 of managing AI constitutes the top level that companies may achieve at present. At some point in the future, however, there may be an additional level which goes beyond today's maximum (Finlay, 2017; Mueller & Massaron, 2018). In the context of further substantial evolutions of various technology fields, management may be further shared among AI and human executives. Consequently, the competitive impact of AI would be even higher, and this Level + would refer to *Intuitive Ingenuity*. This additional level would require self-awareness systems with some degree of consciousness, which constitute the form of AI that is envisioned in some science fiction movies (Mueller & Massaron, 2018). On this basis, AI solutions would comprise some degree of emotional intelligence, ingenuity, and intuition. These solutions may be able to accomplish a larger portion of the activities that currently still require uniquely human skills, such as creativity, motivation, and storytelling (Lichtenthaler, 2018). Throughout the next decades, nearly all companies will move along the different maturity levels from Level 0 to Level 5 with a growing relevance of *Integrated Intelligence* – and potentially even beyond this level due to future scientific evolutions in AI and similar scientific fields.

4 Distinguishing the maturity levels

The AI management framework with five maturity levels presents new insights into the evolution of AI activities in companies. In this respect, it is essential to highlight the major differences among the maturity levels. A key difference between Level 0 and Level 1 is *activating* the relevant persons to enable experimentation with AI technologies. With regard to Level 2, major emphasis is placed on *arranging* an AI initiative that includes the different AI activities. On this basis, firms focus on *accomplishing* the key tasks to ensure a successful AI execution, which constitutes a core part of Level 3. With respect to Level 4, companies focus their AI initiatives on *advancing* towards growth and innovation beyond improvements and optimization. Finally, companies concentrate on *amalgamating* AI and human intelligence at Level 5 of Integrated Intelligence. Only this integration of multiple types of intelligence will enable a sustainable competitive advantage in an intelligence-driven future business context (Lichtenthaler, 2020b).

In this regard, the AI management framework guides future discussions about firms' maturity levels in managing AI and in achieving competitive benefits at the interfaces of AI and human expertise (Hirsch, 2018; Oliveira, 2017). On this basis, the framework provides an important starting point for standardized AI maturity assessments, which may be particularly important for measuring the dynamic transformations of AI management over time (Wein, 2018; Woyke, 2017). In addition, the framework contributes to explaining many firms' challenges in creating value with AI and in capturing the value of their AI initiatives in terms of an enhanced competitive position (Fountaine, McCarthy, & Saleh, 2019; Pinto-dos-Santos et al., 2018). For example, if a company remains at Level 2, any AI program is unlikely to produce innovative results that go substantially beyond the optimization of existing business processes. In addition, the five maturity levels help to systematically identify the limitations of AI management even in those companies that are considered to be among the leading firms in managing and profiting from AI (Berman, 2012; Lewrick, Link, & Leifer, 2018).

5 Conclusion and outlook

Based on distinguishing various maturity levels, the AI management framework points to white spots and unrealized opportunities in nearly all companies at present. By addressing these additional opportunities of leveraging AI and achieving an integrated intelligence architecture, firms may overcome the paradoxical situation of being considered AI leaders although they have only captured the low-hanging fruits. In contrast, the major benefits in terms of innovation and competitive advantage have usually not been addressed yet (Davenport & Ronanki, 2018). This situation of perceived high performance levels may sometimes be even more challenging than the situation of firms that have completely ignored AI activities. In fact, the executives in many firms with AI activities believe that these activities are successful in absolute terms and also relative to their firm's potential (Lichtenthaler, 2020b). Consequently, they are convinced that these activities should be continued in their present form or only need to be slightly adapted and extended.

However, this strategic emphasis usually limits the extent of AI activities to realizing efficiency benefits, whereas most further opportunities in terms of innovation and new business models are left unconsidered (Warner & Wäger, 2019; Westerman & Bonnet, 2015). Drawing on an intelligence-based perspective, the core differences among the maturity stages – activating, arranging, accomplishing, advancing, and amalgamating – offer immediate starting points for taking a firm's AI management to the next level based on customized action plans. In addition, they underscore the relevance of an intelligence-based approach to firm performance (Lichtenthaler, 2019). In light of potential future progress in AI technology, firms may not only advance from

Isolated Ignorance to *Integrated Intelligence*. Instead, some degree of *Intuitive Ingenuity* may further expand the strategy space and the competitive alternatives against the background of growing maturity levels of managing AI.

6 References

Agrawal, A., Gans, J., & Goldfarb, A. (2018). Prediction machines: The simple economics of artificial intelligence. Boston: Harvard Business Review Press.

Agrawal, A. K., Gans, J. S., & Goldfarb, A. (2017). What to expect from artificial intelligence. MIT Sloan Management Review, 58(3): 23–26.

Apanesevic, T., Arvidsson, N., & Markendahl, J. (2018). Mobile payments: a proposal for a context-oriented approach based on socio-technical system theory. Journal of Innovation Management, 6(3): 40–97.

Berman, S. J. (2012). Digital transformation: opportunities to create new business models. Strategy & Leadership, 40(2): 16–24.

Brito, C. (2018). Promoting the creation of Innovation Ecosystems: the case of the University of Porto. Journal of Innovation Management, 6(3): 8–16.

Brock, J.K.U., & Wangenheim, F. von. (2019). Demystifying AI: What Digital Transformation Leaders Can Teach You about Realistic Artificial Intelligence. California Management Review, 61(4): 110–134.

Bühring, J., & Moore, P. A. (2018). Emotional and Social Intelligence as 'Magic Key' in Innovation: A Designer's call toward inclusivity for all. Journal of Innovation Management, 6(2): 6–12.

Datta, S.P.A. (2018). Unleashing the new Wealth Of Nations. Journal of Innovation Management, 6(2): 13–37.

Daugherty, P. R., & Wilson, H. J. (2018). Human + machine: Reimagining work in the age of AI. Boston: Harvard Business Review Press.

Davenport, T. H. (2018). AI Advantage: How to Put the Artificial Intelligence Revolution to Work. Cambridge: MIT Press.

Davenport, T. H., & Ronanki, R. (2018). Artificial Intelligence for the Real World. Harvard Business Review, 96: 108–116.

Finlay, S. (2017). Artificial Intelligence and Machine Learning for Business: A No-Nonsense Guide to Data Driven Technologies. Preston: Relativistic.

Fountaine, T., McCarthy, B., & Saleh, T. (2019). Building the AI-Powered Organization. Harvard Business Review, 97(4): 62–73.

Garbuio, M., & Lin, N. (2019). Artificial Intelligence as a Growth Engine for Health Care Startups: Emerging Business Models. California Management Review, 61(4): 59–83.

Gartner. (2019a). Artificial intelligence. Information technology glossary: https://www.gartner.com/en/information-technology/glossary/artificial-intelligence.

Gartner. (2019b). Data management. Information technology glossary: https://www.gartner.com/en/information-technology/glossary/dmi-data-management-and-integration.

Gartner. (2019c). Enterprise information architecture. Information technology glossary: https://www.gartner.com/en/information-technology/glossary/enterprise-information-architecture.

Gartner. (2019d). Information architecture. Information technology glossary: https://www.gartner.com/en/information-technology/glossary/information-architecture.

General Electric. (2019). https://www.ge.com/research/technology-domains/artificial-intelligence.

Haenlein, M., & Kaplan, A. (2019). A Brief History of Artificial Intelligence: On the Past, Present, and Future of Artificial Intelligence. California Management Review, 61(4): 5–14.

Hirsch, P. B. (2018). Tie me to the mast: Artificial intelligence & reputation risk management. Journal of Business Strategy, 39(1): 61–64.

Huang, M. H., & Rust, R. T. (2018). Artificial intelligence in service. Journal of Service Research, 21(2): 155–172.

Ili, S., & Lichtenthaler, U. (2017). FAQ Digital Transformation and Artificial Intelligence: 101 Questions - 101 Answers. Karlsruhe: Ili Consulting.

Kaplan, A. M., & Haenlein, M. (2019). Siri, Siri, in My Hand: Who's the Fairest in the Land? On the Interpretations, Illustrations, and Implications of Artificial Intelligence. Business Horizons, 62(1): 15–25.

Kavadias, S., Ladas, K., & Loch, C. (2016). Artificial Intelligence Is Almost Ready for Business. Harvard Business Review, 94: 91–98.

Kumar, V., Rajan, B., Venkatesan, R., & Lecinski, J. (2019). Understanding the Role of Artificial Intelligence in Personalized Engagement Marketing. California Management Review, 61(4): 135–155.

Lewrick, M., Link, P., & Leifer, L. (2018). The Design Thinking Playbook: Mindful Digital Transformation of Teams, Products, Services, Businesses and Ecosystems. New York: Wiley.

Lichtenthaler, U. (2018). Substitute or synthesis? The interplay between human and artificial intelligence. Research-Technology Management, 61(5): 12–14.

Lichtenthaler, U. (2019). An intelligence-based view of firm performance: Profiting from artificial intelligence. Journal of Innovation Management, 7(1).

Lichtenthaler, U. (2020a). Beyond artificial intelligence: why companies need to go the extra step. Journal of Business Strategy, 41(1): 19-26.

Lichtenthaler, U. (2020b). Integrated intelligence: Combining human and artificial intelligence for competitive advantage. Frankfurt: Campus.

Lloyd-Jones, T. (2016). https://blogs.lexisnexis.com/insurance-insights/2016/06/machine-learning-artificial-intelligence-insurance/.

Lohr, S., (2004, March 1). Microsoft, Amid Dwindling Interest, Talks Up Computing as a Career. New York Times. Accessed January 2020.
https://www.nytimes.com/2004/03/01/business/microsoft-amid-dwindling-interest-talks-up-computing-as-a-career.html.

Metcalf, L., Askay, D. A., & Rosenberg, L. B. (2019). Keeping Humans in the Loop: Pooling Knowledge through Artificial Swarm Intelligence to Improve Business Decision Making. California Management Review, 61(4): 84–109.

Mueller, J. P., & Massaron, L. (2018). Artificial Intelligence for Dummies. Hoboken: Wiley.

Oliveira, E. (2017). Beneficial AI: The next battlefield. Journal of Innovation Management, 5(4): 6–17.

Overgoor, G., Chica, M., Rand, W., & Weishampel, A. (2019). Letting the Computers Take Over: Using AI to Solve Marketing Problems. California Management Review, 61(4): 156–185.

Pinto-dos-Santos, D., Giese, D., Brodehl, S., Chon, S. H., Staab, W., Kleinert, R., Maintz, D., & Baessler, B. 2018. Medical students' attitude towards artificial intelligence: a multicentre survey. European Radiology, 1(1): 1–7.

Plastino, E., & Purdy, M. 2018. Game changing value from Artificial Intelligence: eight strategies. Strategy & Leadership, 46: 16–22.

Rometty, G. 2016. Digital today, cognitive tomorrow. MIT Sloan Management Review, 58(1): 168–171.

SAE International. 2019. https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic.

Shrestha, Y. R., Ben-Menahem, S. M., & Krogh, G. von. 2019. Organizational Decision-Making Structures in the Age of Artificial Intelligence. California Management Review, 61(4): 66–83.

Swift, T. 2018. PhD scientists in the boardroom: the innovation impact. Journal of Strategy and Management, 11(2): 184–202.

Tambe, P., Cappelli, P., & Yabukovich, V. 2019. Artificial Intelligence in Human Resources Management: Challenges and a Path Forward. California Management Review, 61(4): 15–42.

Tegmark, M. 2018. Life 3.0: Being human in the age of artificial intelligence. New York: Vintage Books.

Warner, K.S.R., & Wäger, M. 2019. Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. Long Range Planning, 52(3): 326–349.

Wein, E. 2018. Artificial Intelligence Making Machines Learn: A friendly Introduction.

Westerman, G., & Bonnet, D. 2015. Revamping your business through digital transformation. MIT Sloan Management Review, 56: 10–13.

Wilbert, J.K.W., Durst, S., Ferenhof, H. A., & Selig, P. M. 2018. Unlearning at the Individual Level: An Exploratory Case Study in a High Power Distance Country. Journal of Innovation Management, 6(3): 17–39.

Wilson, H. J., Daugherty, P., & Bianzino, N. 2017. The jobs that artificial intelligence will create. MIT Sloan Management Review, 58(4): 14–16.

Wilson, H. J., & Daugherty, P. R. 2018. Collaborative intelligence: Humans and AI are joining forces. Harvard Business Review, 96(4): 114–123.

Woyke, E. 2017. General Electric builds an AI workforce. MIT Technology Review, Online: 1–3.

Biographies

Ulrich Lichtenthaler. Ulrich Lichtenthaler is a Professor of Management and Entrepreneurship at ISM – International School of Management in Cologne, Germany. He holds a Ph.D. degree in technology management and further is an Executive Consultant, who has successfully completed over 20 digital transformation projects over the past years. He has written multiple books and articles for journals and newspapers, such as MIT Sloan Management Review and Wall Street Journal, and he has taught executive education courses at leading business schools.

Journal of Innovation Management
JIM 8, 1 (2020) 51-83
HANDLE: https://hdl.handle.net/10216/126987
DOI: https://doi.org/10.24840/2183-0606_008.001_0006
SM: Dec/2019 AM: Mar/2020

The Moderating Effects of Dynamic Capabilities on Radical Innovation and Incremental Innovation Teams in the Global Pharmaceutical Biotechnology Industry

Heather A. Johnson
heather57johnson@gmail.com | University of Maryland Global Campus 3501 University Blvd East Adelphi, MD 20783 USA

Abstract. The purpose of this paper was to conduct a qualitative, integrative systematic literature review of the moderating effects of dynamic capabilities associated with radical innovation and incremental innovation teams in the global pharmaceutical biotechnology industry. This paper utilizes a conceptual framework of dynamic capabilities and socio-technical theory to underpin the study. The study includes reading 250 peer reviewed articles which were originally surveyed from a larger set of articles, and then a final selection of 66 articles was based on a structured quality assessment tool and coding system. The study outcome reveals that knowledge sharing strengthens existing professional knowledge and enhances internal work coordination and consistency in employees' behavior, and effectively integrates diverse team knowledge and experience. Open innovation has a positive effect on radical innovation and enables knowledge acquisition to form a symbiotic relationship with knowledge sharing. Learning orientation has a stronger effect on incremental innovation than on radical innovation. The limitations of the study are intrinsic to a systematic literature review as this research approach does not uncover causality. The mediating effects of dynamic capability on teams are not explored for this research. The implications for management practice could be highlighted as follows: teams must be given the autonomy to make decisions from a technical perspective; tacit knowledge, open innovation, knowledge acquisition and learning orientation are areas in which priority must be given during and after acquisitions in the global pharmaceutical biotechnology industry.

Keywords. Innovation; Knowledge Management; Pharmaceutical Industry; Biotechnology; Open Innovation.

Cite paper as: Johnson, H., (2020). The Moderating Effects of Dynamic Capabilities on Radical Innovation and Incremental Innovation Teams in the Global Pharmaceutical Biotechnology Industry, *Journal of Innovation Management*, www.open-jim.org, 8(1), 51-83.

1 Introduction

"A strong team can take any crazy vision and turn it into reality", John Carmack. The pharmaceutical biotechnology business environment is a very complex one, some of its traits are: many decision makers; fierce competition; and very difficult to transmit the value proposition to all stakeholders (Perez la Rotta and Herrera, 2011). The complexity is exacerbated by the existence of complicated regulatory requirements which all organizations must contend with to get their products to market. The question is: "how to communicate value and connect with customers in this context?" (Perez la Rotta and Herrera, 2011, p.77). The United States of America Government Accountability Office (GAO's) analysis of revenue, profit margin, and merger and acquisition deals within the worldwide drug industry from 2006 through 2015 identified key trends: (1) Estimated pharmaceutical and biotechnology sales revenue increased from $534 billion to $775 billion in 2015 dollars; (2) 67 percent of all drug companies saw an increase in their annual average profit margins from 2006 to 2015. Among the largest 25 companies, annual average profit margin fluctuated between 15 and 20 percent. For comparison, the annual average profit margin across nondrug companies among the largest 500 globally fluctuated between 4 and 9 percent; (3) The number of reported mergers and acquisitions generally held steady during this period, but the median disclosed deal value increased. (United States Government Accountability Office, 2017).

In the face of disruptive innovation, the pharmaceutical biotechnology corporations not only have to support radical innovation, but they must support incremental innovation. Radical innovation has to do with explorative areas of future products or services within an industry. While incremental innovation has to do with exploitative areas of current products or services. Ambidexterity has been purported to be the management mechanism to address the organizational duality of radical innovation and incremental innovation. Several leadership types, organizational structures, conceptual frameworks and associated theories have evolved over the past 20 years on ambidextrous innovation research.

1.1 Problem statement

Global corporations, small and medium enterprises, non-profits and other businesses are faced with the constant onslaught of disruptive innovation in order to survive in the 21st century. This has led to these entities being forced to support ambidextrous innovation (explorative and exploitative) to remain competitive within their industries (Rosing et al., 2011; Soosay and Hyland, 2008). The precise problem for many pharmaceutical biotechnology corporations, they have not survived the competitive environment of both radical innovation and incremental innovation (Shin, et al., 2016). As a result, these organizations have become extinct or have been surpassed in terms of performance by their competitors (Visscher and De Weerd-Nederhof, 2006; Hannachi, 2016).

ISSN 2183-0606
http://www.open-jim.org

1.2 Gaps in the literature

The significance of this research is, for over the past 20 years, there has been a proliferation of articles written on ambidextrous innovation (Tushman and O'Reilly, 1997; Rothaermel and Deeds, 2004; Van Looy et al., 2005; Jansen et al., 2005; Grover et al., 2007; O'Reilly and Tushman, 2008; O'Reilly and Tushman, 2013; Ferrary 2011; Wang and Rafiq, 2014; Lee et al., 2019; Vorraber et al., 2019). However, most of the literature has focused on leadership and organizations as complete entities. There has been very little focus on *teams* and the dynamics of how *teams* perform in the ambidextrous innovation management environment within the global Pharmaceutical Biotechnology Industry (PBI). As mentioned in the outset of this paper, *teams* are an essential element in any organization and even more so in the global PBI. Hence an analysis of what "makes or breaks" a *team's* ability to thrive in the innovation management environment within the PBI is critical to understanding survival. In addition, the impact of mergers and acquisitions is a composite part of the gap being analyzed in the current context of the global PBI.

1.3 Research question

The purpose of this paper was to conduct a qualitative, integrative systematic literature review of the dynamic capabilities associated with radical innovation and incremental innovation *teams* in the global PBI. There will be a structuring of the current knowledge and an appraisal of the gap in the literature to help formulate new knowledge in the innovation management research environment.

After looking at the gaps, the decision was made to use "dynamic capabilities" as a mechanism to explore its impact on ambidextrous innovation. The specific population chosen was *teams* in the PBI. The resulting main research question is: What are the moderating effects of dynamic capability on radical innovation and incremental innovation teams in the global PBI? Figure 1 shows an overview of the conceptual model of the constructs associated with the research question.

The additional supporting questions formulated are:

1. What constructs play strategic roles on the performance of innovative teams?
2. How are enterprises able to remain competitive in the tenuous environment of radical and incremental innovation in the PBI?

2 Method

2.1 Integrative systematic literature review

Govindan et al. (2015) stated that an integrative systematic literature review should involve several steps such as:

1. Conducting a survey of the available articles published on the subject.

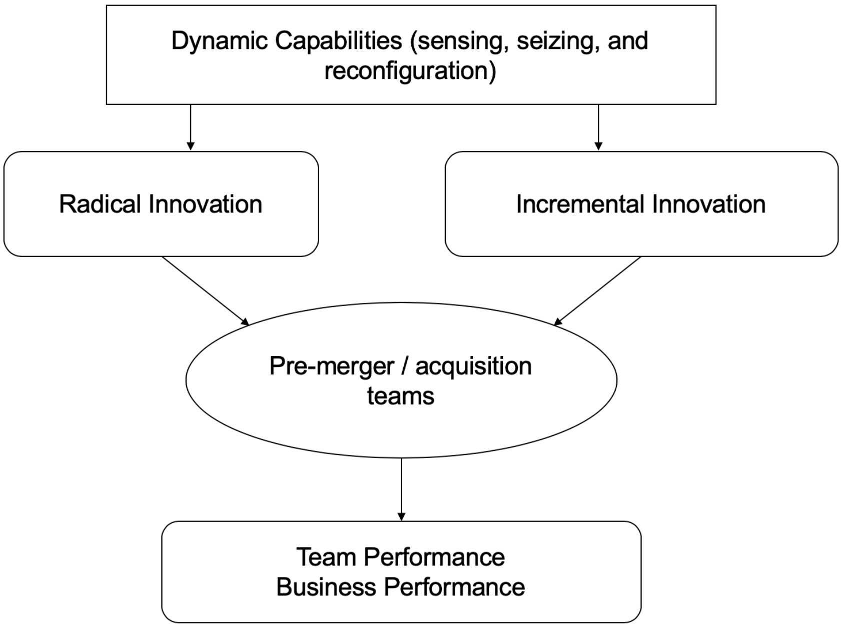


Fig. 1. Model of dynamic capabilities, radical and incremenatl (ambidextrous) innovation and teams conceptualized pre-research analysis**.**

2. Developing and use a structured classification coding system to clarify and provide structure to the existing knowledge on the subject.
3. Identifying the main results of the articles based on the coding system.
4. Analyzing the gaps as well as the opportunities and challenges for future studies.

Boolean search strings using keywords were developed and executed utilizing the University of Maryland Global Campus One Search tool. (See Table 1 for examples of search strings). The University of Maryland One Search tool consists of over 50 reputable databases such as Emerald Insight; Business Source Complete; JSTOR; Oxford Reference; PsycINFO; SAGE knowledge and ScienceDirect. In addition, the following other highly respected databases were explored: ABI/INFORM Collection; Dissertation and Theses Global (PROQUEST); Mendeley and Scopus. A few articles were found using snowballing after reading articles which would make up the final set of articles for analysis.

Table 1. Boolean search criteria utilized through University Maryland Global Campus One Search database tool.

Search#	Boolean search strings	Results
1	Ambidextrous innovation peer reviewed only English	833
2	Radical Innovation and Incremental Innovation	2518
3	Radical Innovation and Incremental Innovation and Dynamic capabilities	78
4	Dynamic capabilities	119,772
5	Dynamic capabilities limiter 1995-2019	116,757

ISSN 2183-0606
http://www.open-jim.org

Search#	Boolean search strings	Results
6	Dynamic capabilities and Innovation	7,334
7	Dynamic capabilities and Innovation and team*	311
8	Dynamic capabilities and Innovation and Ambidexter*	169
9	Dynamic capabilities and Radical innovation and Incremental Innovation	74
10	Dynamic capabilities and pharmaceutical	1,172
11	Dynamic capabilities and pharmaceutical and innovation	143
12	Dynamic capabilities and biotechnology	2,261
13	Dynamic capabilities and biotechnology and innovation	284
14	Socio-technical theory	3,644
15	Socio-technical theory and innovation	921
16	Team and Innovation and Ambidexter*	168
17	Knowledge management and radical innovation and incremental innovation	489
18	Exploration and exploitation and innovation	2,522
19	Radical innovation* and incremental innovation* and "team*"(2009-2019) peer reviewed only	99
20	("dynamic capabilit*) AND (radical OR incremental OR ambidext* OR explorator* OR exploitat*) n5 innovat* (2009-2019) peer reviewed only	306

After utilizing the Boolean operations two (2) final comprehensive search strings were developed. Final search string one (1) was for "targeted articles" using key study variables and search string two (2) was to ensure the search was comprehensive.

1. "radical innovation*" AND "incremental innovation*" AND "team*
2. ("dynamic capabilit*) AND (radical OR incremental OR ambidext* OR explorator* OR exploitat*) n5 innovat*

Figure 2 captures the overall method applied for analysis of articles utilized in the research. After initial phase 1 exploration, the search for literature was narrowed down to 10 years from 2009 through 2019. The search criteria were narrowed even further to 2014 through 2019 to better understand the gaps in the literature and areas of opportunities for future studies. The following limiters were established for phase 2 of the search: (a) Peer reviewed only articles and (b) English only. Exclusion criteria were: (a) not education; (b) not university and (c) not school. In addition, no grey literature was included. Articles were then chosen based on an in-depth review of abstracts looking for empirical studies and strong conceptual/theorectical papers. A systematic checklist was used to further evaluate articles which would be surveyed/read in depth; the checklist looked at the following features: year of publication; sample size; study validity such as internal/external or scale reliability such as Cronbach's alpha; study design; sample characteristics such as longitudinal study or cross sectional studies; findings and conclusions; limitations and constraints; research hypotheses and relevance of the article to the research question for this research paper. After the in-depth analysis of over 250 articles, a quality assessment tool was employed to choose the final primary articles for the research paper. The quality assessment

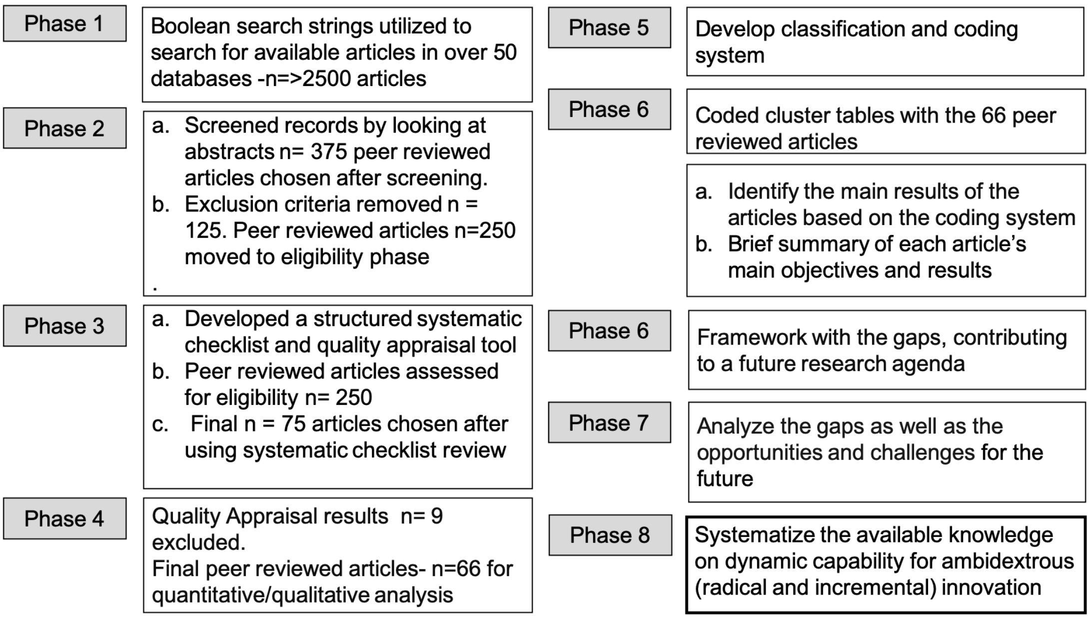


Fig. 2. The methodology phases of the integrative systematic research.

tool looked at the following features to establish rigor: transparency; accuracy; purposivety; utility; propriety; accessibility and specificity. Then the number of articles were narrowed down to 66 articles. A structured classification coding system was established; this included looking at SCOPUS citations as a criterion to establish credibility. Appendix A, Tables A.1 through A.8 features cluster tables with the coding of each article. Clusters were formed using titles and abstracts of the 66 articles chosen as final data set for the research. The methodology was rounded out by: (a) Identifying and analyzing findings; (b) Evaluating gaps; and (c) Challenges and opportunities for future studies. The value of the synthesis of scholarly articles was articulated by Vance et al. (2013). Vance et al. (2013) mentioned it was important not to be swayed by any single article, rather it was important to look at several articles. This look should be to the point of understanding that studies which could be regarded as “scientifically flawed” may in fact “energize the field” of study and drive researchers to “examine their phenomenon of interest in new ways" (p. 69).

2.2 Definitions

- *Radical Innovation* – (Sheng and Chien, 2016) defines radical innovation as involving “the acquisition of new knowledge and the development of new products for new customers or emerging markets” (p.2303). While Norman and Verganti (2014) views radial innovation as a change of frame (i.e., “doing what we did not do before”) (p.82). An example in the pharmaceutical biotechnology industry was moving from small molecules to large molecules such as biologics to cell-based therapy and now in the 21st century to gene therapy (modifying genetic coding) to cure diseases.
- *Incremental Innovation* – (Sheng, 2016) defines incremental innovation as “to enhance the

firm's existing knowledge and improve existing products" (p.2303). On the other hand, Norman (2014) views incremental innovation as improvements within a given frame of solutions (i.e., "doing better what we already do") (p.82). An example of this in the PBI is the improvements of vaccines, from a pentavalent vaccine to an 18 valent vaccine. A single dose of vaccine covering 18 different diseases.

- *Ambidextrous Innovation* - Zacher et al. (2016) elaborated that in the management literature, that ambidextrous innovation is the term employed to refer to an "organization's ability to explore new capabilities and, at the same time, to exploit their existing competencies".
- *Exploration* is defined as "generates new knowledge that supports disruptive innovations" (Ferrary 2011).
- *Exploitation* is defined as "industrializes and commercializes them [current innovations]" (Ferrary, 2011).

3 Background

3.1 Theoretical framework

Socio-technical theory (STT) was explored along with dynamic capabilities for this research paper. Dynamic capabilities were viewed as a mechanism or intervention for the research question which was being explored. The research question being analyzed is associated with *teams* hence there was the need to look at a theory associated with *team* behaviors. STT was chosen because it emphasizes the strong relationship between people, task, behavior and technology, which will be explored both from the STT vantage point but also the connection of STT to dynamic capabilities from a behavioral and technology perspective. Slayton and Spinardi (2016) contended that companies which operate under competitive innovative spaces must contend with being "compatible with a broader *sociotechnical* regime—a complex, heterogeneous, and interdependent network of organizations, artifacts, engineering practices, skilled workers, government policies, financing systems and consumers" (p.47).

Xiang et al. (2014) observed that STT perceives the group or company as a work structure with two interconnected substructures: the technical structure and the social structure. The technical structure is concerned with the "processes, tasks, and technology" needed to convert inputs such as drug substances to outputs such as drug products; the social structure is concerned with the interactions among "people and their attitudes, skills, and values". The outputs of a work structure are a result of the shared interface between these two structures (p.775).

While Klein (2014) made the critical observation, STT "makes explicit" that technology and people are "interdependent" (p.138). Technology affects the behavior of the people and the behavior of the people affects the "working of the technology". This connection begins at the design and development stages of the technology. Klein (2014) furthers the examination by stating that factors which impact the outputs at the end of a technology implementation also affect the inputs at the beginning. This interdependence becomes a crucial part of the argument being constructed to support innovation management in the presence of ambidextrous activities. The distinction between the "social" constructs and the "technology" constructs in the PBI must be understood along with its impact to *teams*. The research in this area lends support to understanding the underpinnings of STT when supported by a framework. This lends more value to *teams* existing in a radical innovation space within the PBI. The underpinnings of *socio-technology* constructs with the dynamic capabilities conceptual framework becomes the basis for this research paper.

3.2 Conceptual Framework

There are multiple definitions associated with dynamic capabilities. Dynamic capabilities were defined by Dora (2015) as a new construct with "the ability of firms to innovate and create value for the company's resources to deal with environmental changes both inside and outside the company" (p.9). A strategic management researcher, (the originator of the term dynamic capabilities), Teece et al. (1997) referred to dynamic capabilities as the "the capacity to renew competencies so as to achieve congruence with the changing business environment". This is done by "adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competencies" (p.515).

Teece (2007) conceptualizes dynamic capabilities from four (4) distinct yet pivotal angles as illustrated in the conceptual diagram in Figure 3. For this study dynamic capabilities and its moderating effects are being explored from the perspective of *teams* in the PBI using the core elements of Knowledge Management; Co-specialization; Governance and Decentralization/Decomposability. Teece (2007) further proposed three organizational and managerial processes: (1) Coordinating or integrating; (2) Learning; and (3) Reconfiguring as core elements of dynamic capabilities. These processes are a subset of the ones that support "sensing, seizing, and managing threats". Together they might be thought of as "asset 'orchestration" processes (Lessard et al, 2016, p. 222). The conceptual framework makes abundantly clear the complex nature of innovation in the PBI.

Teece (2007) updated his 1997 definition of dynamic capabilities by stating that it "refers to the capabilities of a company to integrate, build, and reconfigure internal and external resources/competencies to innovate in rapidly changing environments. Teece (2007) is renowned (over 3,500 Scopus citations) for the further definition of dynamic capabilities which states:

> *For analytical purposes, dynamic capabilities can be disaggregated into the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets (p.1319).*

On the other hand, (Wang and Ahmed 2007) made the connection between dynamic capabilities and behavior by defining dynamic capabilities:

> *As a firm's behavioral orientation to constantly integrate, reconfigure, renew and recreate its resources and capabilities, and most importantly, upgrade and reconstruct its core capabilities in response to the changing environment to attain and sustain competitive advantage (p.31).*

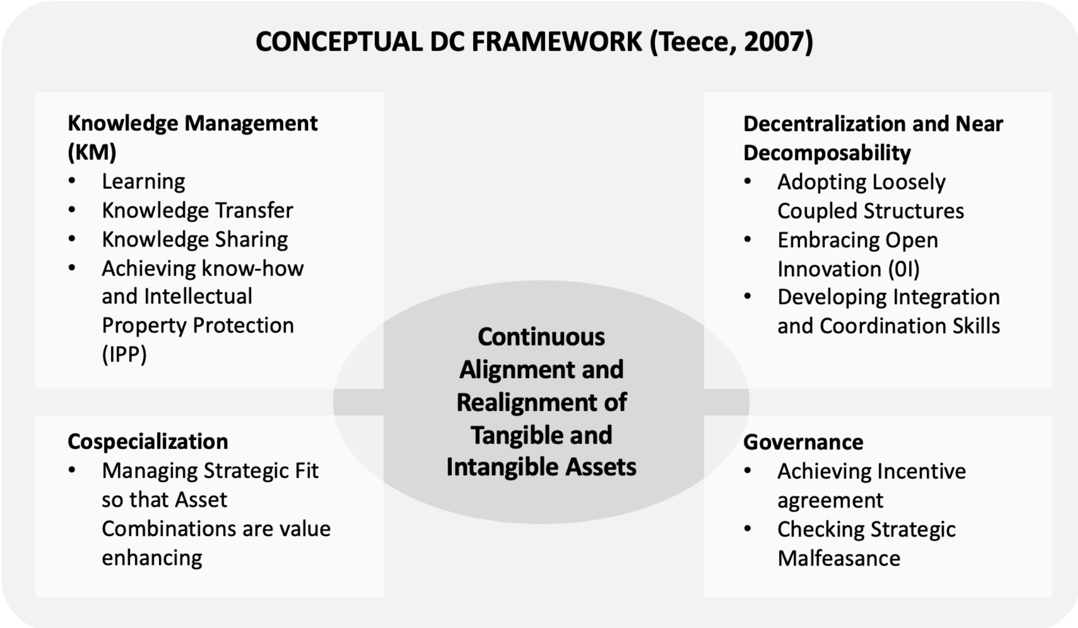


Fig. 3. The dynamic capabilities model "Combination, reconfiguration, and asset protection skills". (D. Teece, 2007, p.1340)

This connection to behavior will also be used to underpin STT to the research and its association with dynamic capabilities for this research paper.

At the core of dynamic capabilities is the ability of senior managers to "seize opportunities through orchestration and integration" (O'Reilly, 2008, p.188). The ability to learn new routines is seen as an "underpinning of long-term competitive advantage" associated with senior *teams* (p.187). The current research for this paper can thereby take the argument further to posit that ambidextrous innovation t*eams* must search for synergy between the radical innovation teams and the incremental innovation teams by "sensing and seizing opportunities and managing threats" (Teece, 2007, p.1341).

According to Teece's (2007) model, knowledge management covers the following: (a) Knowledge transfer; (b) Knowledge sharing; (c) Learning; (d) Know-how integration; and (e) Achieving know-how and intellectual property protection. This larger focus on knowledge management is a direct match for the associated activities within the knowledge intensive arena of the global PBI. This understanding is critical when analyzing the dynamics being faced by the PBI with the never-ending quest for acquisitions and mergers.

4 Literature review

Christensen (1997; 2016) seminal work makes the case for *teams* in line with this research paper. He posited that organizations capabilities lie with "its people" (p.168). Further, he theorized that in the innovation space that *teams* and in particular "heavyweight teams" perform best in the dynamic environment of radical innovation (p.178). This conjecture supports the idea of creating two (2) separate *teams* in the innovation management of the PBI. One would be centered around radical innovation (exploratory) and other to support incremental innovation (exploitative) capabilities.

Christensen (1997; 2016) further discusses the special needs of *teams* who operate within the scope of mergers and acquisitions by noting that the *team* members are not only learning "new processes, new ways of working" which in turn switches over to "new capabilities" but they are "charged to act like general managers, making decisions and trade-offs" in the innovation space (p.178). This autonomy is the crux of the argument associated with this research paper, challenging that more research is needed in the global PBI to examine the dynamic capabilities of *teams* in the environment of ambidextrous innovation. The seminal work by Christensen (1997; 2016) only dedicated one (1) chapter to *teams*, the rest of the research was centered on the organizational and leadership aspects of innovation management. This observation also supports the gap recognized in the literature as alluded to earlier in this research paper.

4.1 Radical Innovation

Evaluation of the data showed, eight (8) of the 66 articles out of the bibliographic database centered on radical innovation. Many of the articles accentuated the relevance of radical innovation to the PBI. Slayton (2016) findings are particularly relevant to understanding the challenges facing "commercialization of radical innovations (for example, biotechnology)" (p.55). Slayton further made a salient point that "classic distinction between process and product innovations maybe misleading in such emerging areas" such as the PBI (p.56). This article was a unique article because of its significance to this research paper due to the research looking at STT (people, behavior, skills) and radical innovation simultaneously On the other hand, (Cheng et al., 2016) results revealed that the effects of open innovation inbound and outbound activities on radical innovation are contingent on both *knowledge acquisition* and sharing capabilities. While, Carlo et al. (2012), evaluated knowledge diversity, depth, and linkages which are tied to the level of radical innovation in the organization. In addition, Fores and Camison (2016), study emphasized the multi-dimensional nature of this complex construct, and explicitly recognizes the importance of transformation capability. This capability is the combination of new external knowledge with the existing knowledge base and mental models. The purpose of doing so is to create a more tacit and specific knowledge that is not observable easily and thus imitated by competitors. Zhou and Li (2012), determined that firms with a broad and deep knowledge base could develop radical innovation in the presence of internal knowledge sharing rather than external focused market knowledge acquisition. Norman (2014) observed that radical innovation is "what everyone wants" given its significant potential to differentiate successful organizations. Further observation by Norman (2014) was, "successful radical innovation is surprisingly rare, and most attempts at it fail" (p.83). Lassen et al. (2006), study solidifies the discussion of radical innovation by linking it to "proactiveness, risk-taking, autonomy, and competitive aggressiveness" which causes stimulation and development of radical innovation (p.363). Kelley et al. (2011), research resonates with this research paper by identifying that not only must *team* members have high expertise and diverse thinking, but their behaviors must be considered. Kelley (2011) positioned that "innovative capabilities are more than an orientation, but also a skill that can be identified and observed in one's behavior, and perhaps developed" (p.260). It is therefore critical for managers in the radical innovation environment to understand this concept and ensure *teams* are structured based on this knowledge. One of the most profound findings in this study was the feedback from the participants in the research. It was proposed that management and organizations needed to support and accept "failure" in a radical innovation environment (p.264). Only when this happens can *team* members surmount many obstacles to bring cutting edge technology to the market.

4.2 Incremental Innovation

Further evaluation revealed that seven (7) of the 66 articles from the bibliographic database centered on incremental innovation and its relevance to the PBI. Several studies examined *team* efforts for incremental innovation "encourage teamwork, *team* decision making, and internal communication" (Doran and Ryan, 2014; Beck et al.,2016; Sheng, 2016). The studies made the connection of incremental innovation to learning. Learning orientation in high-technology firms occurs when core organizational competencies continually develop and refine, thereby maintaining the competitive advantage of a firm within the focal market (Sheng, 2016). Learning orientation in high-tech firms such as the PBI can thus cause them to fail to appreciate the wider context in which learning takes place such as the need to move away from incremental innovation and pivot towards radical innovation. The creation of procedures enables incremental innovation *teams* to "sense" or are alerted to "threats and opportunities" as part of maintaining a strategic competitive edge (Beck et al. 2016, p.872). This becomes a critical decision-making intersection for *team* managers to support incremental innovation.

Doran and Ryan (2014) postulated that several skills are critical for incremental innovation, "problem solving skills, market research skills and management skills" (p.107; p.109) The process of learning orientation involves responding to market conditions. This is a critical point to take into consideration when forming *teams* in the PBI. Most scientists in the PBI arena need to acquire or learn marketing and management skills. Doran (2014) further expounded on the need to distribute the resulting knowledge within the organization and take responsive actions internally and externally. This point supports the mergers and acquisitions constructs which are routine in the PBI.

Fores and Camison (2016) findings provided support for the view that as "firms develop their internal knowledge creation capability, they are better able to apply the new knowledge created to refine and extend product, process and management methods" (p.844). This argument supports the "generation of incremental innovation performance, but not radical innovation performance" (Fores, 2016, p.844). Norman and Verganti (2014) further positioned that incremental innovation refers to the "small changes in a product that help to improve its performance, lower its costs, and enhance its desirability, or simply result in a new model release" (p.84). This study made a strong statement in support of incremental innovation by noting that "successful products undergo continual incremental innovation, intended to lower their costs and enhance effectiveness" (Norman, 2014, p.84). Further postulation by (Chen et al, 2014; Mei et al., 2013) supported that there was need for balance of ambidextrous (radical and incremental) innovation. Chen et al. (2014) further contended that "pursuit of both exploration and exploitation(ambidexterity) is one of the key determinants of innovation outcomes" (p.7792). This need recognizes that there is "short term efficiency" to be gained by improving "existing products". However, as noted incremental innovation is not sustainable in the face of market and technological shifts (Mei, 2013, p.5). This observation puts more onus on *team* managers to recognize the delicate balance needed between radical innovation and incremental innovation.

4.3 Dynamic capabilities

Among the 66 articles from the bibliographic database, the total of 15 articles were chosen under the topic of dynamic capabilities. The articles featured in this discussion (Teece, 2007; O'Reilly and Tushman, 2008; Ambrosini et al., 2009; Cetindamar et al., 2009; Hung, et al., 2010; Gao and Tian, 2014; Tseng and Pei-Shan, 2014; Arifin and Frmanzah,2015; Lessard et al., 2016; Shin, et al. 2016; Prescott, 2016; Dangelico, et al., 2017; Hasegan, et al., 2018; Wang and Hsu, 2018; Shan, et al., 2018;) viewed dynamic capabilities as the mechanism by which innovation is driven or hindered. These articles ran the gamut in terms of types of studies over a 10-year period solidifying the strong tie between dynamic capabilities and innovation. Prescott (2016) captured the essence of dynamic capabilities in the PBI by stating that they include "capabilities and routines for acquisitions or mergers, for research and development, for business process reengineering, for quality control, and for technology transfer" (p,94).

There are several good examples of the effects of dynamic capabilities in the PBI. Gillespie et al., (2019) detailed the collaborative efforts of Pfizer, Novartis, Takeda, Johnson & Johnson, Astra Zeneca, Sanofi and Merck to name a few multinational global pharmaceutical biotechnology companies. Many of these organizations had to use Open Innovation, going as far as setting up global platforms to support research and development while forming affiliations and consortiums with academia (pp. 68-69). Furthermore, use of social media platforms, crowdsourcing and outsourcing became the new age way of doing business in the 21st century (p.63).

In addition, Pfizer, Novartis and other top-ranking pharmaceutical organizations decided to move away from historical pharmaceutical small molecule products to large molecules biotechnology products. There has been a more recent leap towards gene therapy, the cutting-edge technology utilizing genetic modification to treat patients both in oncology and rare disease settings. Pfizer who is renowned for its vaccines sensed the change in the types of medicine and treatment for oncology and the unmet needs of rare disease, it quickly acquired a small gene therapy biotechnology company, Bamboo Therapeutic, in 2016 with rapid expansion as part of its acquisition vision (pharmaceutical-technology.com,, 2018). Novartis renowned for its deep pipeline of oncology drugs sensed the rapid growth in the gene therapy arena and acquired the gene therapy company, AveXis, in 2018 (Novartis.com, 2018). Both Pfizer and Novartis sensed the threat of medicines going off patent as well as the trajectory in different treatment plans for oncology patients and rare diseases. They both had to seize the opportunities either to acquire organizations using cutting edge technology such as gene therapy and reconfigure their areas of expertise by way of mergers and acquisitions. Divestment of their portfolios was a strategic effort on the part of both Pfizer and Novartis to ensure both entities could remain competitive and solvent.

Wang and Hsu (2018) posited that critical theory and practice of dynamic capabilities indicates a firms' competitive advantages, particularly in complex, volatile, and uncertain external environments such as the PBI. Furthermore, capabilities are shared within organization *teams* before being distributed across the firm. A firm's ability to absorb knowledge or its absorptive capacity proves that it possesses learning capability. The data indicated that learning capability is the most critical interaction factor for firms in the PBI. The most interesting part of this finding is that organizational *teams* are being associated with *learning,* a dynamic capability moderator as noted in Teece's work.

Lessard et al (2016) expounded on the effect of dynamic capabilities that allow a firm to "sense and seize opportunities or threats, and integrate, build, and reconfigure" internal and external resources and routines to address rapidly changing environments. Dynamic capabilities are rooted in high-level routines and analytical methodologies that determine the speed and degree of aligning specific resources. This enables modification or even transformation continuously in order to match the requirements of the business environment (p.214). Lessard et al., (2016) stated that dynamic capabilities are reliant on the organization's values, culture, and collective ability, which mainly result from past management efforts and are embedded in the organization's habitual domains. This argument is quite profound because *teams* are not being recognized as part of the intangible or tangible assets of the organization. It also supports the gap noted earlier in the research paper. Furthermore, it should be mentioned that "analytical methodologies" indicated earlier are performed by highly skilled *teams.* Hence during mergers and acquisitions it is important to ensure that this aspect of dynamic capabilities is addressed appropriately.

4.4 Teams

Quite striking in the research was the fact that only four (4) articles of the 66 articles in the bibliographic database for this research paper focused on *teams* in radical innovation and incremental innovation. This lends support to the gaps observed in the literature within the radical innovation and incremental innovation in the global PBI previously stated in this paper. The research by Patanakul et al. (2012) confirmed that "heavyweight *teams*" consist of a core group of people who are typically dedicated and physically located near each other. The distinguishing feature of this *team* is the authority or weight of the project manager. Advantages of "heavyweight *teams*" include effective coordination across disciplines, a feeling of being on a *team* with a shared sense of purpose and mission, and the authority to complete the job (p.736). These observations are in sync with the writings of Christensen (1997;2016) around the importance of "heavyweight *teams*" in innovative spaces in radical innovation.

Heavey and Simsek (2014) recognized the behavioral element of *teams* was important to radical innovation and incremental innovation by stating that "behavioral integration explains how top management *teams* meet the integrative challenges of ambidexterity" (p.19). In addition, it was noted in the study that "knowledge can be cultivated and exchanged" in the ambidextrous environment due to the intellectual capacity of the *teams.* The study did not emphasize *teams* at the cellular level, at the technical specialist levels but focused more on *teams* at the senior managerial level and CEOs. This observation lends more credibility to the fact that there is a gap in the literature for radical innovation and incremental innovation *teams* in the global PBI.

The study by Alexander and van Knippenberg (2014) underscored that the more radical the innovation, the less *teams* can rely on prior competencies, knowledge, and experience, because these may in part or whole be inadequate or extraneous. This means that *teams* must invest in developing new competencies and knowledge to be able to successfully pursue radical innovation. Learning and development are integral parts of the radical innovation process. Learning from failure is essential, if not *teams* may take the option of less radical alternatives. Therefore, unless *teams* pursuing radical innovations respond effectively to negative feedback and rejection from senior management and view failure as an opportunity to learn, the stream of radically new innovative ideas critical for organizational growth will decline (p.428). *Teams* must act as dynamic systems that respond to shifting demands (p.434).

Another study by Nissen et al. (2014) recognized that "knowledge sharing, and the building of a shared knowledge base are needed to deal with [team] heterogeneity" (p.479). It is important to effectively balance the "different complementary knowledge bases" which are attached to "tacit knowledge held by *team* members". The study underscores that "re-establishment or re-creation of shared knowledge" bases are needed because shared knowledge bases are not "static" communal pools of knowledge (p.480).

4.5 Knowledge Management

Subsequent evaluation revealed that nine (9) articles out of the 66 articles in the bibliographic database featured knowledge management and its link with innovation. Early into the research for this paper, and as noted in previous sections of the paper, the connection of knowledge with innovation was made in past research. However, it is critical to understand the different facets of knowledge to be able to understand the types of connections to innovation. Knowledge is categorized into tacit and explicit patterns. Tacit knowledge is defined as personal knowledge embedded in individual experience that involves intangible factors such as personal belief, perspective, and value system (Yu et al., 2013, p.146). This type of knowledge is not easily transferred or cannot be written down. In contrast, explicit knowledge is defined as knowledge which can be articulated in formal language including grammatical statements, mathematical expressions, specifications, manuals, and so forth (Yu et al.,2013, p.146). A key facet of the study by (Yu et al, 2013) is the moderating effects of knowledge and by deduction dynamic capabilities is quite striking in the innovation space. In addition, the association of innovative behavior and its effects not only at the individual level but at the *team* level. This supports the use of the STT used to underpin the current research paper due to behavior and culture being associated with knowledge management a dynamic capability moderator.

It is imperative with this understanding of tacit knowledge for the PBI to codify and convert tacit knowledge to explicit knowledge in the form of data capturing tools, operational manuals, operating procedures and other learning tools after mergers and acquisitions. In addition, with the advent of Big Data, most pharmaceutical and biotechnology must have data analytics tools in place to capture the tacit knowledge and convert it to knowledge which can be replicated and used for decision making.

Schneckenberg et al. (2015) study revealed that innovative capabilities of firms in fast moving, fast markets rely more on creating and sharing higher-level contextual knowledge than on reusing existing knowledge. This focus on contextual knowledge is essential for innovative performance, as firms in fast-moving markets require a continuous evolution of dynamic capabilities (p.359). Work organization in innovation projects occurs mostly at the group level while project *teams* define targets and specify resource requirements. It is important to take note of the power of *teams* in this context.

Basnayaka & Jayakody (2018) study showed that knowledge management practices resulted in *team* performance. Furthermore, the study showed that the theory of dynamic capabilities may be a useful conceptual framework for understanding the relationship between a *team's* knowledge management practices and its performance (p.22). The connection of dynamic capabilities to acquisitions and mergers further underpins the connection of dynamic capabilities to "resource endowment" in response to external partners. This connection ultimately determines *teams* and associated organizational competitive edge.

Learning. The observation was made by (Sheng, 2016) that there was the "need to resolve the strategic dilemma and overcome the myopia of learning orientation, high-technology firms can implement exploratory learning, which involves learning and acquiring knowledge outside existing customer boundaries and often entails experimentation and risk-prone behavior" (p.2307). Hannachi (2016) expounded on the value of learning and the connection to *teams*. This idea of acquiring, sharing and developing knowledge is recognized as value that organizations is carried out in the *team* environment (pp.51-52). Therefore, this needs to be nurtured and promoted at the individual and *team* level for competitive edge. Overall, learning is critical to innovation and particularly in high technology organizations like the global PBI.

Knowledge Transfer. In knowledge transfer, an enterprise should encourage their employees to proactively retrieve, filter, store, transfer, and share knowledge from individuals to the organization (Tseng, 2014, p.172). Knowledge management capability is significantly associated with the degree of dynamic capabilities and organizational performance and by extension *team* performance. The factors of knowledge management capability show a significantly positive correlation with dynamic capabilities and organizational performance. This means that if the knowledge management capability factors in knowledge transfer and knowledge protection as superior, it can significantly enhance dynamic capabilities. This implies that knowledge transfer can effectively enhance dynamic capabilities and organizational performance rather than knowledge protection.

Knowledge Sharing. Yu, et al., (2013) observed that "to survive in a highly competitive environment, enterprises must continue to focus on innovation derived from knowledge" (p.143). The authors further theorized that

when organizations are facing a competitive environment with trans-national and trans-team characteristics, knowledge sharing should achieve trans-disciplinary integration and those working to promote knowledge sharing in their organization should identify and utilize factors that promote knowledge sharing at multiple levels instead of focusing only on sharing and transfer itself" (p.144).

The magnitude of knowledge sharing therefore is critical to sustainability particularly in "fast industrial and technological shifts" such as in the global PBI. Thus, organizations can convert tacit and explicit knowledge into strengths.

Knowledge sharing interactions of *team* members often reach beyond the work group to expert communities, for example to access complementary knowledge inflows or to evaluate the potential value of innovative technologies for the project context (Schneckenberg et al., 2015, p.364). One area of dilemma that is being faced at this juncture is when *team* orientations become very rigid or unyielding. This run counter to the idea of knowledge sharing hence an awareness need surfaces and must be tended by managers in this environment to support knowledge sharing.

Tseng (2014) stated that the "knowledge infrastructure includes technology, structure, and culture; while knowledge management processes include the organizational capabilities of knowledge acquisition, conversion, application, and protection. Simultaneously, in order to effectively leverage knowledge infrastructure, it is crucial to rely on knowledge management processes, which makes it possible to store, transform, and transfer knowledge" (p.159). This is yet another observation which ties together the underpinnings of the chosen theory STT with dynamic capabilities as being integral to understanding how *teams* operate in the PBI innovation arena

Knowledge sharing promotes internalization of a greater amount of knowledge. Such conditions benefit innovative behavior. Personal innovation is affected by cognitive ability, character, knowledge, inner motives, and social networks; noted that faster knowledge transfer through sharing helps cultivate the ability to think and create. Socialization, externalization, combination and internalization have been identified as conducive to knowledge creation and exchange showed that top-down, bottom-up, and horizontal knowledge flows all affect the innovative behavior of midlevel managers (Tseng, 2014, p.145). An organization itself is unable to create knowledge and individuals are the medium to spread knowledge through sharing. The organizational culture in each department may cause variations in organizational atmosphere among departments. Such variations influence employees' perceptions of atmosphere and their behavior (Tseng, 2014, pp. 146-147). Therefore, managers in the global PBI should actively strengthen employees' understanding of knowledge sharing so that employees can share knowledge in an unrestricted manner. The more that employees are involved in individual knowledge sharing, the more such knowledge is internalized (Tseng, 2014, p.152). Organizational innovation climate is an organizational-level issue, whereas knowledge sharing, and employees' innovative behavior are individual-level issues. These issues should not be treated as a single-level problem (Tseng, 2014, p.153).

4.6 Open Innovation

This topic featured eight (8) papers out of the total 66 articles from the bibliographic database. Cheng et al., (2016) and Ferrary (2011) studies observed very specific findings associated with open innovation, *knowledge acquisition* and knowledge sharing:

1. In the open innovation paradigm, specialized organizations that outsource innovation and focus on exploitation can be more competitive than ambidextrous organizations.

2. Innovation life cycle should be understood and managed as an inter-organizational process instead of as an intra-organizational one.
3. The effectiveness of an acquisitive strategy depends partly on the firm's capability to nurture informal social ties with the network of organizations bearing innovations, such as research labs.
4. Implementation of an outsourcing strategy of innovation depends on the embeddedness of the firm in its business environment.
5. Organizations should have an embedding strategy to access information on innovation.

Amponsah and Adams (2017); Shi and Zhang (2018); Kang and Hwang (2019) studies confirmed the strong relationship with knowledge, ambidextrous innovation and open innovation. Amponsah (2017) concluded that classification of "open innovation requires a balancing act of knowledge exploration and exploitation (ambidexterity) for commercialisation of the firm" (p. 1750027-18). This was one (1) of the few studies that made the connection between systemization and open innovation at all levels of the organization including the individual level and group level (*teams*). Shi and Zhang (2018) observed the need for "open innovation networks" and the development of strong relationships with "knowledge transfer" being a top priority (p.592). Peris-Ortiz et al (2018) study confirmed the connection of open innovation to radical and incremental innovation in knowledge-based companies. These findings are quite relevant to the PBI because open innovation has become one (1) of the strategic mechanisms to support competitive edge.

Gassmann et al., (2012) observed that network building comprises measures to establish personal networks between senior and middle managers of exploration units (teams) and operational business based on social platforms. Direct exchange and communication are regarded crucial for the formation of personal linkages. The personal contacts are used to identify and interact with innovation champions throughout the company. This network discussion ties in with the STT theory utilized for this research as well the open innovation, dynamic capabilities and knowledge management discussions. The synergy in these areas must be captured and nurtured during mergers and acquisitions in the PBI.

4.7 Ambidextrous (Explorative and Exploitative) Innovation

The final clusters of 15 articles within the 66 articles for the bibliography database were related to ambidextrous innovation also known as exploitative innovation and explorative innovation. These articles were accessed and reviewed together because of the inter-connectedness of the subject areas associated with innovation. One observation which was a common theme was the need for effective *team* leaders to foster both exploitation and exploration, and switch flexibly between them (Rosing et al., 2011). Hoang and Rothaermel, 2010; Soosay and Hyland, 2008; Wang and Rafiq, 2014; Andriopoulos and Lewis, 2009; Wang et al., 2014; Martini et al., 2013; Gilsing and Nooteboom, 2006; Dunlap et al, 2016; examined exploratory innovation and exploitative innovation from the following perspective: (a) meeting the emerging market and customer needs; (b) carrying out new designs; and (c) developing new markets or opening new distribution channels relying on new knowledge. By doing these activities organizations can accomplish the following: (a) broaden the breadth of knowledge; (b) produce a series of product and process innovations; and (c) improve the flexibility and diversity of the organization. It therefore becomes critical for leaders and managers to understand how to position *teams* to be exploitative and explorative simultaneously in the PBI.

On the topic of ambidextrous innovation, (Yi et al. 2019; Martini et al., 2013; O'Reilly and Tushman, 2008; Lee et al., 2019; Vorraber et al., 2019; Dunlap et al.,2016; Jansen et al., 2012), postulated that ambidextrous innovation requires both "opening and closing" capabilities to remain competitive. In addition, Zacher et al. (2016) verified that *team* leaders needed to engage in both "opening and closing" or ambidextrous behaviors to produce high levels of innovation. However, risk tolerance plays a role in the effectiveness of *team* leaders. The research found that risk-taking managers tended towards exploratory (radical) innovation and risk-intolerant managers tended towards exploitative (incremental) innovation. This knowledge should help leaders to position the risk tolerant managers and *teams* in the radical innovation environment or explorative innovation space not in the incremental innovation space.

5 Analysis

Two (2) areas closely connected came to the surface during the quest for answering the research question and it was the deep connection between *knowledge acquisition* and open innovation. These two elements are closely associated with the Teece's framework and the conceptual framework being featured in this research paper. However, *knowledge acquisition* was not specifically called out in the Teece framework. This deep and profound connection was not evident at the outset of the research but in looking more in depth at the research being explored this connection surfaced in the literature. Gedvilaitė (2015) and Fores (2016) among other studies observed the close-knit connection to *knowledge acquisition* and innovation, Fores (2016) used the word "symbiosis" which gives the connotation that both knowledge acquisition (internal and external) and radical innovation feeds and thrives directly off of each other (p.835). In addition, Gedvilaitė (2015) saw that "*knowledge acquisition* is important to apply, store, share and preserve vital knowledge resources" (p.25) and view "*knowledge acquisition* as partnerships, recruitments or organic growth, company acquisitions and internal learning" (p.45). Therefore, the conclusion one can draw from this analysis is that *knowledge acquisition* has been identified as a source of competitive edge.

This observation should not be lost on organizations, managers and leaders in the global PBI. The management and care of knowledge that is acquired should be on the top agenda of any CEO and manager of *teams* in the PBI. The ability to harness this source of power in any organization by hiring a Chief Information Officer to oversee *knowledge acquisition* aspects of the organizations being merged or acquired. Prioritization of this often-overlooked area should be given and be added to the overall vision and strategy of organizations in the PBI.

Several articles featured in this systematic literature review transcended major key areas being explored in this study, for example several articles researched featured knowledge management, dynamic capability and ambidexterity in combination. Thereby reinforcing the deep connectivity of the conceptual framework to this area of research. This lends credibility to the research method and search criteria employed for this study. The following studies: (Jansen et al., 2005; Jansen et al., 2008; Bierly, et al., 2009; Jansen et al., 2009; Faffery, 2011; Jansen et al., 2012; Norman and Verganti, 2014; Fores, 2016; Kang and Hwang, 2019a; Kang and Kim, 2019b); encompassed several of the keywords, constructs and key ideas as can be noted in their abstracts. This connection was on a multi-dimensional level such as looking at radical innovation, open innovation in combination with knowledge management and/or dynamic capabilities. These studies were comprehensive in nature and helped to determine that there is opportunity for future studies associated with ambidextrous innovation *teams* in the PBI. The gap in the literature was quite evident that *teams* and the dynamics of *teams* operating and functioning in the global PBI is lacking. Furthermore, this gap needs to be addressed to create new knowledge and support *knowledge acquisitions* during mergers and acquisitions. These areas having been identified in this study serves as precursors for future research.

6 Findings and managerial implications

The moderating effects of dynamic capabilities on *teams* in the PBI are centered on rapid team alignment with the triplex of sensing, seizing and managing threats [reconfiguring] (Teece, 2007). Table 2 captures the research findings. Figure 4 is the updated conceptual model post research analysis of Figure 1.

Table 2. Research finding showing relationships of innovation to knowledge management and moderating effects

Innovation type	Knowledge management type	Moderating effect
Radical innovation	Knowledge transfer Knowledge share Knowledge creation	Positive
Incremental Innovation	Learning	Positive
Open Innovation	Knowledge acquisition	Positive on radical innovation

Knowledge management is the most impactful element of dynamic capabilities in the PBI followed closely by intellectual property protection. By seizing new knowledge, sensing tacit knowledge, reconfiguring explicit knowledge and implicit knowledge, *teams* constantly seek the advantage through radical innovation. This is accomplished by *teams* through transferring, sharing and creating knowledge which determines the success of *teams*. Knowledge sharing strengthens existing professional knowledge, enhances internal work coordination and consistency in employees' behavior, and effectively integrates diverse *team* knowledge and experience (Yi et al., 2019). This huge responsibility is borne by technologists or specialists, but their role is not emphasized in the literature. The literature is extant on how teams are affected by governance, a dynamic capability element. Open innovation, another critical dynamic capability element, enables knowledge acquisition from external sources, knowledge sharing and know-how (internal sources) into a symbiotic relationship (Fores, 2016). Open Innovation has a positive effect on radical innovation (Cheng et al., 2016). Learning orientation which is refining existing knowledge and processes has a stronger effect on incremental innovation than on radical innovation (Sheng, 2016).

Zacher et al. (2016) along with other researchers have proposed that ambidextrous organizations are more successful because of their greater capacity to innovate. The research has shown that organizations with high levels of both exploration and exploitation activities have higher sales growth rates and organizational performance than organizations with low levels in either or both activities. Senior leaders must give t*eams* the autonomy to make decisions from a technical perspective even if this means failure (Alexander, 2014). Due to the nature of the technology, *teams* must be allowed to explore and exploit simultaneously in the innovation space for organizations in the PBI to outperform their rivals. This requires managers to be sensitive to balancing *team* activities of radical innovation and incremental innovation.

Knowledge sharing and knowledge transfer must be managed in a systematic way to retain authenticity of information. Tacit knowledge by its very nature will need to be transferred on a larger scale to help with new knowledge creation. Based on the findings, open innovation, must be promoted during mergers and acquisitions and should be a value enhancing activity. On the other hand, investments in learning orientation for teams should be given priority during and after acquisitions and mergers. The value of knowledge acquisition must be explored, quantified and become a core central element of innovation particularly in the open innovation spaces after mergers and acquisitions have taken place. The global PBI environment is ripe with knowledge intensive *teams* and managers need to recognize and capitalize on this to be successful and remain competitive.

The PBI outranks all other industries in terms of mergers and acquisitions as previously stated by the United States of America Government Accountability Office. Therefore, this research paper is bringing to the forefront the salient message that innovation at all levels (radical, incremental, open) must be addressed in terms of knowledge management. The need for pharmaceutical and biotechnology entities to remain competitive should motivate leaders within the industry to support *knowledge acquisition* not only in words but also by actions such as providing resources for data protection. Consequently, this research should serve as impetus to garner knowledge in its various forms (sharing, transferring, acquiring) and treating it is as tangible assets during mergers and acquisitions.

The case history of Pfizer and Novartis mentioned earlier in this research paper plays into the management implications. The acquisitions and mergers entail the merger of *teams* across an established entity and a newer organization. It is therefore of great value to ensure that both entities on either side of the paradigm shift maximize the opportunities for growth within and outside of the *teams* involved in these transactions. This can be done by ensuring the dynamic capabilities of open innovation, knowledge management, and most critically *knowledge acquisition*, are given the greatest priority. Gillespie, et al (2019) concurred with this deduction by stating both open innovation and knowledge management must be viewed as "strategic capability alignment" (p. 70) towards a sustainable business model in support of radical innovation and incremental innovation (ambidextrous innovation).

ISSN 2183-0606
http://www.open-jim.org

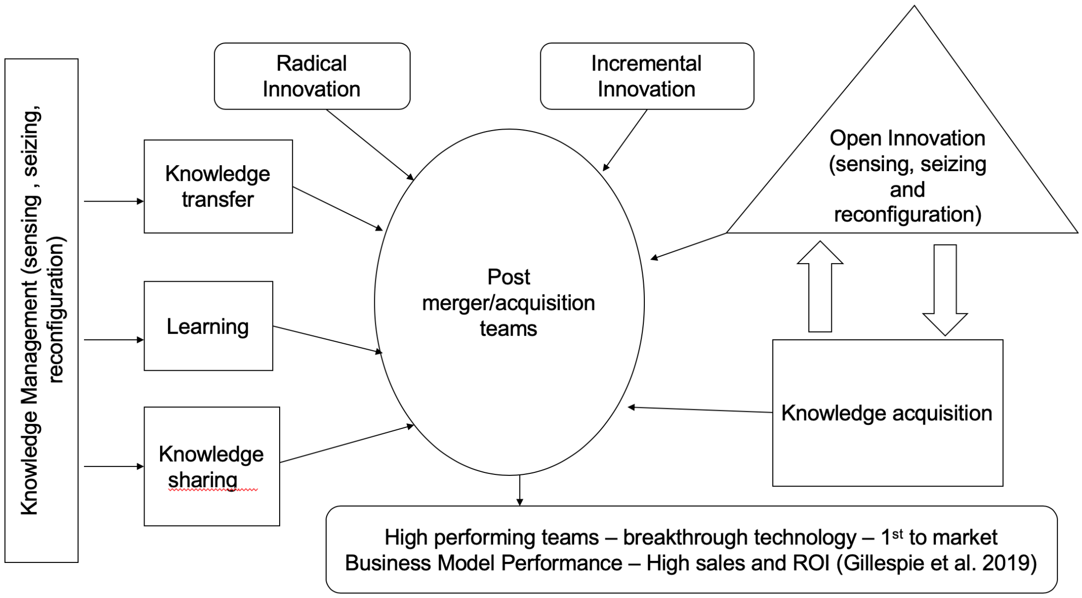


Fig. 4. Model of dynamic "knowledge management" capabilities, radical and incremenatl (ambidextrous) innovation and *teams* conceptualized post research analysis**.**

7 Limitations and future research

The limitations of the study are intrinsic to a systematic literature review, as this research approach does not uncover causality. Hence a longitudinal study of *teams* in the PBI would support a deeper understanding of dynamic capabilities and its moderating effects on radical innovation and incremental innovation. The mediating effects of dynamic capabilities on *teams* in the PBI were not explored for this research. There exist opportunities for future research in this area. The depth and magnitude of dynamic capabilities' effects on teams in the global PBI were not measured, this is an opportunity for future research. The unique skills and traits of *team* members in the ambidextrous innovation *team* environment of the PBI is also another topic for future research. In addition, the research was conducted through the theoretical lens of STT. Future studies could utilize other theoretical frameworks to understand impact to *teams* in the ambidextrous innovation arena.

8 Conclusions

The wide-ranging review, analysis, and synthesis of the moderating effects of dynamic capabilities on radical innovation and incremental innovation in the PBI represents an important contribution to *teams* in this area of research. Success in the PBI is measured in terms of market share. The *team* or entity which gets to market fastest with the most cutting-edge technology is positioned to gain the most financially and have a competitive edge due to intellectual property protection. New knowledge acquired from this study has resulted in the conceptual work done by Teece

(2007) needing to be expanded and updated to incorporate *knowledge acquisition* as a dynamic capability moderator. Hence further research needs to be conducted to fully comprehend the extent of impact *knowledge acquisition* has on radical innovation and incremental innovation in the context of *teams* in the PBI.

Acknowledgements

The author wishes to thank the reviewers and editor for exceptional feedback and valuable insights on earlier versions of this manuscript.

10 References

Alexander, L., & van Knippenberg, D. (2014). Teams in pursuit of radical innovation: A goal orientation perspective. *Academy of Management Review, 39*(4), 423-438.

Ambrosini, V., Bowman, C., & Collier, N. (2009). Dynamic Capabilities: An Exploration of How Firms Renew their Resource Base. *British Journal of Management, 20*, S9–S24.

Amponsah, C. T., & Adams, S. (2017). Open innovation: Systematisation of knowledge exploration and exploitation for commercialisation. *International Journal of Innovation Management, 21*(3).

Andriopoulos, C., & Lewis., M. W. (2009). Exploitation-Exploration Tensions and Organizational Ambidexterity: Managing Paradoxes of Innovation. *Organization Science, 20*(4), 696.

Ardito, L., Messeni Petruzzelli, A., Dezi, L., & Castellano, S. (2018). The influence of inbound open innovation on ambidexterity performance: Does it pay to source knowledge from supply chain stakeholders? *Journal of Business Research.* Online. https: sciencedirect.com/science/article/abs/pii/S01

Arifin, Z., & Frmanzah. (2015). The Effect of Dynamic Capability to Technology Adoption and its Determinant Factors for Improving Firm's Performance; Toward a Conceptual Model. *Procedia - Social and Behavioral Sciences*, 207, 786–796.

Basnayaka, W. B. M. D., & Jayakody, J. A. S. K. (2018). The Effect of Team Knowledge Management Practices on Team Performance: The Moderating Effect of Transformational Leadership and Team Cohesiveness. *Sri Lankan Journal of Management*, 23(2), 1–33

Beck, M., Lopes-Bento, C., & Schenker-Wicki, A. (2016). Radical or incremental: Where does R&D policy hit? *Research Policy, 45*(4), 869–883.

Bianchi M, Croce A, Dell'Era C, Di Benedetto C, Frattini F. (2016) Organizing for Inbound Open Innovation: How External Consultants and a Dedicated R& D Unit Influence Product Innovation Performance. *Journal of Product Innovation Management;33*(4):492.

Bierly, P. E., Damanpour, F., & Santoro, M. D. (2009). The Application of External Knowledge: Organizational Conditions for Exploration and Exploitation. *Journal of Management Studies (Wiley-Blackwell), 46*(3), 481–509.

Campos, E. B., & Sánchez, M. P. S. (2003). Knowledge management in the emerging strategic business process: Information, complexity and imagination. *Journal of Knowledge Management, 7*(2), 5–17.

Carlo, J. L., Lyytinen, K., & Rose, G. M. (2012). A Knowledge-Based Model of Radical Innovation in Small Software Firms. *MIS Quarterly*, 36(3), 865-A10.

Cetindamar, D., Phaal, R., & Probert, D. (2009). Understanding technology management as a dynamic capability: A framework for technology management activities. *Technovation*, 29(4), 237–246.

Chen, Y-U., Chang, C-H & Lin, Y-H. (2014). The Determinants of Green Radical and Incremental Innovation Performance: Green Shared Vision, Green Absorptive Capacity, and Green Organizational Ambidexterity. *Sustainability,* (11), 7787.

Cheng, C. C. J., Yang, C., & Sheu, C. (2016). Effects of open innovation and knowledge-based dynamic capabilities on radical innovation: An empirical study. *Journal of Engineering and Technology Management,* 41, 79–91.

Christensen, C. M. (1997: 2016) *The Innovator's Dilemma: When new technologies cause great firms to fail.* Boston, MA: Harvard Business Review Press.

Dangelico, R. M., Pujari, D., & Pontrandolfo, P. (2017). Green product innovation in manufacturing firms: A sustainability-oriented dynamic capability perspective. *Business Strategy and the Environment*, 26(4), 490–506.

Donate, M. J., & Sánchez de Pablo, J. D. (2015). The role of knowledge-oriented leadership in knowledge management practices and innovation. *Journal of Business Research, 68*(2), 360–370.

Dora, Y. M. (2015) The development of dimensions dynamic capabilities. International conference on social science and management (ICSSAM). Japan. Accessed August 2019. https://www.researchgate.ne

Doran, J., & Ryan, G. (2014). Firms' skills as drivers of radical and incremental innovation. *Economics Letters, 125*(1), 107–109.

Dunlap, D., Parente, R., Geleilate, J.-M., & Marion, T. J. (2016). Organizing for Innovation Ambidexterity in Emerging Markets. *Journal of Leadership & Organizational Studies, 23*(2), 175–190.

Ferrary, M. (2011). Specialized organizations and ambidextrous clusters in the open innovation paradigm. *European Management Journal, 29*(3), 181-192.

Fores, B. & Camison, C. (2016). Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size? *Journal of Business Research, 69*(2), 831-848.

Gao, I. & Tian, Y. (2014). Mechanism of supply chain coordination cased on dynamic capability framework-the mediating role of manufacturing capabilities. *Journal of Industrial Engineering and Management,* (5), 1250.

García Sánchez, E., García Morales, V. J., & Martín-Rojas, R. (2017). Do social networks and technological capabilities help knowledge management? *Journal of Technology Management & Innovation, 12*(4), 65–69.

Gassmann, O., Widenmayer, B., & Zeschky, M. (2012). Implementing radical innovation in the business: the role of transition modes in large firms. *R&D Management*, 42(2), 120–132.

Gedvilaite, D. & Paul, S. (2015) Knowledge Acquisition for a New Business Model Creation and Enabling Factors. (2015). *Lund University Library.* Accessed November 2019. https://lup.lub.lu.se/student-papers/search/publication?q=author+exact+tka12dge.

Gillespie, J. J., Privitera, G. J. & Gaspero, J. (2019). Biopharmaceutical Entrepreneurship, Open Innovation, and the Knowledge Economy. *Journal of Innovation Management*, *(2),* 59.

Gilsing, V., & Nooteboom, B. (2006). Exploration and exploitation in innovation systems: The case of pharmaceutical biotechnology. *Research Policy, 35*(1), 1–23.

Govindan, K., Soleimani, H. & Kannan, D. (2015). Reverse logistics and closed-loop supply chain A comprehensive review to explore the future. *European Journal of Operational Research, 240*(3), 603-626.

Grover, V., Purvis, R. L., & Segars, A. H. (2007). Exploring ambidextrous innovation tendencies in the adoption of telecommunications technologies. *IEEE Transactions on Engineering Management*, 54(2), 268–285.

Grundstein, M. (2013). Towards a technological, organizational, and socio-technical well-balanced KM initiative strategy: A pragmatic approach to knowledge management. *Knowledge Management Research & Practice, 11*(1), 41-52.

Hannachi, Y. (2016). The Impact of the Learning Organization on Product Innovation Performance: An Empirical Assessment in the French Biotechnology Industry. *Management International / International Management / Gestión Internacional, 20*(3), 49-61.

Hasegan, M. F., Nudurupati, S. S., & Childe, S. J. (2018). Predicting performance – a dynamic capability view. *International Journal of Operations & Production Management*, 38(11), 2192–2213.

Heavey, C., & Simsek, Z. (2014). Distributed Cognition in Top Management Teams and Organizational Ambidexterity: The Influence of Transactive Memory Systems. *Journal of Management, 43*(3), 919–945.

Hoang, H., & Rothaermel, F. T. (2010). Leveraging internal and external experience: exploration, exploitation, and R&D project performance. *Strategic Management Journal (John Wiley & Sons, Inc.), 31*(7), 734–758.

Hung, R. Y. Y., Yang, B., Lien, B. Y.-H., McLean, G. N., & Kuo, Y.-M. (2010). Dynamic capability: Impact of process alignment and organizational learning culture on performance. *Journal of World Business, 45*(3), 285–294.

Jansen, J. J. P., Van den,Bosch, F. A. J., & Volberda, H. W. (2005). Exploratory innovation, exploitative innovation and ambidexterity: The impact of environmental and organizational antecedents. *Schmalenbach Business Review (SBR*), 57(4), 351-363.

Jansen, J. J. P., George, G., Van den Bosch, F. A. J., & Volberda, H. W. (2008). Senior Team Attributes and Organizational Ambidexterity: The Moderating Role of Transformational Leadership. *Journal of Management Studies (Wiley-Blackwell)*, 45(5), 982–1007.

Jansen, J. J. P., Vera, D., & Crossan, M. (2009). Strategic leadership for exploration and exploitation: The moderating role of environmental dynamism. *Leadership Quarterly,* 20(1), 5–18.

Jansen, J. J. P., Simsek, Z., & Cao, Q. (2012). Ambidexterity and performance in multiunit contexts: Cross-level moderating effects of structural and resource attributes. *Strategic Management Journal*, 33(11), 1286–1303.

Kang, S., & Hwang, J. (2019). An Investigation into the Performance of an Ambidextrously Balanced Innovator and Its Relatedness to Open Innovation. *Journal of Open Innovation*, 5(2), 23.

Kang, H. & Kim, M. (2019). The Differential Effect of Exploration and Exploitation on Work Performances. *Sustainability, 11*(7), 2074.

Kelley, D. J., O, C. G. C., Neck, H., & Peters, L. (2011). Building an organizational capability for radical innovation: The direct managerial role. *Journal of Engineering and Technology Management, 28*(4), 249–267.

Klein, L. (2014). What do we actually mean by 'sociotechnical'? On values, boundaries and the problems of language. *Applied Ergonomics*, 45(2), 137–142.

Lassen, A. H., Gertsen, F. & Riis, J. O. (2006). The nexus of corporate entrepreneurship and radical innovation. *Creativity & Innovation Management, 15*(4), 359-372.

Lee, Y.J., Shin, K., & Kim, E. (2019). The Influence of a Firm's Capability and Dyadic Relationship of the Knowledge Base on Ambidextrous Innovation in Biopharmaceutical M&As. *Sustainability, 18*, 4920.

Lessard, D., Teece, D. J., & Leih, S. (2016). The Dynamic Capabilities of Meta-Multinationals. *Global Strategy Journal, 6*(3), 211–224.

Martini, A., Laugen, B. T., Gastaldi, L., & Corso, M. (2013). Continuous innovation: towards a paradoxical, ambidextrous combination of exploration and exploitation. *International Journal of Technology Management, 61*(1), 1–22.

Mei, M., Laursen, K., & Atuahene-Gima, K. (2013). Learning to Innovate: How Does Ambidextrous Learning Matter to Radical and Incremental Innovation Capabilities?. Paper presented at The 35th DRUID Celebration Conference 2013: Innovation, Strategy and Entrepreneurship, Barcelona, Spain. In 35th DRUID Celebration Conference (pp. 1-35). Barcelona. Accessed 18th July 2019. http://druid8.sit.aau.dk/druid/acc_papers/sqovmqjil4ot05j9t81opesodanv.pdf

Nielsen, A. P. (2006). Understanding dynamic capabilities through knowledge management. *Journal of Knowledge Management*, 10(4), 59–71.

Nissen, H. A., Evald, M. R., & Clarke, A. H. (2014). Knowledge sharing in heterogeneous teams through collaboration and cooperation: Exemplified through Public–Private-Innovation partnerships. *Industrial Marketing Management, 43*(3), 473–482.

Norman, D.A. & Verganti, R. (2014). Incremental and radical innovation: Design research vs technology and meaning change. *Design Issues, 30*(1), 78-96.

Novartis successfully completes acquisition of AveXis, Inc. Accessed 15th February 2020. https://www.novartis.com/news/media-releases/novartis-successfully-completes-acquisition-avexis-inc.

O'Reilly, C. A., & Tushman, M. L. (2008). Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in Organizational Behavior*, 28, 185–206.

O'Reilly, C. A., & Tushman, M. L. (2013). Organizational ambidexterity: Past, present, and future. *Academy of Management Perspectives, 27*(4), 324–338.

Patanakul, P., Chen, J., & Lynn, G. S. (2012). Autonomous Teams and New Product Development Autonomous Teams and New Product Development. *Journal of Product Innovation Management, 29*(5), 734.

Pérez la Rotta, A., & Herrera, L.C. (2011) Integral business transformation: a global case study. *Industrial and Commercial Training.* 43 (2), 75-78.

Peris-Ortiz, M., Devece-Carañana, C. A., & Navarro-Garcia, A. (2018). Organizational learning capability and open innovation. *Management Decision, 56*(6), 1217–1231.

Pfizer's Gene Therapy Manufacturing Facility Expansion, North Carolina. Accessed 15th February 2020. https://www.pharmaceutical-technology.com/projects/pfizers-gene-therapy-manufacturing-facility.

Prescott, M. E. (2016). Big Data: Innovation and Competitive Advantage in an Information Media Analytics Company. *Journal of Innovation Management, 1*, 92.

Rothaermel, F. T., & Deeds, D. L. (2004). Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development. *Strategic Management Journal (John Wiley & Sons, Inc.)*, 25(3), 201–221.

Rosing, K., Frese, M., & Bausch, A. (2011). Explaining the heterogeneity of the leadership-innovation relationship: Ambidextrous leadership. *Leadership Quarterly*, 22(5), 956–974.

Schneckenberg, D., Truong, Y., & Mazloomi, H. (2015). Microfoundations of innovative capabilities: The leverage of collaborative technologies on organizational learning and knowledge management in a multinational corporation. *Technological Forecasting & Social Change*, 100, 356–368.

Shan, S., Luo, Y., Zhou, Y., & Wei, Y. (2018). Big data analysis adaptation and enterprises' competitive advantages: the perspective of dynamic capability and resource-based theories. *Technology Analysis & Strategic Management, 31*(4), 406–420.

Sheng, M. L., & Chien, I. (2016). Rethinking organizational learning orientation on radical and incremental innovation in high-tech firms. *Journal of Business Research*, *69*(6), 2302–2308.

Shi, X., & Zhang, Q. (2018). Inbound open innovation and radical innovation capability: The moderating role of organizational inertia. *Journal of Organizational Change Management, 31*(3), 581–597.

Shin, K., Kim, S. J., & Park, G. (2016). How does the partner type in R&D alliances impact technological innovation performance? A study on the Korean biotechnology industry. *Asia Pacific Journal of Management*, 33(1), 141-164.

Slayton, R., & Spinardi, G. (2016). Radical innovation in scaling up: Boeing's Dreamliner and the challenge of socio-technical transitions. *Technovation, 47*, 47–58.

Soosay, C., & Hyland, P. (2008). Exploration and exploitation: the interplay between knowledge and continuous innovation. *International Journal of Technology Management, 42*(1–2), 20–35.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal (John Wiley & Sons, Inc.), 18*(7), 509–533.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal (John Wiley & Sons, Inc.*), 28(13), 1319–1350.

Tseng, S-M., & Pei-Shan, L. (2014). The effect of knowledge management capability and dynamic capability on organizational performance. *Journal of Enterprise Information Management*, 27(2), 158-179.

Tushman, M. L. & O'Reilly, C.A. (1997). *Winning through Innovation: A practical guide to leading organizational Change and Renewal*. Boston Mass. Harvard Business School Press.

United States Government Accountability Office, Report to Congressional requesters. Drug Industry: Profits, research and development spending, a merger and acquisitions deals. GAO-18-40: Published: Nov 17, 2017. Publicly released Dec 19, 2017. Accessed 27th September 2019 from Government Accountability Website: https://www/gao.gov/products/GAO-18-40

Vance, D. E., Talley, M., Azuero, A., Pearce, P. F, & Christian, B. J. (2013). Conducting an article critique for a quantitative research study: perspectives for doctoral students and other novice readers. *Nursing: Research and Reviews*, *default* [online] 67-75.

Van Looy, B., Debackere, K., & Martens, T. (2005). Organizing for Continuous Innovation: On the Sustainability of Ambidextrous Organizations. *Creativity and Innovation Management, 14*(3), 208–221.

Visscher, K., & De Weerd-Nederhof, P. C. (2006). Rise and Fall of an Innovative Organisation: The Innovation Journey of Ericsson Enschede. *International Journal of Innovation Management, 10*(3), 217–235.

Vorraber, W., Neubacher, D., Moesl, B., Brugger, J., Stadlmeier, S., & Voessner, S. (2019). UCTM—An Ambidextrous Service Innovation Framework—A Bottom-Up Approach to Combine Human- and Technology-Centered Service Design. *Systems, 7*(2), 23.

Wang, C. L., & Ahmed, P. K. (2007). Dynamic capabilities: A review and research agenda. *International Journal of Management Reviews*, *9*(1), 31–51.

Wang, C., Rodan, S., Fruin, M., & Xu., X. (2014). Knowledge Networks, Collaboration Networks, and Exploratory Innovation. *Academy of Management Journal, 57*(2), 454–514.

Wang, C. L., & Rafiq, M. (2014). Ambidextrous Organizational Culture, Contextual Ambidexterity and New Product Innovation: A Comparative Study of UK and Chinese High-tech Firms. *British Journal of Management, 25*(1), 58–76.

Wang, Y.-S., & Hsu, T.-H. (2018). Dynamic capabilities of biologics firms in the emerging business market: Perspective of dynamic capabilities evident. *Industrial Marketing Management, 71*, 5–18.

Xiang, J., Archer, N., & Detlor, B. (2014). Business process redesign project success: the role of socio-technical theory. *Business Process Management Journal,* (5), 773.

Yi, L., Mao, H. & Wang, Z. (2019). How paradoxical leadership affects ambidextrous innovation: The role of knowledge sharing. *Social Behavior & Personality: An International Journal*, *47*(4), 1–15.

Yin, X., Chen, J. & Chuang Zhao., C. (2019). Double Screen Innovation: Building Sustainable Core Competence through Knowledge Management. *Sustainability, 16,* 4266.

Yu, C., Yu, T.-F., & Yu, C.-C. (2013). Knowledge sharing, organizational climate, and innovative behavior: a cross-level analysis of effects. *Social Behavior and Personality: An International Journal*, *1*, 143.

Zacher, H., Robinson, A. J., & Rosing, K. (2016). Ambidextrous Leadership and Employees' Self-reported Innovative Performance: The Role of Exploration and Exploitation Behaviors. *Journal of Creative Behavior*, *50*(1), 24–46.

Zhou, K. Z., & Li, C. B. (2012). How knowledge affects radical innovation: Knowledge base, market knowledge acquisition, and internal knowledge sharing. *Strategic Management Journal (John Wiley & Sons, Inc.)*, *33*(9), 1090–1102.

Appendix A

Table A.1. Cluster of radical innovation articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Slayton and Spinardi	2016	Case study	24	A
2	Cheng et al.	2016	Survey; empirical study	17	A
3	Carlo et al.	2012	Survey; longitudinal study	77	A
4	Fores and Camison	2016	Questionnaires; mixed studies method	102	A2
5	Zhou and Li	2012	Survey; Cross sectional – high technology companies	308	A30
6	Norman and Verganti	2014	Conceptual framework paper	186	A2
7	Lassen et al.	2006	5 case studies	43	A

8	Kelley et al.	2011	Interviews across 12 different organizations. Good longitudinal study	41	A

Table A.2. Cluster of incremental innovation articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Doran and Ryan	2014	Survey. Longitudinal data	7	B
2	Beck et al.	2016	Survey. Longitudinal data; Swiss firms	21	B
3	Sheng and Chien	2016	Questionnaires; 1000 firms; Empirical study	31	B
4	Chen et al.	2014	Research framework; new constructs	30	B
5	Fores and Camison	2016	Questionnaires; mixed studies method	102	B2; A2;
6	Norman and Verganti	2014	Conceptual framework paper	186	B2; A2
7	Mei et al.	2013	Conference paper	4	B

Table A.3. Cluster of *teams* articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Nissen et al.	2014	Two (2) case studies	57	C
2	Heavey and Simsek	2014	Surveys, CEOs firms in the USA	47	C
3	Patanakul et al.	2012	Theoretical conceptual frameworks. Technology companies in NE USA	38	C
4	Alexander and van Knippenberg	2014	Theoretical framework, large mature firms	65	C

Table A.4. Cluster of dynamic capabilities articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Cetindamar et al.	2009	Theoretical framework	115	D2
2	Hung et al.	2010	Survey data high tech	81	D1
3	Gao and Tian	2014	Survey; Manufacturing companies	8	D

	Author	Year of publication	Type of research	Scopus citations	Code
4	Arfin and Frmanzah	2015	Conceptual framework; Survey across firms	2	D
5	Hasegan et al.	2018	Case study manufacturing plant	0	D
6	Tseng and Pei-Shan	2014	Questionnaire and statistical analysis	74	D1
7	Shin et al.	2016	Empirical study of Korean biotechnology firms	16	D
8	Wang and Hsu	2018	Theoretical conceptual framework. Asia Pacific region biologics firms	1	D
9	Teece	2007	Conceptual Framework	3537	D350
10	O'Reilly and Tushman	2008	Conceptual paper	187	D2
11	Dangelico	2017	Structural modeling 189 Italian manufacturing firms	88	D1
12	Shan	2018	Conceptual modeling	2	D
13	Lessard et al.	2016	Multinational enterprises analysis using dynamic capabilities model	19	D
14	Prescott	2016	case-study global information/media analytics company using RBV and dynamic capability framework	2	D
15	Ambrosini	2009	Conceptual paper	306	D30

Table A.5. Cluster of open innovation articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Cheng et al.	2016	Survey; empirical study	17	E
2	Ferrary	2011	Longitudinal study high tech companies USA	54	E
3	Ardito et al.	2018	Longitudinal study of Italian firms	5	E
4	Peris-Ortiz et al.	2018	Comparative analysis 29 companies in Spain, France and Portugal	4	E
5	Shi and Zhang	2018	Longitudinal study	3	E
6	Kang and Hwang	2019	Innovation survey Korean companies	0	E
7	Bianchi et al.	2016	R & D units 841 Spanish manufacturing firms	34	E

ISSN 2183-0606
http://www.open-jim.org

8	Amponsah and Adams	2017	Global companies with patents including PBI	1	E

Table A.6. Cluster of knowledge management articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Garcia- Sanchez et al.	2017	Theoretical paper	0	F
2	Grundstein	2013	Conceptual and theoretical paper	2	F
3	Basnayaka & Jayakody	2018	Survey 100 teams	0	F
4	Yin et al.	2019	Conceptual paper	0	F
5	Schneckenberg et al. 2019	2015	Case study of global industrial corporation	19	F
6	Nielsen	2006	Literature review	103	F2
7	Campos and Sanchez	2003	Conceptual paper	0	F
8	Donate and Sanchez de Pablo	2015	Empirical data from technological firms	152	F2
9	Hannachi	2016	French biotechnology firms	Not available	

Table A.7. Cluster of exploratory and exploitative innovation articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Hoang and Rothaermel	2010	412 R&D projects in PBI; longitudinal study	224	G2
2	Soosay and Hyland	2008	Case study; Australian firm	43	G
3	Wang and Rafiq	2014	Data from150 UK and 242 Chinese high-tech firms; conceptual framework	105	G1
4	Andriopoulos and Lewis	2009	Case study five ambidextrous firms	751	G7
5	Wang et al.	2014	US manufacturing firms	135	G1
6	Martini et al.	2013	Theoretical framework	49	G
7	Gilsing and Nooteboom	2006	Case study pharmaceutical biotechnology; theoretical framework	188	G1
8	Dunlap et al.	2016	Business unit level of emerging firms in Brazil	5	G

Table A.8. Cluster of ambidextrous innovation articles

	Author	Year of publication	Type of research	Scopus citations	Code
1	Yi et al.	2019	306 senior or intermediate leaders in high technology companies in China	Not available	
2	Martini et al.	2013	Theoretical framework	49	H
3	O'Reilly and Tushman	2008	Theoretical conceptual	778	H70
4	Lee et al.	2019	Biopharmaceutical patent data – negative binomial regression	2	H
5	Vorraber et al.	2019	Case study	1	H
6	Dunlap et al.	2016	Business level units in Brazil	5	H
7	Jansen et al.	2012	285 organizational units across 88 autonomous branches	125	H2

Biographies

Heather A. Johnson. Heather Audrene Johnson is currently a doctoral candidate pursuing a degree in Management/Business Administration from the University of Maryland Global Campus, Maryland, (2020). Heather was born in Jamaica and migrated to the USA in 1980. Heather received the A.S. degree from Broward College, Florida in Medical Laboratory Technology (Clinical Lab Science) 1986. Heather received the B.S. in applied science and technology from Thomas Edison University, New Jersey (2012). Heather Johnson received the M.S. in quality management from Eastern Michigan University, Michigan (2016). The focus of her dissertation is "Radical Innovation and Strategic Management in a Volatile, Uncertain, Complex and Ambiguous (VUCA) world". She is conducting research in several areas: Ambidextrous (Radical and Incremental) Innovation organizations and Big Data and data analytics. She is an entrepreneur owner, President, CEO of MontRose Consulting Inc and has over 35 years of experience as scientist, engineer and practitioner in the pharmaceutical biotechnology industry. Ms. Johnson is a member of Project Management Institute and American Society of Quality. She authored an article "Meaningful Mentoring" [Women in Quality] in Quality Progress magazine (2019).