

Project Management Process Barriers Impacting the Delivery of Technology Transition:

A Systematic Literature Review

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Summary

The management of technology projects must consider a wide range of socio-political factors if these technologies are to transit through the maturity scales and delivery viable solutions/products.

This development paper seeks to explore the project management process barriers that impacting the successful transition of technologies that lie within the median range of the Technology Readiness Level (TRL) scale. This is achieved by undertaking a Systematic Literature Review (SLR) of carefully selected material. Initial findings indicate that the subject of technology transition has not been covered extensively in the context of delivering project output, and that further work is required to inform this observation.

This research contributes to a wider research project that aims at identifying and project management barriers impacting the acceleration of technology and innovation development in the Post COVID-19 era.

Track: Project Experiences

Submission: Development Paper

Keywords: Technology Project Management, Technology Transition, Valley of Death (VoD), Technology Readiness Level (TRL)

Word count: 1890

Introduction

Over the years, there has been research undertaken on defining project success (Freeman and Beale, 1992; Cooper and Kleinschmidt, 1987; Baccarini, 1999), but the conclusion still remains, there is no “one size that fits all” encapsulating definition for project success (Kerzner, 2019).

The success of a project is usually measured in terms of achieving its objectives within a defined budget, timescale and an agreed acceptance criteria upon the start of a project (APM, 2020). An examination into what constitutes an agreed acceptance criteria for the technology transition projects is required to ensure that such projects are not prematurely terminated due to lack of general understanding and stakeholder buy-in on the agreed acceptance criteria.

It is thus necessary to ensure the correct application of project management processes, methods, and tools in order to successfully deliver the project objectives more so in the case of technology and innovation projects.

This development paper is set to inform and contribute to existing research on barriers that impact successful delivery technology transition projects.

Research Scope and Relevance

Fig. 1 provides a summary of the TRL maturity levels and the scope for this research in the context of technology transition.

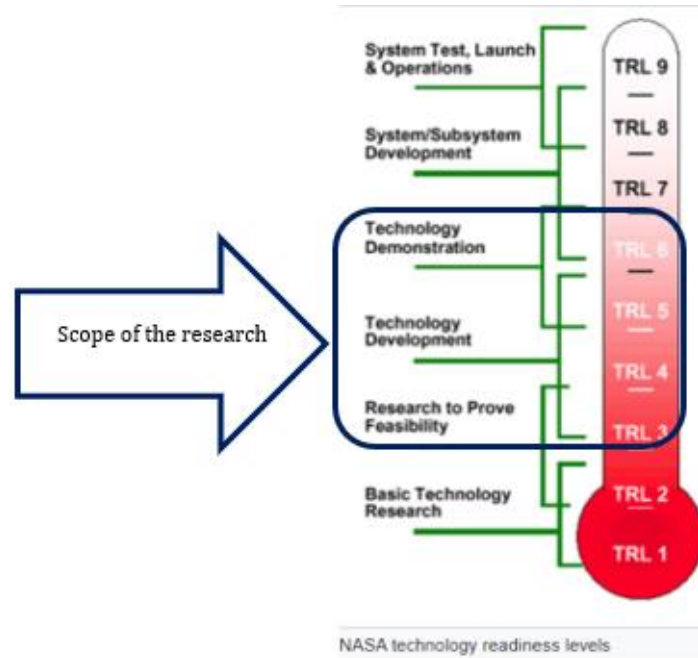


Fig. 1 TRL scale diagram (NASA, 2021)

TRLs 4 - 6 as presented at Fig. 1 represents a gap between academic research and industrial commercialization. This gap is colloquially referred to as the technological “Valley of Death” (VoD) to emphasize that many new technologies reach TRLs 4–6 and remain stalled here. This range of the scale has been identified as the focus for this research due to the association with developments that fail or are stalled within this level (Davis and Ballenger, 2017, Benešová, A. et al, 2021). Consequently, developed technologies are at risk of becoming obsolete and/or overtaken by other emerging innovations if they are not exploited within a defined timeframe. While the ingredients and pathways of technological progress are well understood, there are few best-practice or standard mechanisms to measure and manage technology transition efforts (Davis and Ballenger, 2017). Fig. 2 shows the TRL scale plotted against profit and loss graph with the VoD in the unprofitable area. Further work is required to review of the TRL process and the role of project

management processes in technology transition projects, to inform the cost of technology development, the impact on profitability and likewise highlight the related losses.

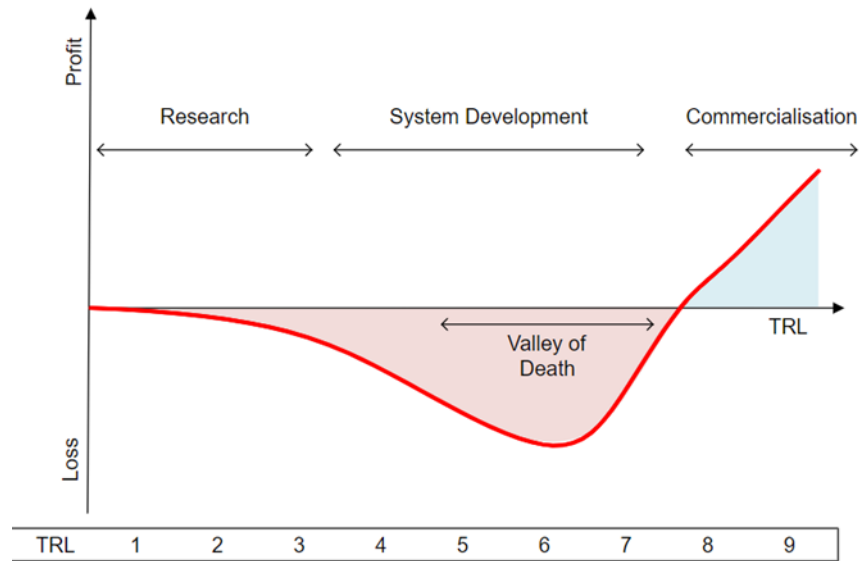


Fig. 2 Profit and loss plotted against TRL (Technology Readiness Level)

Research Methodology

This research is set on an evidence-based approach using a systematic literature review (SLR) of existing literature to inform the research question and validate the research gap. The review process involves locating, evaluating, analysing, synthesizing the findings, and concluding with reported evidence. We have done this for the purposes of drawing conclusions about what is known and also, what is not known from the research question (Denyer and Tranfield, 2009, Wallace and Wray, 2011). By so doing we minimize bias (Petticrew, 2001), as the process involves the generation of a constructive critical analysis of existing literature in an unbiased manner. The process is summarized at Fig. 3 below.

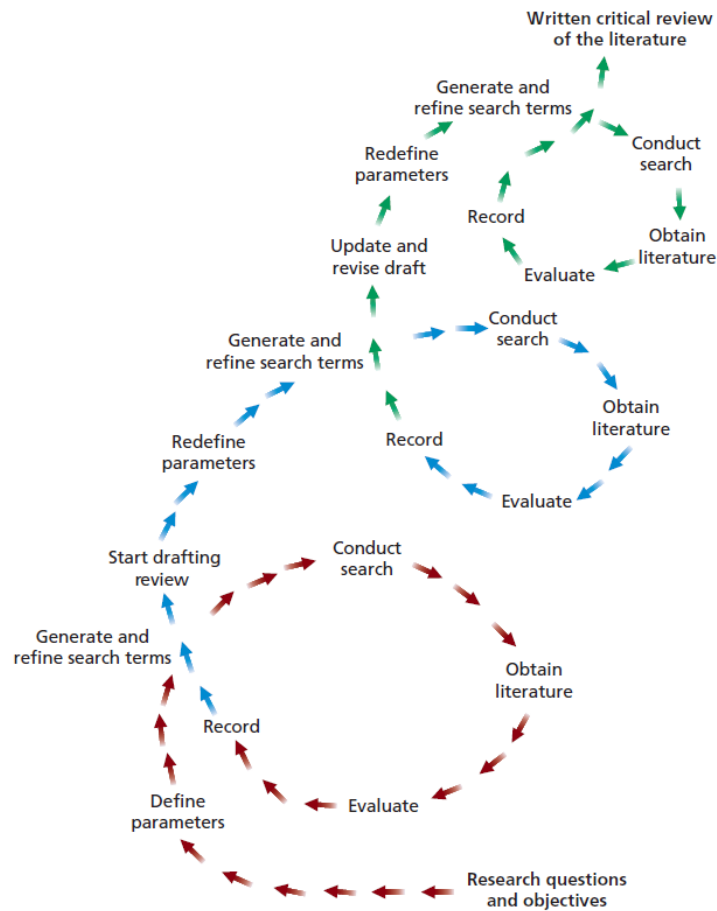


Fig. 3 The literature review process (Saunders et al, 2016)

Given the reiterative nature of the review cycle, we are able to further review, refine and develop initial findings as the research matures. This approach has been selected as it prevents us from arriving at premature conclusions before the completion of this research project. The deep dive review of literature allows us to fully engage with the selected articles to explore the perceived research gap.

Search criteria and approach

The words ‘Technology Project Management’, ‘Technology/Innovation Transition’ and ‘TRL’ were used for the search criteria. These gave us a broad enough search criteria from a project management perspective but narrow enough to inform the technology aspect of the research topic. The search strings are a play on the key words to give us the highest yield from the literature search,

e.g., “Project Management” AND “Technology Transition” AND “TRL” or Project Management” AND “Innovation” AND “Technology Transition” AND “TRL”. The literature search was conducted on selected databases (Web of Science and Scopus), Google Scholar and outputs from relevant empirical studies. The initial search generated 659 articles, from which 212 duplicates were removed, and of the remaining 447 articles 428 were further excluded as they were deemed to be out of the research scope. For example, articles that focused on the management of technology in general as opposed to the management of technology projects. A final sample of 19 articles was identified to inform the initial analysis (Table 1 below).

	Author	Title	Yr
1	Albert, T.	Measuring Technology Maturity: Theoretical Aspects. In T. Albert (Ed.), <i>Measuring Technology Maturity: Operationalizing Information from Patents, Scientific Publications, and the Web</i> (pp. 9-113). Springer Fachmedien Wiesbaden.	2016
2	Bazan, C.	“From lab bench to store shelves:” A translational research & development framework for linking university science and engineering research to commercial outcomes. <i>Journal of Engineering and Technology Management</i> , 53, 1-18.	2019
3	Davies, A., Gann, D., & Douglas, T.	Innovation in Megaprojects: Systems Integration at London Heathrow Terminal 5. <i>California Management Review</i> , 51(2), 101-125.	2009
4	Fernez-Walch, S	Innovation Project Management in Theory. In <i>The Multiple Facets of Innovation Project Management</i> (pp. 1-31). John Wiley & Sons.	2017
5	McGarvey, D. a. O., J.	Department of Homeland Security Science and Technology Readiness Level Calculator (ver 1.1). 79.	2009
6	Meier, S. R. (2008).	Best Project Management and Systems Engineering Practices in the Preacquisition Phase for Federal Intelligence and Defense Agencies. <i>Project Management Journal</i> , 39(1), 59-71. https://doi.org/10.1002/pmj.20035	2008
7	Olechowski, A. L., Eppinger, S. D., Joglekar, N., & Tomaschek, K.	Technology readiness levels: Shortcomings and improvement opportunities. <i>Systems Engineering</i> , 23(4), 395-408.	2020
8	Raffaini, P., & Manfredi, L.	Chapter 15 - Project management. <i>Endorobotics Design, R&D and Future Trends</i> , 337-358.	2022
9	Sauser, B. J., Gove, R., Forbes, E., & Ramírez-Márquez, J. E.	Integration maturity metrics: Development of an integration readiness level. <i>Inf. Knowl. Syst. Manag.</i> , 9, 17-46.	2010
10	Walker, A	Creativity, organisational climate and innovation: An interdisciplinary, multilevel perspective (Publication Number 992983202436401631) UoM].	2015
11	Atkinson, R	Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria	1999
12	Garel, G	A history of project management models: From pre-models to the standard models. <i>International Journal of Project Management</i> , 31(5), 663-669.	2013
13	Jensen, A., Thuesen, C. and Geraldi, J	The projectification of everything: Projects as a human condition. <i>Project Management Journal</i> , 47(3), 21-34.	2016
14	Lenfle, S. and Loch, C	Lost roots: How project management came to emphasize control over flexibility and novelty. <i>California Management Review</i> , 53(1), 32-55.	2010
15	Flyvbjerg B.	The Oxford Handbook of Megaproject Management. 21-38.	2017
16	Mantel, S. and Meredith, J	Project management: a managerial approach	2009
17	Verma, D	Toward a theory of project interdependencies in high tech R&D environments	2002
18	Baccarini, D	The logical framework method for defining project success. <i>Project management journal</i> , 30(4), 25-32.	1999
19	Svetlana, C and Hodgson, D	New Possibilities for Project Management Theory: A critical engagement	2006

Table 1 Reviewed articles.

The process followed has been adapted from the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) checklist developed by Moher et al, 2009 (Fig 4 below).

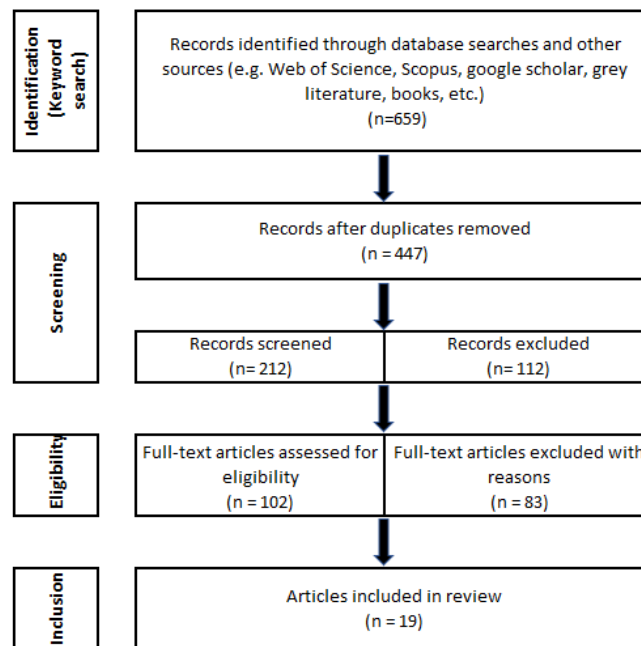


Fig. 4 Flowchart of the review process

Using the word cloud below we are able to start drawing some initial findings from the literature review.



Fig. 5 Literature review word cloud Top 50 words

Key Findings

i) Terminology

Firstly, it is evident that the terms ‘technology’ and ‘innovation’ have been used interchangeably in most of the literature reviewed. While this continues to be a topic for further discussion, this study defines ‘innovation’ as the introduction of something new, or novel and ‘technology’ as exploitation of science and innovation for the purposes of generating a new product or service.

Innovation can be intangible, as opposed to technology, which is tangible. Technology can be used to implement innovation, but the technology itself doesn’t produce innovation (Callegaro. A, 2017)

ii) Technology Transition

The management of technology transition projects has not featured highly in the review of the sample literature limiting the amount of information available relating to the management of mid-range TRL technology transition projects.

Further the management of technology transitions has also not been covered extensively in the context of delivering project outputs that are deemed to mature a technology from one TRL level to another. This has not featured in the literature reviewed.

iii) Management of Technology Maturity

Evidently with the literature reviewed there is limited literature on the delivery of technology maturity as a key feature of the project output. This finding presents an opportunity for further research into the redefinition of project outputs to include a measure of maturity especially for innovation or technology projects. The inherent uncertainty of project work is exaggerated by the evolving nature of the technology. This influences the ability to fix the objectives and define realistic expectations during the planning stages of international projects with a technology transfer component. The direct implication is that conventional methods of managing the project, commonly dominated by management-by-objective, become less effective (Picciotto, 2020; Lannon and Walsh, 2020, Kwadwo Oti-Sarpong, Roine Leiringer, 2021).

iv) *Academic gap*

The findings suggest that the project management of technology projects has been done more in practice than has been explored academically. Peter, in his paper has highlighted the difficulty academics have in presenting the (Project Management) discipline as a whole (Morris, 2013).

Most of the literature reviewed deal with the project outputs in the context of ‘iron triangle’ of cost, scope and schedule but not quantified or qualified through the lens of technology maturity.

Roughly 10% of development technologies advance fully to TRLs qualifying for infusion, whereas another 10% still remain at the levels of fundamental discovery rather than readiness for exploitation. This may be *due to a funding profile* resulting from a strategic game, in which both parties make decisions based on assumptions regarding the next step (Pyka & Lee, 2021). Subsequently Nuno et al, 2012 conclude that technological decisions in mega projects can be fundamentally *schedule-constrained* (Gil et al, 2012). Given each company has its own definition of performance (Kerzner, 2019), the element of *project scope* in the execution of technology projects remains a topic of further research. These findings highlight the fundamental constraints brought about by the classic project management ‘iron triangle’ at Fig. 6.

The factors of Scope/Quality, Cost & Schedule are regarded as the success criteria for determining project success. This perceives the ‘project’ as a homogenous entity with no regard for technology transition as a significant success criterion for delivery of innovation maturity.

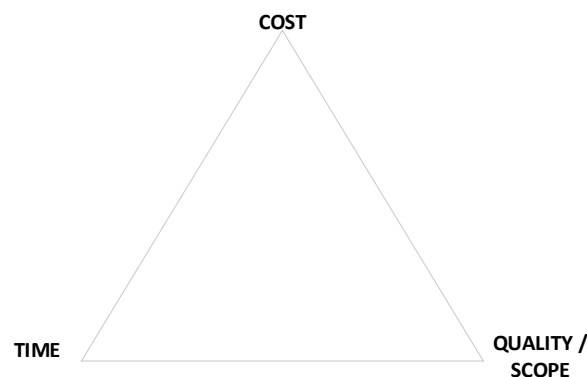


Fig. 6 Project Management ‘Iron Triangle’

It is worth noting that the concept of the ‘Iron Triangle has been explored extensively with some conclusions offering alternatives such as alternatives, such as Scope, Performance, and/or Requirements (Pollack and Adler 2018).

Further research is needed to identify the applicability and suitability of different systemic constructs in various innovation environments (Kapsali, 2011). This is also highlighted in the initial findings presented herein.

Research Contribution

This work contributes to the field of learning relating to the management and delivery of technology transition within VoD of the TRL scale. The understanding of innovation *and technology maturity* continues to develop through systematic research, experimentation and the ultimate test of management practice and experience (Tidd and Bessant, 2021).

The objective of technology transition is to make the desired technology available to the operational units as quickly as possible and at the lowest cost (Dobbins, J. H., 2004). This means a rapid acceleration of a particular technology through the TRL scale at the shortest time possible, with minimum cost but ensuring ‘fitness for purpose’ to the end user. This research project seeks to explore the effectiveness of project management processes that are used to manage the acceleration of technology maturity transitions through the VoD.

While the concept of VoD has been well documented, the literature provides little guidance on how this gap can be overcome within firms and what role broader organizational factors play in this process (Dean et al, 2022).

Conclusion

Project Management of Innovation and Technology carries a level of complexity at multiple levels. Azim et al. propose a project complexity triangle – people, product, and process”, highlighting their importance as the three major areas contributing to project complexity (Azim, 2011). This could be broadened to include the management of technology transition projects. Merely inventing

a solution and proving the technology are not the hardest parts. Being ready in all aspects to traverse the VoD is the real work in innovation (Newman D, 2017). Furthermore, an examination into what constitutes an agreed acceptance criteria for a technology project is required to ensure these types of projects are not prematurely terminated due to lack of a general understanding of their construct and anticipated outputs. (Kerzner, 2019).

Needless to say, the question then remains, what are the project management process barriers that stand in the way of mid-range TRL technology transition technologies through to the full-scale maturity required for market exploitation. It is worth noting that other maturity models have been developed e.g., CMM(I), IMM, KMM, and Gartner's Hype Cycle however none of these specifically address the management of technology transition through the TRL scale.

It is necessary to ensure the correct application of project management processes, models, methods, and tools in order to successfully manage the delivery of technology transition projects. This research study continues to explore barriers and enablers within the project management practice that impact the successful transition of technologies. Project management is no longer merely a practice to plan, schedule, and execute projects effectively, but it is an academic field and one of the key management disciplines that consist of both practical/empirical research and theoretical research-based on solid academic theories and foundations (Kwak & Anbari, 2009).

References

- APM, 2020. APM Body of Knowledge, 7th Edition. Princes Risborough: Association for Project Management.
- Atkinson, R. (1999). Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management*, 17(6), 337-342
- Azim, S. (2011). Understanding and managing project complexity. The University of Manchester (United Kingdom).
- Baccarini, D. (1999). The logical framework method for defining project success. *Project management journal*, 30(4), 25-32.
- Bannerman, P. L. (2008). Defining project success: a multilevel framework. *Proceedings of the Project Management Institute Research Conference*.
- Benešová, A., Basl, J., Tupa, J., & Steiner, F. (2021). Design of a business readiness model to realise a green industry 4.0 company. *International Journal of Computer Integrated Manufacturing*, 34(9), 920-932.
- Callegaro, A. 2017 <https://www.unhcr.org/innovation/innovation-technology-arent-the-same/> (accessed 10th Mar 2023)
- Cooper, R. G., & Kleinschmidt, E. J. (1987). New products: what separates winners from losers?. *Journal of product innovation management*, 4(3), 169-184.
- Davis, A., & Ballenger, T. (2017). Bridging the “Valley of Death”. *Defense AT&L*, 1, 13-17.
- Dean, T., Zhang, H., & Xiao, Y. (2022). The role of complexity in the Valley of Death and radical innovation performance. *Technovation*, 109, 102160.
- Denyer, D., & Tranfield, D. (2009). Producing a systematic review.
- Dobbins, J. H. (2004). Planning for technology transition. *Defense AT&L*, 33(2), 14-17.
- Freeman, M., & Beale, P. (1992). Measuring project Success. *Project Management Journal*, 23 (1), 8-17.
- Gil, N., Miozzo, M., & Massini, S. (2012). The innovation potential of new infrastructure development: An empirical study of Heathrow airport's T5 project. *Research Policy*, 41(2), 452-466.
- Kerzner, H. (2019). *Innovation project management: methods, case studies, and tools for managing innovation projects*. John Wiley & Sons, Inc.
- Kwak, Y.H. and Anbari, F.T. (2009) Analyzing Project Management Research: Perspectives from Top Management Journals. *International Journal of Project Management (IJPM)*, 27, 435-446.

- Lannon, J., & Walsh, J. N. (2020). Project facilitation as an active response to tensions in international development programmes. *International Journal of Project Management*, 38(8), 486-499.
- Mankins, J. C. (2009). Technology readiness assessments: A retrospective. *Acta Astronautica*, 65(9-10), 1216-1223.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group*, T. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, 151(4), 264-269.
- NASA, 2012
https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level (accessed 10th Mar 2023)
- Newman D, 2017. Technology Readiness and the Valley of Death
<https://www.boeing.com/features/innovation-quarterly/may2017/feature-thought-leadership-newman.page> (accessed 10th Mar 2023)
- Oti-Sarpong, K., & Leiringer, R. (2021). International technology transfer through projects: A social construction of technology perspective. *International Journal of Project Management*, 39(8), 902-914.
- Petticrew, M. (2001). Systematic reviews from astronomy to zoology: myths and misconceptions. *Bmj*, 322(7278), 98-101.
- Picciotto, R. (2020). Towards a 'New Project Management' movement? An international development perspective. *International Journal of Project Management*, 38(8), 474-485.
- Pollack, J., Helm, J. and Adler, D. (2018), "What is the Iron Triangle, and how has it changed?", *International Journal of Managing Projects in Business*, Vol. 11 No. 2, pp. 527-547.
- Pyka, A., & Lee, K. (Eds.). (2021). *Innovation, Catch-up and Sustainable Development: A Schumpeterian Perspective*. Springer International Publishing.
- Shenhar, A. J., Tishler, A., Dvir, D., Lipovetsky, S., & Lechler, T. (2002). Refining the search for project success factors: a multivariate, typological approach. *R&d Management*, 32(2), 111-126.
- Tidd, J., & Bessant, J. R. (2020). *Managing innovation: integrating technological, market and organizational change*. John Wiley & Sons.
- Wray, A., & Wallace, M. (2011). Accelerating the development of expertise: a step-change in social science research capacity building. *British Journal of Educational Studies*, 59(3), 241-264.