Coventry University

DOCTOR OF PHILOSOPHY

Unpacking the 'black box'

Implementation evaluation of interventions to improve motor skill competence in children and adolescents.

Ma, Jiani

Award date:
2022

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Coventry University
Deakin University

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Unpacking the 'black box': Implementation evaluation of interventions to improve motor skill competence in children and adolescents

By

Jiani Ma

April 2022

Unpacking the 'black box': Implementation evaluation of interventions to improve motor skill competence in children and adolescents

By

Jiani Ma

April 2022

Certificate of Ethical Approval

Applicant:

Jiani Ma

Project Title:

Using Collective Intelligence Analysis to identify barriers to improving Fundamental Movement Skill(FMS) proficiency among children: A realist feasibility study of Skill-Ed scale-up

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

31 May 2019

Project Reference Number:

P90462

Memo

To:	A/Prof Lisa Barnett, Dr Natalie Lander, Dr Emma Eyre, and Prof Michael Duncan
	School of Health and Social Development
From:	Executive Officer – HEAG-H
	Faculty of Health
CC:	Jiani Ma
Date:	3 September 2020
Re:	HEAG-H 173_2020: *Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skills interventions*

Approval has been given for A/Prof Lisa Barnett, Dr Natalie Lander, Dr Emma Eyre, and Prof Michael Duncan, of the School of Health and Social Development, to undertake this project for a period of 1 years from 03 September 2020. The project has been given approval as it meets the requirements of the National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). The current end date for this project is 03 September 2021.

Please note: if you have indicated that your project will be conducted while COVID-19 restrictions are in place, approval has been granted in line with the current restrictions. It is the responsibility of the principal investigator to remain aware of any changes to the restrictions and in the event that such changes make the approved research non-compliant with the restrictions, to either seek approval for a further modification to the project, or postpone the research until the restrictions are lifted.

The approval given by the Deakin University HEAG-H is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Executive Officer immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time
- Any events which might affect the continuing ethical acceptability of the project
- The project is discontinued before the expected date of completion
- Modifications that have been requested by other Human Research Ethics Committees

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

Please complete the Annual/Final Project Report Form and return to Administrative Officer to the HEAG-H, Pro-Vice Chancellor's office, Faculty of Health, Burwood campus by 1st December 2020 and when the project is completed. HEAG-H may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human 2007 (Updated 2018).

Coventry University

Certificate of Ethical Approval

Applicant: Jiani Ma

Project Title: A two-arm pragmatic non-randomised trial assessing
                               strategies for improving the implementation of Project FLAME

This is to certify that the above named applicant has completed the Coventry University Ethical
Approval process and their project has been confirmed and approved as Medium Risk

Date of approval: 18 Dec 2020

Project Reference Number: P116006

v

Memo

To:	A/Prof Lisa Barnett
	School of Health and Social Development
From:	Executive Officer – HEAG-H
	Faculty of Health
CC:	Dr Natalie Lander, Dr Harriet Koorts, Prof Michael Duncan, Dr Emma Eyre, Dr Wesley O'Brien, Dr Diarmuid Lester, and Jiani Ma
Date:	27 May 2021
Re:	HEAG-H 52_2021: *A two-arm pragmatic non-randomised trial assessing effectiveness of strategies to improve implementation and engagement of Project FLAME*

Approval has been given for A/Prof Lisa Barnett, of the School of Health and Social Development, to undertake this project for a period of 1 year from 27 May 2021. The project has been given approval as it meets the requirements of the National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). The current end date for this project is 27 May 2022.

Please note: if you have indicated that your project will be conducted while COVID-19 restrictions are in place, approval has been granted in line with the current restrictions. It is the responsibility of the principal investigator to remain aware of any changes to the restrictions and in the event that such changes make the approved research non-compliant with the restrictions, to either seek approval for a further modification to the project, or postpone the research until the restrictions are lifted.

The approval given by the Deakin University HEAG-H is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Executive Officer immediately should any of the following occur:
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Please complete the **Annual/Final Project Report Form** and return to Administrative Officer to the HEAG-H, Pro-Vice Chancellor's office, Faculty of Health, Burwood campus by 1st December 2021 and when the project is completed. HEAG-H may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human 2007 (Updated 2018).

Publication and presentations

List of publications

Ma, J., Lander, N., Eyre, E. L. J., Barnett, L. M., Essiet, I. A., and Duncan, M. J. (2021). It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence. *Sports Medicine*, 51(12), pp.2547-2569. https://doi.org/10.1007/S40279-021-01519-5

Ma, J., Hogan, M.J., Eyre, E.L., Lander, N., Barnett, L.M., and Duncan, M.J. (2021). Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skill interventions: A rationale and application example. *Journal of sports sciences*, 39(6), pp.691-698. https://doi.org/10.1080/02640414.2020.1841395

Ma, J., Hogan, M.J., Eyre, E.L., Lander, N., Barnett, L.M., and Duncan, M.J., (2021). Enhancing the implementation and sustainability of fundamental movement skill interventions in the UK and Ireland: lessons from collective intelligence engagement with stakeholders. *International Journal of Behavioral Nutrition and Physical Activity* 18, 144. https://doi.org/10.1186/s12966-021-01214-8

List of presentations

Peer-reviewed conference abstracts

Ma, J., Hogan, M.J., Eyre, E.L.J., Lander, NJ, Barnett, L.M., and Duncan, M.J. (2021). Collective Intelligence for the Collective Effort in improving implementation of fundamental movement skill interventions. in The Health & Fitness Journal of Canada: Proceedings from the 8th International Society for Physical Activity and Health Congress. 3 edn, vol. 14, 8th International Society of Physical Activity and Health Congress, Vancouver (virtual), October, 2021. (oral presentation) https://doi.org/10.14288/hfjc.v14i3.495

Ma, J., Hogan, M.J., Eyre, E.L.J., Lander, NJ, Barnett, L.M. & Duncan, M.J. (2019). Evaluation of Fundamental Movement Skill (FMS) interventions via the UK Medical Research Council (MRC) Process Evaluation guidance: a systematic review." In International Society of Behavioral Nutrition and Physical Activity, Prague, June, 2019. ISBN: 978-1-7324011-1-2. (poster presentation)

Professional presentations

Ma, J., O'Brien, W., Duncan, M.J. Fundamental movement skill interventions in the UK and Ireland. National Assembly of the International Motor Development Research Consortium, South Carolina (virtual), October, 2020. (symposium presentation)

Grants and awards

2018-2021	Coventry University-Deakin University Cotutelle PhD Scholarship
2019	Deakin University Faculty of Health open access publication grant (AUD$3153)
2019	Pragmatic Evaluation Training Scholarship (£350)
2019	Barry Gidden Fund (£1000)
2021	Overall Winner and People's Choice at Deakin University School of Health and Social Development Three Minutes Thesis (3MT) competition
2021	Nominee for Coventry University Postgraduate of the Year (£100)
2022	Finalist at Coventry University 3MT competition

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Acknowledgement

What a journey this PhD has been! I have heard from many who compare doing a PhD to mountain climbing. I echo this metaphor for the many ups and downs I have come across, as well as the wonder I have witnessed during the journey. Arriving at this milestone, I would like to sincerely thank all those who have guided me along the way and climbed with me.

To my supervisory team, thank you for your commitment and for spending countless hours to guiding me through PhD. I am extremely privileged to have your multidisciplinary expertise in motor development research, which has shaped my research development in different ways and made possible the originality of this research. Thank you, Prof. Michael Duncan, for your constant belief in my abilities and support to develop my most 'random' ideas. I hope I continue to live up to the Top Gun call sign you honoured me with – the 'Maverick' Ma. Thank you, Prof. Lisa Barnett, for inspiring me to be my best. You have unreservedly taught me how to think and write clearly and reliably been my source of knowledge and confidence. Dr. Emma Eyre and Dr. Natalie Lander, my guarding angels, have gone above and beyond for supporting my professional and personal journey. I feel truly lucky to have supervisors like you who show all the care and understanding that you do. Further thanks to Lisa and Natalie, being my supervisors in a different time zone, have always been there to guide me when I needed help. I am also indebted to Dr. Michael Hogan and Dr. Harriet Koorts, who have generously shared with me their expertise in systems science and implementation science.

I would also like to acknowledge the organisations and individuals who have been instrumental in this journey. I am fortunate to have been a member of the International Motor Development Research Consortium (I-MDRC). Engaging with the I-MDRC community has developed me both academically and professionally. Thanks to Doctoral College, especially Carolyn Wynne and Lisa Millard, for the help to navigate through the cotutelle programme. A special call-out to colleagues from the University College Cork, especially Dr Wesley O'Brien and Dr Diarmuid Lester. Your passion for Physical Education has been hugely inspiring and I thank you for the many stimulating discussions. I also wish to thank Garry Bidden fund for the financial support in the Collective Intelligence study.

Living so far away from family is challenging, although I am fortunate to have made lifelong friends. To Ricardo, who has been an amazing housemate and PhD buddy. I truly appreciate our daily Tofu dinners, over which we shared our achievements and challenges—thank you! I wish to thank all PhD friends that I share the office with, Theresa, Sophie, Sofie, Ruth, those banter and encouragement have been my source of energy. I also extend my gratitude to those who have provided moral support remotely, Sam, Inny, and Alethea, I appreciate you listening to my problems. Thank you, the Cotutelle crew, particularly Erica and Seth for giving advice whenever I was in a quandary. To Ellis, Yazmin, Maria, Anna, and Katie, thank you for being a ray of sunshine in isolated times. Laura and Martin, and your adorable bunnies (Hiccup, Maximus, Pascal), I am immensely grateful for our friendship which

has helped me get through the darkest winter. My special thanks go to Prof. Andy Jones, who has always been on duty as a Good Samaritan and rescued me from meltdowns. To Dr. Emiliano Mazzoli, I cannot think of any words to express my gratitude for your immense patience and loving support. I could not have done these final miles without knowing you were waiting for me at the end of the tunnel. I look forward to the next chapter with you, "Camminiamo insieme, con la tua mano nella mia mano".

To my dear family, I could not have done this PhD without receiving the unwavering support and unconditional love from you. Mom, your positivity and kindness have always been an inspiration. Dad, thank you for making me believe that if I start building it, things will eventually come. Thank you, Uncle, for caring for me like a father. Finally, to my grandparents who combined had spent 100 years in the teaching profession, for instilling in me a love of learning. You are my first and best teachers. 爷爷奶奶, 感谢您们的谆谆教诲, 我的博士学位也是您们的成就。

All mentioned in this acknowledgement have had to cope with major challenges in personal and work lives in the past years, the courage and ingenuity you have shown to overcome setbacks have been hugely inspiring. Thank you!

List of abbreviations

CI	Collective Intelligence
ERIC	Expert Recommendations on Implementation Change
FMS	Fundamental Movement Skill
ISM	Interpretive Structural Modelling
MC	Motor skill Competence
MRC	Medical Research Council
NCCA	National Council for Curriculum and Assessment
PA	Physical Activity
PE	Physical Education
PRACTIS	PRACTical planning for Implementation and Scale-up
QPE	Quality Physical Education
QR	Quick Response
UCC	University College Cork
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

Glossary of terms

Collective Intelligence
An applied systems science approach aiming to generate, clarify, and structure interdependencies between problem elements, and further develop options to address the system of interdependent problems (Warfield and Cárdenas 1993).

Fundamental movement skill
Skills that are considered as the foundation of more advanced, complex movements required to participate in sports, games, or another context-specific physical activity (Clark and Metcalfe 2002, Logan et al. 2018, Hulteen et al. 2018).

Implementation
The process of integrating an intervention into practice within a particular setting (Milat, Bauman, and Redman 2015).

Implementation research
A multi-disciplinary field that aims to study the development, spread, and sustainability of broadly applicable programmes that are contextually relevant and robust across diverse settings, delivery staff, and subgroups (Glasgow and Chambers 2012)

Implementation evaluation
Implementation evaluation examines the processes, factors, and strategies necessary to promote authentic adoption of evidence-based interventions, thereby increasing the effectiveness and likelihood of interventions to be integrated into routine practice (Eccles and Mittman 2006).

Methodology
A set of principles and ideas that inform the design of a research study (Mills and Birks 2017, p.4).

Motor development
A study of "the changes in motor behaviour over the lifespan *and* process(es) which underlie these changes" (Clark and Whitall 1989, p.194).

Motor skill competence
A global term used to describe an individual's proficient performance in a broad range of motor skills as well as the underlying mechanisms including quality of movement, motor coordination, and motor control (Robinson et al. 2015, Utesch and Bardid 2019). Motor skill competence in children and adolescents–the focus of this thesis–incorporates fundamental movement skills, including object control (e.g., throwing and catching), locomotor (e.g., running and jumping), and stability skills (e.g., balancing and twisting) (Gallahue, Ozmun, and Goodway 2012, Rudd et al. 2016).

Physical activity
'Any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level' (Caspersen, Powell, and Christenson 1985)

Project FLAME
Project FLAME targeting to improve Fundamental and Functional Literacy for Activity and Movement Efficiency among Irish adolescents (Lester 2020).

Process evaluation   A study which aims to understand the functioning of an intervention, by examining implementation, mechanisms of impact, and contextual factors (Moore et al. 2015).

Sustainability   The continued implementation of programme components for the continued achievement of desirable programme and population outcome (Scheirer and Dearing 2011).

Systems thinking   An approach to problem solving, where the problem is viewed as part of a system of interrelated component parts (Northridge and Metclaf 2016).

Abstract

Despite the irrefutable evidence of the health benefits of adequate physical activity, children and adolescents worldwide are not sufficiently active. Motor skill competence (MC) has been suggested as integral to individuals being able to competently participate in physical activity. However, levels of MC in children and adolescents are low globally. This is despite the preponderance of effective interventions and initiatives promoting MC in schools (e.g., Physical Education), thus highlighting a potential gap between effective MC interventions and sustained routine practice that benefits the wider population (e.g., integration into teaching practice). The process of integrating effective interventions into practice is defined as implementation. To improve the implementation of MC interventions, and thus their translatability into practice, factors that influence the implementation process need greater focus. Yet, implementation research in MC interventions is underdeveloped and limited. This PhD therefore aimed to improve the understanding of the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice and provide suggestions regarding implementation evaluation.

A systematic review was conducted to investigate how process evaluations (a study that examines the intervention process) have been reported in MC interventions and identify any factors that may impact MC intervention outcomes. Only half of the identified intervention studies (n = 30) reported process evaluation and no studies reported (or employed) theoretical frameworks to guide process evaluation. Common process evaluation measures and potential moderators of MC intervention outcomes were identified in this review, but this was insufficient to fully understand the implementation of MC interventions given process evaluation is underused. Subsequently, a systems science approach, namely Collective Intelligence (CI), was employed in three stakeholder consultations in the UK and Ireland to identify barriers to the implementation and sustainability of school-based MC interventions and their interrelationships, as well as design solutions to the barriers. Critical barriers were identified relating to policy, physical education curriculum, and stakeholders' knowledge and appreciation. A roadmap of actions was created to inform decisions when supporting implementation of MC interventions. The synthesised findings from the review and CI were then used to develop strategies intended to improve the implementation of a specific MC intervention—Project FLAME, followed by a mixed methods evaluation to understand the influences of the strategies on the implementation of the intervention. Findings highlighted that the intervention could be effectively integrated into routine practice, provided adaptations specific to teachers' practice and students' needs are made.

This PhD research presents the first systematic inquiry into the implementation evaluation of MC interventions. Findings highlighted the complex and context-specific influences on the implementation and sustainability of interventions. The thesis considers the implications for researchers regarding improving evaluation practice, as well as strategies to improve the implementation of MC interventions into practice.

Chapter 1. Introduction to the thesis

1.1 The research problem

Movement is an integral part of our lives. The development of movement abilities – motor development is an important aspect of health and well-being from birth (Gabbard 2021). One of the important outcomes of interest in motor development is motor skill competence (MC). Although there is no universally accepted definition, MC is a global term used to describe an individual's proficient performance in a broad range of motor skills as well as the underlying mechanisms including quality of movement, motor coordination, and motor control (Robinson et al. 2015, Utesch and Bardid 2019). MC in children and adolescents–the focus of this thesis– refers to an individual's degree of proficiency in performing various fundamental movement skills (FMS), including object control (e.g., throwing and catching), locomotor skills (e.g., running and jumping), and stability skills (Gallahue, Ozmun, and Goodway 2012, Rudd et al. 2016). Level of MC has been associated with children's and adolescents' weight status (Barnett et al. 2022), health-related fitness (Utesch et al. 2019, Barnett et al. 2022), and other social and cognitive outcomes (Bremer and Cairney 2016). Notably, MC offers a developmental view of physical activity (PA) (Malina 2014); the development of MC at an early age was postulated as being integral to regular PA engagement as well as sports participation throughout life (Stodden et al. 2008, Hulteen et al. 2018).

The study on motor development spans various disciplines, including exercise physiology, psychology, public health, and public education. Despite subject-related differences, an indisputable focus within motor development research is the process of change in motor behaviours (Haywood and Getchell 2009). As defined in the dictionary, *to develop* means *to grow or cause to grow (or change) into a more advanced form* (Cambridge English

Dictionary 2002). What is implied in this definition is that development does not solely stand for chronicle changes (i.e., growth); it also occurs under external stimuli (i.e., causes). Indeed, human motor development does not occur with maturation alone; rather, it is influenced by the dynamic, constantly changing interactions between an individual, the task, and the environment over time (Clark and Whitall 1989, Newell 1986). Consequently, when we try to use external stimulus to improve MC, we must observe changes from which improvements emerge. When observing these changes, motor development researchers are also curious about the factors underlying those changes. To conduct such programmes and observations, researchers often employ two study designs: one being observational studies where investigators observe natural relationships between factors and outcomes, the other being intervention studies where investigators intercede as part of the study design to develop and evaluate strategies to promote a positive outcome or prevent a harmful outcome to occur (Thiese 2014).

Globally, children and adolescents are not achieving MC levels to their expected capability. Of concern, low MC levels are evidence among the 9- to 10- year-olds (Bolger et al. 2020), by which age children should theoretically master all FMS (Gallahue, Ozmun and Goodway 2012). Moreover, much evidence have suggested that lower MC levels have been shown in children that are younger (age), female (sex), overweight or obese (weight status), and have low socioeconomic backgrounds (Barnett et al. 2016). Therefore, interventions to improve MC are a research priority (Foweather and Rudd 2020). A diverse range of strategies that are developmentally and instructionally appropriate, such as modified physical education (PE) and free play, have been used in interventions to improve MC (Jiménez-Díaz, Chaves-Castro, and Salazar 2019). Predominantly, MC interventions are conducted in schools and delivered by PE teachers (Morgan et al. 2013). Multiple systematic reviews have reported that these interventions are effective, under controlled settings and over a short term (Lorås 2020, Jiménez-Díaz, Chaves-Castro, and Salazar 2019, Eddy et al. 2019a, Morgan et al. 2013,

Graham et al. 2021). What is of concern is that low MC levels have still been observed around the globe over the same period as effective MC interventions (see Bolger et al. 2020 for a review on global data). This inconsistency highlights the issue that interventions, albeit effective in the short term, have not been integrated into practical settings (e.g., teaching practice) over a longer term or adapted to suit the varied population to support young people's motor development at a population level. Considering the low MC levels among youth, it is crucial to evaluate MC interventions in a way that elucidates barriers and facilitators to their effective and sustained implementation and formalise them into potential mechanisms that support MC development. This PhD is therefore 'problem-centred' (Posner 2009)— recognising the lack of the real-world applicability of MC interventions and extending the inquiries into why this is the case and how to improve such a situation.

Evaluation, by its literal meaning, is to assess the *value* of a programme (Nutbeam and Bauman 2006). What is commonly seen in the reporting of MC interventions is outcome evaluation – acquiring a numerical value referring to the change in the skill outcome of interest before and after the intervention (Sullivan and Feinn 2012). For controlled interventions, this numerical value is often the amount of difference between groups that is directly attributed to either receiving the intervention or not – this is a primary means used to establish intervention effectiveness in many MC interventions (Eddy et al. 2019a). Naturally, the interpretation of intervention effectiveness in this case, e.g., being small, large, or null, only applies in the pre-defined experimental setting. Researchers then postulate the experimented intervention may have an impact on another population group with similar characteristics under similar conditions. This research process has been long-standing and has its de facto merit. However, it poses questions as to applicability of interventions in real-world settings. Firstly, using outcome evaluation alone to establish intervention effectiveness has its caveats. Even applying the best analytical practice such as using power calculation to infer a sample size required to

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detect an effect, the results may still not be generalisable (Glasgow 2008). Without a sound theoretical underpinning (and a sound experiment design to test the theory), it is hard to make an inference that intervention effects are induced by the intervention alone. Secondly, hypothesising the intervention can work under another condition and population without carefully examining the original context where the intervention worked is questionable. Thirdly, even if we investigated how the intervention worked and under which conditions, we still needed detailed information to inform the likelihood of embedding the intervention into practice and its maintenance in the longer term.

A recent transition in public health research to explore the true '*value*' of intervention has gained momentum. In particular, researchers have advocated for the consideration of ecological validity of the intervention (e.g., interventions delivered by school staff as part of their routine practice) (Love, Adams, and van Sluijs 2018). This requires evaluation to go beyond the quantification of improvement in an outcome from pre- to post-intervention (i.e., outcome evaluation) and to look inside the so-called 'black box' to see what happened during the programme and how that could affect programme outcomes (Saunders, Evans, and Joshi 2005). This provides a pathway to access detailed information relevant to the implementation of the intervention (i.e., integrating into practice for population-level changes). Implementation of evidence-based health interventions remains a ~~big~~ research gap (Lee et al. 2021). In the field of PA interventions, a decade ago, only 3% factored in implementation and dissemination in the trial development and reporting (Milat et al. 2011). Since then, there has been a modest increase in implementation research in PA interventions, but outcome evaluation is still prioritised in the field, partially due to the time and funding limitations in a research project (Lee et al. 2021). The lack of focus on implementation is even more apparent for MC interventions, demonstrated by a rare consideration of implementation research in MC interventions (Lopes et al. 2020, Foweather and Rudd 2020). One likely explanation is

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researchers' lack of experience, expertise, and organisational support in conducting implementation research (Koorts et al. 2020).

Implementation research is a multidisciplinary field that aims to study the development, spread, and sustainability of broadly applicable programmes that are contextually relevant and robust across diverse settings, delivery staff, and subgroups (Glasgow and Chambers 2012). Implementation evaluation examines the processes, factors, and strategies necessary to promote authentic adoption of evidence-based interventions, thereby increasing the effectiveness and likelihood of interventions to be integrated into routine practice (Eccles and Mittman 2006). To this end, implementation research lends itself to addressing the gap in MC intervention research as aforementioned. While the implementation science field is considered in its infancy, there are many established implementation theories that aid in the design, delivery, and evaluation of interventions, influencing the intervention effectiveness and dissemination (Tabak et al. 2012). However, implementation theories and frameworks need to be used in conjunction with a deep understanding of the issues specific to the subject field and practical context for them to be applicable (Moullin et al. 2020). For MC interventions targeting children and adolescents more specifically, to fulfil their potential in providing opportunities for youth motor development, it is important to examine the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice.

1.2 PhD aims and objectives

This PhD aims to improve the understanding of the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice, and provide suggestions regarding implementation evaluation. There are six research objectives:

1. To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).
2. To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.
3. To develop strategies intended to improve the implementation of a MC intervention.
4. To plan, design, and conduct an implementation evaluation of a MC intervention using strategies developed.
5. To report on the effectiveness of strategies intended to improve the implementation of a MC intervention.
6. To understand the process(es) and factors impacting the implementation and sustainability of a MC intervention.

Table 1.1 below presents a series of interconnected studies undertaken for this thesis and how they address these objectives. These studies are presented sequentially in Chapters 4-7 in this thesis. Each chapter builds on the previous one and begins with a brief introduction to highlight the links between them and how each contributes to the overall PhD aim.

TABLE **1. 1** S**UMMARY OF HOW EACH CHAPTER WITHIN THIS THESIS ADDRESS EACH**
RESEARCH OBJECTIVE

Chapter	Research objective(s) addressed
4. A systematic review of process evaluation of MC interventions	1. To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions	2. To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.
6. Developing implementation strategies and a protocol for implementation evaluation of a MC intervention	3. To develop strategies intended to improve the implementation of a MC intervention. 4. To plan, design, and conduct an implementation evaluation of a MC intervention using strategies developed.
7. Outcomes of implementation evaluation of a MC intervention	5. To report on the effectiveness of strategies intended to improve the implementation of a MC intervention. 6. To understand the process(es) and factors impacting the implementation and sustainability of a MC intervention.

1.3 Thesis structure

The thesis is organised into a linked narrative. The current chapter provides an overview of the research problem focussed on in this thesis and the thesis aims and structure. **Chapter 2** presents a narrative review of the literature that sets out the context for the research and highlights the research gaps to be addressed in this thesis (ontology). **Chapter 3** provides a summary of the research strategy and processes utilised in the research (methodology). Specifically, a conceptual framework is presented by which the research was guided.

Chapter 4 A systematic review of process evaluation of motor skill competence interventions

This chapter presents a systematic review that aimed to investigate whether process evaluation has been reported in the published MC interventions and, if reported, which process evaluation

measures have been used. Within limited reporting of process evaluation, there was some

evidence that process evaluation can help identify influences on intervention processes and

outcomes. This chapter has been published as:

Ma, J., Lander, N., Eyre, E. L. J., Barnett, L. M., Essiet, I. A., and Duncan, M. J. (2021). It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence. *Sports Medicine*, 51(12), pp.2547-2569. https://doi.org/10.1007/S40279-021-01519-5

Chapter 5 Using collective intelligence to understand the implementation and sustainability of MC interventions

Chapter 5 comprises of two parts. Given the novelty of applying collective intelligence in MC

intervention research.

<u>Part 1 Rationalising the use of collective intelligence to understand barriers to the implementation and sustainability of motor skill competence interventions</u>

Part 1 details the rationale and procedures of the application. This part has been published as:

Ma, J., Hogan, M.J., Eyre, E.L., Lander, N., Barnett, L.M., and Duncan, M.J. (2021). Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skill interventions: A rationale and application example. *Journal of sports sciences*, 39(6), pp.691-698. https://doi.org/10.1080/02640414.2020.1841395

<u>Part 2 Results of using collective intelligence to understand barriers to the implementation and sustainability of motor skill competence interventions</u>

Part 2 of Chapter 5 presents the synthesised findings from three collective intelligence

workshops on describing the complexity of barriers to implementing and sustaining MC

interventions and provides a roadmap of actions that help navigate through the complexity.

This part has been published as:

Ma, J., Hogan, M.J., Eyre, E.L., Lander, N., Barnett, L.M., and Duncan, M.J., (2021). Enhancing the implementation and sustainability of fundamental movement skill interventions in the UK and Ireland: lessons from collective intelligence engagement with stakeholders. *International Journal of Behavioral Nutrition and Physical Activity* 18, 144. https://doi.org/10.1186/s12966-021-01214-8

Chapter 6 Developing implementation strategies and a protocol for implementation evaluation of a motor skill competence intervention

Based on the barriers and solutions identified in Chapter 5, Chapter 6 documents a rigorous development process of strategies to improve implementation of a specific MC intervention (Project FLAME). This chapter also draws from the evaluation outcomes and measures identified in Chapter 4 to present the design of an evaluation protocol to investigate the implementation of Project FLAME and test the effectiveness of implementation strategies developed.

Chapter 7 Outcomes of implementation evaluation of a motor skill competence intervention

Chapter 7 presents the empirical findings of the implementation evaluation of Project FLAME. Specifically, it aimed to investigate the impact of the newly developed strategies on the implementation outcomes and examine the contextual influences on the implementation and sustainability of Project FLAME.

Chapter 8 draws together key findings related to the research objectives and discusses how these findings contribute to addressing the overall PhD aim. Then, overall implications for research and practice regarding MC intervention evaluation and implementation are presented.

1.4 Thesis contribution and role of the researcher

Under the primary supervision of Prof Michael Duncan (Coventry University) and Prof Lisa Barnett (Deakin University), and the co-supervision of Dr Emma Eyre (Coventry University) and Dr Natalie Lander (Deakin University), the work comprising this thesis was conducted by the PhD candidate. The three research studies were led by the candidate, from the conception to delivery and conduct, involving: engaging with stakeholders, completing the necessary research ethics processes, data collection, database management and data analysis. In the study reported in Chapter 5, the candidate invited Dr Michael Hogan – the leading expert in the CI method to advise on the study protocol and design. The candidate completed training to use

the method under his mentorship. Dr Hogan's contribution is outlined and declared in Chapter 5. For the study reported in Chapter 6 and Chapter 7, the supervisory team and the candidate collaborated with a MC intervention research team at University College Cork (UCC). From 2016 to 2018, UCC designed, developed, and conducted efficacy trials of a MC intervention programme (Project FLAME). The candidate proposed the implementation evaluation of the Project FLAME and led the design, development, and conduct of this study. The candidate is the first author of the three published papers contained in Chapter 4 and 5, author contribution agreements for these papers have been included in Appendix 23.

Chapter 2. A narrative review of literature

2.1 Motor skill competence

MC is a global term used to describe an individual's proficient performance in a broad range of motor skills as well as the underlying mechanisms including quality of movement, motor coordination, and motor control (Robinson et al. 2015, Utesch and Bardid 2019). It reflects a broad range of terminologies used across the various disciplines of motor development (Logan et al. 2018), including motor proficiency, fundamental movement skill (FMS), motor ability, and motor coordination (Robinson et al. 2015). MC in children and adolescents–the focus of this thesis–incorporates FMS, including object control (e.g., throwing and catching), locomotor (e.g., running and jumping), and stability skills (e.g., balancing and twisting) (Gallahue, Ozmun, and Goodway 2012, Rudd et al. 2016). These skills are considered as the foundation of more advanced, complex movements required to participate in sports, games, or other context-specific PA (Clark and Metcalfe 2002, Logan et al. 2018, Hulteen et al. 2018).

2.1.1 Health outcomes of motor skill competence

Having adequate levels of MC has numerous health benefits. The purported association between MC and PA is one of the most commonly examined health outcomes in motor development literature. It has been reported that children with low MC levels do not meet the recommended PA levels (de Meester et al. 2018). Therefore, developing MC may be synergistically targeting PA participation (Robinson et al. 2015). The focus on the MC-PA association is necessary, for this association is reciprocal and developmentally dynamic, as theorised by Stodden and colleagues (Stodden et al. 2008) (Figure 2.1). The term 'reciprocal' in this case refers to PA offering more opportunities to develop MC which in turn promotes PA, while 'developmentally dynamic' indicates the relationship between PA and MC strengthens over time from early childhood to middle and late childhood. Essentially, in early

childhood, an individual who is more physically active will develop higher levels of MC. This relationship then reverses from middle to late childhood, i.e., an individual with higher levels of MC will engage in more PA.

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FIGURE 2. *1* DEVELOPMENT RELATIONSHIPS BETWEEN MOTOR SKILL COMPETENCE, HEALTH-RELATED PHYSICAL FITNESS, PERCEIVED MOTOR COMPETENCE, PHYSICAL ACTIVITY, AND RISK OF OBESITY. *EC=EARLY CHILDHOOD, MC=MIDDLE CHILDHOOD, LC=LATE CHILDHOOD. IMAGE EXTRACTED FROM STODDEN ET AL. (2008)*

Systematic reviews have assessed the MC-PA association, with three reviews focussed on children and adolescents reporting a low to moderate association between MC and PA (Lubans et al. 2010, Logan et al. 2015, Barnett et al. 2016). A meta-analysis of 19 studies (with the majority being cross-sectional studies) showed a small positive association between MC and PA (r = .20) (Jones et al. 2020). Another recent meta-analysis by Graham et al., including 14 intervention studies, found that interventions containing MC components improve daily levels of moderate to vigorous PA by 4.3 min/day among children aged 5-11 years old (Graham et al. 2021). However, the intervention studies from which the effect was drawn from lacked

retention assessment of MC, and Graham et al. critiqued that the effect reported in the review may not reflect the developmental nature of MC-PA relationship. The latest meta-analytical study prioritising longitudinal observational research, however, reported an inconclusive link between MC and PA (Barnett et al. 2022). Authors of the review performed a synthesis on published experimental studies to determine the level of evidence in support of the pathways depicted in the Stodden et al. model. For the pathway from PA to MC, only 8 out of 98 (8%) published analyses reported a significant positive association. For the reverse pathway, there was only limited indeterminate evidence, with 41% of analyses (excluding a study that skewed the overall results) supporting a significant positive association (Barnett et al. 2022). In the discussion of their review, authors attributed these variations to the measurement of PA and MC, age, sex, and the length of follow-up. A further analytical study employing a network analysis approach showed that the relationship between MC and PA may change with age (Martins et al. 2020). Specifically, both locomotor and object control skills were positively associated with PA in children at three years old but one year later the association weakened.

The Stodden et al. model also highlights the role of other health outcomes in MC development (i.e., perceived motor competence, health-related fitness, weight status), which highlights MC, in its own right, as an underestimated yet critical determinant of one's health behaviours. For health-related fitness, the most recent systematic review by Barnett et al. (2022) found a positive association between locomotor and stability skills with fitness and confirmed the mediating role of fitness in the relationship between MC and PA (as suggested in the Stodden et al. model). This is in agreeance with earlier meta-analytical evidence that concluded a moderate to the large positive association of MC and health-related fitness (r = .43), pooling data from 19 studies comprising of 15,984 participants aged 4-20 years (Utesch et al. 2019). Regarding weight status, the evidence base is strong in supporting the bi-directional, negative relationship between MC and weight status (Barnett et al. 2022). A

systematic review of 27 studies reported that overweight or obese children (aged 6-10 years) are likely to show lower MC levels compared to normal-weight peers (Trecroci et al. 2021). The final health outcomes mentioned in the Stodden et al. model is perceived motor competence, which can be defined as children's physical self-concept (de Meester et al. 2020). In the latest evidence, the strength of the relationship between perceived competence and MC was found to be low to moderate (r = .25) (de Meester et al. 2020) and the mediating role of perceived motor competence in the relationship of PA and MC is indeterminate (Barnett et al. 2021).

Stodden et al. model is one of the most influential theoretical models in motor development literature as indicated by a substantial number of investigations (Barnett et al. 2021). So far in this literature review, the model has been utilised to outline the wide array of health outcomes associated with MC. Researchers recently argued the further expansion of the model to include more outcomes related to psychological, cognitive, and academic domains (Lima, Drenowatz, and Pfeiffer 2022). A recent meta-analysis including data on 4,866 children aged 3 to 12 years (51% boys, 49% girls) revealed a small positive association between MC and executive functions (r = .18) (Gandotra et al. 2021). Furthermore, a systematic review that included 24 observational studies reported a weak association between MC and academic performance in both reading and mathematics (r = .10 - .28) (MacDonald et al. 2018). In terms of psychological outcomes, having low MC levels is associated with anxiety and depression (Rodriguez et al. 2019) and poor body image (Brown and Cairney 2020, Corr, McSharry, and Murtagh 2019). It is therefore unsurprising that children's MC is positively associated with school readiness (observed in a cross-sectional sample of 4-6 year old children in England), which is a multi-faceted construct that involves cognitive, emotional, social, physical, and academic competencies (Jones et al. 2021).

The importance of improving MC has been increasingly recognised, and strategies have been proposed to support MC development (Lopes et al. 2020). These strategies support the notion that a health promotion strategy targeting the early years can synergistically enhance MC and PA participation, and ultimately produce and maintain health benefits across the life course (Robinson et al. 2015).

2.1.2 Motor skill competence levels

Despite the health benefits associated with MC, young people's MC levels are low worldwide—a recent systematic review that synthesised MC levels of over 21,000 children, from 60 studies in 25 countries conducted over a time span of 2004-2019 revealed that children are not achieving MC to their expected capability (Bolger et al. 2020). The low levels of MC were also found regardless of the geographical locations, including in the US (Brian et al., 2019), Brazil (Nobre, Valentini, and Nobre 2018), England (Duncan et al. 2020), China (Zhang and Cheung 2019), and Ireland (Bolger et al. 2018). One longitudinal report described downward trends in a large sample (n =13,752, aged 9-15 years old) of Australian children's MC levels from 1997 to 2010 (Hardy et al. 2013). Reporting of MC outcomes varied but the results generally suggested that the proportion of children achieving mastery of their FMS (i.e., displaying correct performance of all skill components) is less than 50% (Bolger et al. 2020). According to motor development theories, FMS should be mastered by the age of 10 (Gallahue, Ozmun and Goodway 2012). However, Bolger et al.'s review presented concerning evidence that low MC levels were prevalent among the 9- to 10- year-olds. Similar low levels of MC were also observed in adolescents. Belton et al. (2014) presented cross-sectional data on MC levels of Irish youth (n = 256, aged 12-14 years old) and reported that 99.5% of the participants did not achieve the MC expected for their age. This revealed a phenomenon that Irish adolescents may fail to make the successful transition towards more advanced PA participation (O' Brien, Belton, and Issartel 2015). More recently, Philpott et al. (2020) examined MC levels

in a sample of Irish adolescents (n = 373; aged 12-16 years old) and found the low overall MC among the participants and even lower proficiency levels in object control skills than previously published figures in Irish samples.

Low MC levels are also observed in specific populations. Global data suggest that older children demonstrate higher levels of proficiency than their young peers, and boys generally perform better in object control skills than girls (see Barnett et al. (2016) and Bolger et al. (2020) for reviews). Overweight and obese children are reported to demonstrate inferior MC compared to their non-overweight peers (see Trecroci et al. (2021) for a review). When looking at external influences on children's MC levels, two systematic reviews that examined socioeconomic status as a correlate of MC found that children from higher socioeconomic status have better locomotor skills (Barnett et al. 2016, Venetsanou and Kambas 2010). Moreover, experimental studies reported that children of a South Asian background demonstrated lower MC levels compared to peers with a White or Black ethnic background (Eyre, Walker, and Duncan 2018, Eyre et al. 2018).

2.1.3 Correlates and determinants of motor skill competence

Understanding correlates and determinants of MC is integral to designing strategies aiming to improve MC in a targeted population. Improving MC may target different correlates, hence producing different impacts (Barnett et al. 2016). As reviewed in the previous section, Barnett et al.'s review reported age (older) as a consistent positive correlate of MC; gender (male), weight status (healthy), and socioeconomic background (higher) were found to positively associate with subcategories of MC. Equally important, but far less understood, is that MC levels also differ as a function of a range of modifiable environmental, social, cognitive, and psychological correlates (Barnett et al. 2019, Smith et al. 2016). As an example, several studies revealed cross-cultural differences in children's MC apart from geographical differences.

These differences were attributed to a wide range of factors, including PE curriculum and practice (Bardid et al. 2015, Ma et al. 2021a), national PA recommendations and guidelines (Luz et al. 2019), and cultural preferences for sports (Haga et al. 2018, Tietjens et al. 2020). There are several underlying mechanisms to explain the variant influences on MC levels, which are commonly depicted in theoretical models of motor development.

Enhancing MC is an integral part of motor development, which refers to the study of "the changes in motor behaviour over the lifespan *and* process(es) which underlie these changes" (Clark and Whitall 1989, p.194). The mountain of motor development (Clark and Metcalfe 2002) was used as a metaphor to describe a cumulative and sequential pattern of MC development (Figure 2.2). Each individual was analogous to a mountaineer that climbs the mountain of motor development through five stages: 1) reflexive, 2) preadapted, 3) fundamental motor patterns, 4) context-specific, and 5) skilful. The first stage describes a period from birth to when an individual can move independently. Children then begin to develop fundamental movement patterns and continue to adapt movements to a broad range of context-specific movements. As linear as it seems, the climb on the mountain of motor development is a nonlinear process, in which "the level of success attained are products of the characteristics of the mountain, environmental conditions on the mountain, and the individual skills and abilities of the mountaineer" (Clark and Metcalfe 2002). The metaphor aptly describes motor development as an individual's journey, shaped by the interaction between the individual and the environment.

FIGURE 2. 2 THE MOUNTAIN OF MOTOR DEVELOPMENT (CLARK AND METCALFE 2002)

Similarly, the theory of constraints by Newell (1986) outlined the environmental influences on

MC development. The constraint model proposed three factors (i.e., individual constraints, task

constraints, environmental constraints) that interact to promote or demote the MC development

(Figure 2.3). Individual constraints include structural factors that encompass a range of

unmodifiable biological makeup (e.g., height and weight) and functional factors that relate to

psychological attributes (e.g., perceived competence). Environmental constraints refer to those

present in the physical environment (e.g., weather) that may influence children's performance.

Task constraints refer to the process and goal of the activity, for example, the equipment being

used may influence how well children perform a skill.

FIGURE 2. 3 THE THEORY OF CONSTRAINTS (NEWELL 1986)

The environmental contexts are not limited to the physical environment where the motor behaviours occur, but also include the circumstances, objects, or conditions by which one is surrounded (Gabbard 2021). The motor development process is therefore complex, with multiple factors interacting and exerting influences. This demands equal attention be paid by researchers to the contributions of biological and environmental systems (Gabbard 2021). A prominent theory that contributes to this insight is Bronfenbrenner's bioecological systems theory (Bronfenbrenner 1992; see Figure 2.4). This model implies that a child does not develop in isolation nor do their motor behaviours. An individual is influenced by a broad range of situations and contexts which make up the physical, social, and phenomenological experience that can shape motor development (Gabbard 2021). Empirical findings in motor development research support the notion underlying the model by demonstrating that children do not develop MC with maturation alone, the development occurs with quality instruction, encouragement, and feedback (Gallahue, Ozmun, and Goodway 2012). Another implication of the model on motor development is the interconnectedness among layers of influences such as the relationship of school experience to the community, or of school experience to the family. From a bioecological systems perspective, improving MC requires the understanding and manipulation of factors at various levels. Consequently, strategies to improve MC also need to be developmentally appropriate and suit the individual needs.

FIGURE 2. 4 BRONFENBRENNER'S BIOECOLOGICAL SYSTEMS THEORY OF DEVELOPMENT (BRONFENBRENNER 1992) (IMAGE EXTRACTED FROM GABBARD 2021)

2.2 Evaluation of motor skill competence interventions

A diverse range of strategies that are developmentally and instructionally appropriate, such as modified PE and free play, have been used in interventions to improve MC (Jiménez-Díaz, Chaves-Castro, and Salazar 2019). The immediate effects of interventions on MC outcomes have been reported extensively and are mainly established through controlled trials (Eddy et al. 2019b, Morgan et al. 2013). These controlled intervention studies are also referred to as efficacy research, whereas effectiveness research refers to whether the intended positive effects of an intervention are generated in real-world contexts (Singal, Higgins, and Waljee 2014). Multiple systematic reviews on MC efficacy trials have reported moderate to large intervention effects from such studies. Logan and colleagues conducted a meta-analysis of 11 interventions to improve non-typically developing children's MC, and found a small positive effect on overall MC outcomes (d = .39) (Logan et al. 2012). Among 11 interventions included in the review, 10 interventions were conducted in schools. Interventions included in Logan et al.'s

review involved sample sizes ranging from 8 to 1,045 participants, and were between 6 and 15 weeks with session time ranging from 320 to 1350 minutes. However, no correlation was found between intervention dose and effect size. In 2013, Morgan and colleagues published a meta-analysis of 19 MC interventions for typically developing children and adolescents and reported large effect sizes for overall MC outcomes (Standardised Mean Difference (SMD) = 1.42). Four interventions included in this review were conducted afterschool with the rest conducted in school settings. Very few interventions were conducted in community or home settings. Most interventions were delivered by PE teachers (n = 15), followed by trained preservice teachers (n = 3), classroom teachers (n = 3), and experienced coaches (n = 1). Reviewed in both Morgan et al. (2013) and Logan et al. (2012), many MC intervention studies included lesson plans containing skill instruction (e.g., direct instruction) and compare the effect on MC outcomes with the usual PE practice that focussed on free play or team games/sports. The wealth of evidence have thus been conducted in school and PE settings; however, it remained unclear from the studies which strategies resulted in the optimal improvements in MC outcomes due to the insufficient details reported in the intervention studies (Morgan et al., 2013, Logan et al., 2012).

Tompsett and colleagues conducted a systematic review aiming to identify MC intervention characteristics that make MC interventions efficacious (Tompsett et al. 2017). Authors found that interventions are consistently efficacious in improving MC when they include a multi-component approach, multiple weekly sessions, an 'at-home' practice and parental involvement, last longer than 6 months, or are delivered by trained personnel (e.g., PE specialist). Notably, consistent with previous reviews by Morgan et al. and Logan et al., specialist PE teachers along with professional development are a key feature of most MC interventions. Most recently, a systematic review with a focus on PE-based MC interventions (n = 20; representing 4,009 participants aged 3-13 years old) revealed a medium to large effect

of PE-based interventions on MC outcomes (Hedge's g = .69) (Lorås 2020), confirming the merit of enhanced or modified PE compared to usual PE practice such as free play. In a more in-depth meta-analysis on PE-based MC interventions explored the differing effects on MC outcomes in terms of quantity of PE (frequency and duration of lessons) and quality of PE (teaching strategies), authors found small significant increases in MC outcomes among the seven quality-based interventions that incorporated teaching strategies (Hedge's g = .38; n = 3,873 participants) (García-Hermoso et al. 2020). Further meta-regression analyses found that more PE lessons per week was associated with larger improvements in MC (García-Hermoso et al. 2020). However, these PE-based MC interventions often face implementation barriers due to limited resources and time allocated for teachers (Tompsett et al. 2017) as well as quality of teacher training (Lander et al. 2017).

All reviews on MC interventions reported on substantial heterogeneity among intervention studies included (García-Hermoso et al. 2020, Lorås 2020, Eddy et al. 2019, Jiménez-Díaz, Chaves-Castro, and Salazar 2019, Engel et al. 2018, Logan et al. 2012, Morgan et al. 2013). Significant heterogeneity can arise from intervention diversity (e.g., variability in interventions strategies, populations, and outcomes) or methodological diversity (e.g., variability in study design and quality) (Higgins and Green 2008). For the former, intervention effects on different population groups can be compared by conducting subgroup analyses. In Lorå's meta-analysis, MC interventions can have similar impacts on both children (intervention study n= 13, Hedge's g = .59) and adolescents MC (intervention study n= 10, Hedge's g = .78). Interventions can also have differing effects on skill subsets; for example, Morgan et al's meta-analysis revealed larger intervention effects on locomotor skills (intervention study n= 7; SMD = 1.42) than object control skills (intervention study n= 9; SMD = .63). For the latter, all reviews identified methodological weaknesses related to both internal and external validity with risk of bias analyses (Graham et al. 2021, Eddy et al. 2019, Engel et al. 2018, Jiménez-

Díaz, Chaves-Castro, and Salazar 2019, Logan et al. 2012, Morgan et al. 2013). In comparison, the potential causes for variations in intervention effects are not fully understood (Lorås 2020) which limits our understanding as to why interventions are effective (or not). For example, in reviews by Morgan et al. (2013) and Jiménez-Díaz et al. (2019), interventions delivered using similar approaches and modes did not achieve a similar magnitude of effects. In these two reviews, reviewers could not explain this variance due to the lack of details on intervention evaluation and reporting, thus warranting more comprehensive evaluations of MC interventions to understand what influences intervention outcomes.

Explanations on the variance of intervention effects may come from researchers' close involvement in and observations on intervention processes. In Graf et al. (2008), the intervention was run for four years, and the researchers noticed intervention activities could cause participant disengagement due to repetition during the intervention. However, this anecdotal evidence that could have been better supported by examining the participants' responses to the intervention. Grillich et al. (2016) conducted a school-based teacher-led RCT to improve children's MC and PA and reported there were only small effects on MC improvement and no effects on PA. The author attributed the small effect/null effect partly to the lack of dose delivered to teachers (20hrs training and 8h workshops over 1.5 academic years) (Grillich et al. 2016). Intervention outcomes can also be influenced by unexpected events which occurred during the intervention process (Moore et al. 2015). In a six-week school-based MC intervention conducted by Bryant and colleagues (2016); the authors observed that children's MC in the control group also improved alongside children in the intervention group. This was reported to be a result of the cross-over interactions between students from both groups in the same school (Bryant et al. 2016). These examples demonstrate what happened during an intervention can have important influences on the interpretation of outcomes (Saunders, Evans, and Joshi 2005), but these influences have rarely been recorded to

make and strengthen the causal inferences of intervention and its outcomes. Systematic reviewers have also progressively recognised the importance to record and report process-related measures in MC interventions (Logan et al. 2012, Morgan et al. 2013). Logan et al. (2012) examined the association between intervention duration and effect size, but the results were non-significant. Morgan et al. (2013) also highlighted actual on-task time (i.e., the actual time a child is engaged in an activity in which he or she is practicing a skill) is crucial to report on, to explain intervention effects. These reviews provide some information on how intervention characteristics influence intervention outcomes, but not in the depth required for a broader understanding of MC intervention processes. Meanwhile, some reviews on PE-based MC interventions indicated that quality of PE is a potential moderator of MC intervention effects (Lorås 2020, García-Hermoso et al. 2020). Nevertheless, due to inadequate reporting of intervention characteristics and processes, there is still no direct evidence on the effective strategies to promote students' learning of motor skills (Tompsett et al. 2017).

The conventional outcome evaluation used in intervention studies provides a measure of the magnitude of intervention success, but it is unable to address the questions as to 'how' and 'why' the intervention results in the measured outcomes (Moore et al. 2015). The 'how' and 'why' tap into a crucial inquiry on the practical effectiveness of an intervention programme (Abraham and Michie 2008). Answering these questions will help better understand what and how factors can moderate the change of MC in an intervention. Given that motor development is a complex and multifaceted process that is influenced by various correlates (Robinson et al. 2015), MC evaluations need to account for the broad contextual influences.

2.3 School physical education as a setting to develop motor skill competence

As identified in multiple systematic reviews on MC interventions, PE is a critical and opportunistic medium to improve MC, given children and adolescents need to be taught and instructed to master motor skills (Dudley et al. 2011). MC development is a central focus of PE in many international and national PE curricula and recommendations (National Council for Curriculum and Assessment (NCCA) 2021, Department for Education 2013, United Nations Educational, Scientific and Cultural Organization (UNESCO) 2015). PE curricula, instruction, and pedagogy can be modified or enhanced to optimise students' learning and practice of motor skills (Lawson 2018), and MC is optimally developed when individuals received quality instruction and feedback (Clark and Metcalf 2002). PE can also create motivational climates that are theorised and tested to enhance student's motivation towards and engagement in motor skill practice (Martin, Rudisill, and Hastie 2009). Moreover, PE—as the protected, regular, supervised setting for PA (Bailey et al. 2022)—provides opportunities for students to practice motor skills which is another key mechanism for MC development (Gallhue, Ozmun and Goodway 2012).

However, statutory PE alone does not seem to be sufficient in advancing MC of the student population. Direct evidence of this, is that despite being the focus of many national curricula, MC levels observed are still, if not declining, low across the globe (see Section 2.1.2). Further, the population variation in MC reviewed previously indicate that more targeted strategies need to be developed to meet the need of those who are at risk of low MC. In a cross-sectional study that examined Australian primary-school aged girls' performance in object control skills, authors identified behavioural components of the skills that were poorly executed (e.g., transfer of body weight), and therefore reinforcing the need to target these components when designing and implementing teaching programmes and strategies (Eather et al. 2018).

Strategies to promote students' MC in PE involves applying effective or appropriate pedagogy (Lander et al. 2017a) As reviewed previously, MC interventions often compare impact of a modified PE curriculum with the traditional one, which is represented by 'physical-education-as-sport-technique' where students engage in decontextualized practice of skills (Kirk 2013). Evidence-based pedagogy is therefore needed to guide PE design and delivery to improve student outcomes (Metzler 2017). Pedagogical research in PE has increased in the past two decades (Casey and Kirk 2020). An important focus in pedagogical research is choice of pedagogical models, which are defined as ways of organising interdependent elements of curriculum, learning, and teaching to achieve learning outcomes (Hastie and Casey 2014). Different pedagogical models include but not limited to: Teaching Games For Understanding (TGFU), developed to help students learn skills within the context of the game (Griffin and Butler 2005); Cooperative Learning, whereby students work together and take responsibility for their own learning (Dyson and Casey 2012); Sport Education, which aims to develop students to become competent, literate, and enthusiastic sport player (Siedentop 1984); and Health-based PE, which guides students to value and develop physically active lifestyles to enhance health (Haerens et al. 2011). Fernandez-Rio and Iglesias (2022) recently synthesised evidence on the effectiveness of the different pedagogical models and reviewed several issues to consider for improving teaching effectiveness. They firstly established that applying or combining different pedagogical models benefit student learning in PE. However, some models may benefit more in a particular population than another. For example, PE employing sport education as a model may favour boys and highly skilled students (Fernandez-Rio and Iglesias 2022).

Specific to the learning of motor skills, linear and nonlinear pedagogy can be used to inform the design of facilitating learning environments to develop MC. Linear pedagogy is a teacher-centred instructional approach where students learn skills through movement tasks

designed by teachers (Metzler 2017). MC interventions utilising this approach often consist of prescriptive (e.g., following demonstrations and instructions from teachers) and repetitive actions (e.g., repeating to replicate the optimal technique) (Schmidt et al. 2018), where students learn and practice skills in isolation before performance sequences and game-play are introduced (Rudd et al. 2021). Albeit popular and effective in increasing skill proficiency (Morgan et al. 2013), linear pedagogy has been criticised for its rigidity and lack of variability (Woods et al. 2020). By contrast, nonlinear pedagogy is considered a student-centred instructional approach where children are given autonomy to explore movement solutions within the mastery environment created and facilitated by teachers (Chow and Atencio 2014). There is limited evidence to date of the application and effectiveness of nonlinear pedagogy. However, some PE-based interventions with traits of nonlinear pedagogy demonstrated improvements in MC outcomes, compared to usual PE practice (characterised by direct skill instruction) (Pesce et al. 2016, Invernizzi et al. 2019). Most recently, an intervention study (SAMPLE-PE) was conducted to assess the efficacy of linear and nonlinear pedagogy in PE to promote movement competence (including MC) in 5-6 year old children from North West England (Rudd et al. 2020). Although the intervention effects on students' MC outcomes have yet to be published, a study nested within SAMPLE-PE reported that PE lessons utilising nonlinear pedagogy demonstrated more empowering motivational climates compared to the nonlinear approach, which potentially better supports students' learning of skills.

As reviewed in section 2.2, in many MC interventions teachers are the primary change agents in promoting MC improvement. Indeed, different pedagogical approaches need to be implemented by competent and confident individuals to support students' learning of skills (Chow and Atencio 2014) and shape students' movement experience (Fairclough et al. 2018). For example, although employing sport education as a model may favour boys and highly skilled students, with careful design by a skilled and confident teacher, it can engage and

benefit all students in class (Fernandez-Rio and Iglesias 2022). A recent systematic review showed that the presence of feedback during PE has a positive impact on students' motor skill learning, compared with those without feedback (Zhou, de Shao, and Wang 2021). Congruent with the review findings, a series of experimental studies showed that the provision of choice and positive feedback provided by PE teachers are moderators on students' MC (de Meester et al. 2020, de Meester et al. 2022). In MC interventions, effective teachers need to have a thorough understanding of the mechanism and value of MC development (i.e., content knowledge) and effective delivery approaches of PE/MC interventions (i.e., pedagogical knowledge) to plan, implement, and adapt the most effective teaching to achieve the intervention outcomes (Lander et al. 2017a). Furthermore, teachers' commitment to effectively deliver the intervention is determined by their perceptions, attitudes, and values of MC development and interventions (Lander et al. 2016, Lander et al. 2017a). Thus, collecting information on teacher's practice is important to understand the context and effectiveness of interventions (Tompsett et al. 2017, Lander et al. 2017a). Given the literature reviewed in section 2.2 and 2.3, school PE and teachers are the primary focus of this thesis when examining MC interventions.

2.4 Implementation of motor skill competence interventions

The past reliance on outcome evaluations and the resultant inadequate understanding of the practical effectiveness of MC interventions have hindered the learnings on implementation of MC interventions, which refers to the process of integrating an intervention into practice within a particular setting (Milat, Bauman, and Redman 2015). Notwithstanding the numerous reported efficacious MC interventions, there is a lack of generalisable and sustainable interventions that have been translated into practice (Foweather and Rudd 2020). For the continued achievement of desirable programme and population outcomes, the programme

needs to be continuously delivered over time and institutionalised within settings (Rabin et al. 2006). Continued implementation of effective programme components is needed (i.e., sustainability; Scheirer and Dearing 2011). The reliance on outcome evaluations alone does not seem to support the generation of knowledge and portable principles that can be translated into practice regarding how to effectively implement MC interventions. To address the challenge, implementation evaluation can help by examining the processes, factors, and strategies needed to promote the systematic uptake of research findings (Eccles and Mittman 2006). This includes exploring how participants engage with the intervention, how the intervention is implemented and the potential impact of surrounding contexts on these factors, and the achievement of outcomes (Moore et al. 2015). It also includes the examination of barriers to the implementation and sustainability, and how they can be addressed (Tabak et al. 2012).

Translating effective research to practice requires an understanding of implementation and sustainability (Koorts et al. 2018a). Ineffective/inadequate implementation and sustainability in MC interventions need to be addressed but have received little attention (Foweather and Rudd 2020). A handful of follow-up of MC interventions have been performed (Barnett et al. 2009, Zask et al. 2012, Lai et al. 2014), which have a focus on the maintenance of MC outcomes. By contrast, there has been less investigation of the factors that influenced the implementation and sustainability (Foweather and Rudd 2020, Lander et al. 2020b).

There exist over 150 theories, models, and frameworks in implementation research (Strifler et al. 2018). However, the variety of theories has hampered their appropriate use (Damschroder 2020). Nilsen (2015) proposed a taxonomy that outlines the common theories used in implementation research and their main purposes (see Figure 2.5). The taxonomy proposes three main aims of implementation research. To describe the implementation process,

process models are used to guide the process of translating research into practice (e.g., PRACTIS guide; Koorts et al. 2018b). For the understanding of factors that influence implementation, there are determinant frameworks (e.g., Consolidated Framework for Implementation Research; Damschroder et al. 2009), classic psychology and sociology theories (e.g., Self-Determinant Theory; Deci and Ryan 2012) and implementation theories (e.g., Dynamic Sustainability Framework (Chambers, Glasgow, and Stange 2013) used to explain specific aspects of implementation. Finally, some frameworks provide structure to evaluate implementation. Implementation theories often detail conceptual domains and measurement constructs to break down different aspects of implementation. It has been suggested that multiple uses of implementation theories help conduct intervention research (Moore et al. 2019).

FIGURE 2. 5 THE USE OF THEORETICAL APPROACHES IN IMPLEMENTATION SCIENCE (NILSON 2015)

Process evaluation is important for studying the implementation of interventions (McKay et al. 2019). As defined in the UK Medical Research Council (MRC)'s guidance on process evaluation (Moore et al. 2015), it is "*a study which aims to understand the functioning of an intervention, by examining implementation, mechanisms of impact, and contextual factors*" (Moore et al. 2015, p.8)." The domains assessed in process evaluations can assist in

the understanding of the implementation, including *Implementation*: describes how delivery is achieved and what is delivered; *Mechanism of change*: explains the causal pathway used in the interventions linking the implementation to the intervention outcomes; *Context*: a broad concept of any pre-existing or concurring contextual factors that can shape theories of how an intervention works, interact with implementation, and affect intervention mechanisms and outcomes. The widely acknowledged benefit of conducting process evaluation is to assist in the interpretation of intervention outcomes and ascertain whether intervention outcome is attributed to the intervention design or intervention delivery and implementation (Oakley et al. 2006). As shown in Figure 2.6, outcome evaluation cannot distinguish implementation failure from design failure in intervention without understanding the process. This also shows process evaluation can contribute directly to decision-making that is relevant for a programme to have sustained population-level impacts.
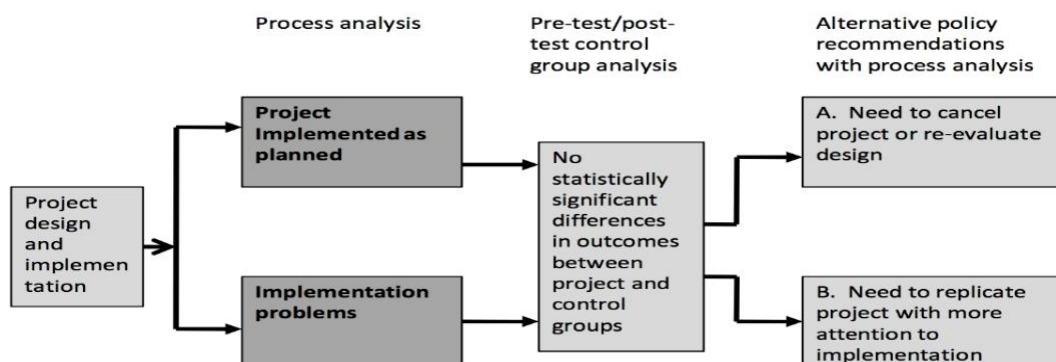
FIGURE 2. *6* ALTERNATIVE POLICY RECOMMENDATIONS AS RESPONSES TO DIFFERENT CAUSES OF INTERVENTION FAILURE (ADAPTED FROM BAMBERGER ET AL. 2009)

Evaluations on the intervention process have the potential to build the evidence base for the implementation and long-term sustainability of effective MC interventions (Rudd et al. 2020). Encouragingly, there are emerging examples of implementation research in MC research. One example is the three-year follow-up evaluation of teachers' perspectives on the implementation of an intervention to improve MC among adolescent girls (Lander et al.,

2020b; Lander et al., 2017). Lander et al. (2020) reported sustained implementation of the programme, which was facilitated by teachers' sustained motivation owing to the programme structure, flexibility to adapt the programme, and student engagement with the programme. The authors also uncovered the barriers to the implementation, including misalignment with the curriculum and limited time to take on new practices (Lander et al. 2020b). The study highlights the value of incorporating an evaluation framework to access a big picture of what makes a teacher-led MC intervention effective and sustainable. Another example is an evaluation of "internet-based Professional Learning to help teachers promote activity in Youth" (iPLAY), an online-based professional development programme for teachers and school leaders to deliver activities designed to improve children's cardiorespiratory fitness, MC, and PA (Lonsdale et al. 2016). The programme used an implementation determinant framework to adapt the content aiming to improve the implementation and increase the potential for the project to be scaled. These adaptations are also referred to as implementation strategies (Leeman et al. 2017). The iPlay study warrants the use of implementation theories to effectively guide the implementation process, although a full report on the implementation evaluation has not been published, which would delve into which specific characteristics of implementation made the programme scalable and sustainable. The use of implementation theories and frameworks in MC intervention evaluations is another critical consideration, which can potentially elucidate effective strategies in improving implementing and sustaining MC interventions.

2.5 Summary of the narrative review of literature

This literature review identified a range of key considerations to be addressed in this PhD. Foremost, MC is associated with a range of health outcomes including PA. However, global MC levels among young people remain markedly low. This is despite the preponderance of school or PE-based interventions and initiatives promoting MC, thus highlighting a need to translate effective MC interventions into practice to benefit the wider population. The outcome evaluation of MC interventions under controlled settings has been questioned, for its inability to access information relevant to the real-world effectiveness of an intervention which resulted in the inadequate understanding of contextual influences on intervention processes and outcomes. This PhD, therefore, aimed to improve the understanding of the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice, and provide suggestions regarding implementation evaluation.

Chapter 3. Methodology

3.1 Chapter overview

This chapter aims to provide an overview of the research paradigm and theoretical frameworks utilised in this thesis, as well as explicitly demonstrate the link between the methods adopted for each research study and the research objectives in a conceptual framework developed for this PhD research. It also introduces the thesis map which is purposed to signpost readers throughout this thesis as well as the ethics approval information.

3.2 Research paradigm

Methodology refers to "a set of principles and ideas that inform the design of a research study" (Mills and Birks 2017, p.4). This set of principles and ideas can include a range of theories and research methods that constitute rational answers to the research questions. As examined in the literature review, MC interventions predominantly use outcome evaluations (Rapport and Braithwaite 2018, Eddy et al. 2019a) (e.g., a quantification of the change of MC outcomes before and after certain interventions, compared to a control group). This research paradigm represents a reductionist view which may fail to provide realistic and holistic insights into the routine practice, which consequently results in the paradox of MC intervention research−that is−numerous effective interventions accompanied by persistent low MC levels observed globally. The apparent priority in this situation is to assess and improve the *implementation* of effective interventions (i.e., integration into routine practice) so that the wider population can benefit from the intervention continuously.

There is growing recognition of the need to use principles and methods from implementation science in motor development research (Foweather and Rudd 2020, Lander et al. 2020b). The applied nature of implementation science can assist in understanding how a

MC intervention was implemented and influenced by contextual factors and provide information to support the adoption of MC interventions into practice (Foweather and Rudd 2020). For these reasons, this PhD research adopted a range of theories, models, and frameworks in implementation science to aid in achieving the overall PhD aim (see Figure 3.1 below).
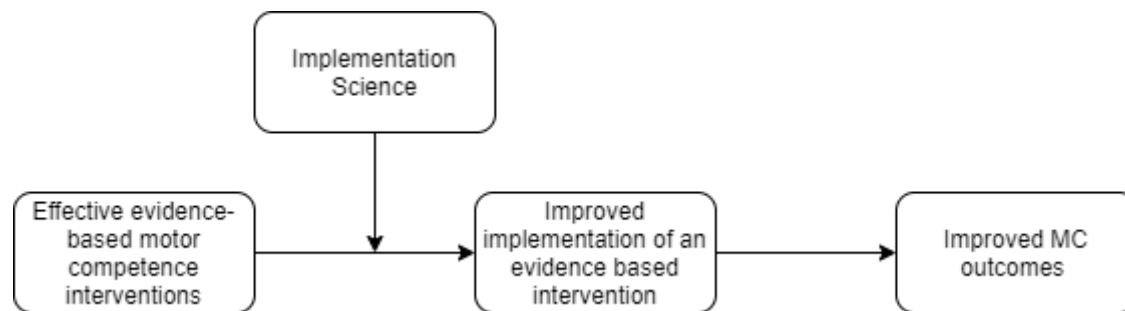
FIGURE 3. *1* **CONCEPTUAL ROLE OF IMPLEMENTATION SCIENCE IN THIS PHD RESEARCH**

3.3 Theoretical framework

In implementation science, a number of theoretical frameworks and approaches are used in the research design and process to detail key concepts and constructs being operationalised and measured (Figure 2.5; Nilsen 2015). Since evaluating a MC programme is complex, it was not possible to use one single general theory to cover all aspects to take into consideration when developing and conducting such an implementation evaluation. Therefore, contingent on study objectives and outcomes, several theories and frameworks were selected in each study. The specification of these theories and approaches follows the recommendation of conducting implementation studies (Moullin et al. 2020), to ensure the rigour of study design and enable broad comparison of study outcomes in the implementation science literature.

In Chapter 4, the UK MRC's guidance on process evaluation (Moore et al. 2015) was used to identify key evaluation dimensions and indicators in evaluating the implementation of

MC programmes. The use of this framework allowed a systematic and exhaustive way to retrospectively examine existing MC interventions in the literature. This study also adopted concepts from Durlak and DuPre framework of implementation (Durlak and DuPre 2008) to outline contextual influences on MC programme implementation at different operational levels. Chapter 5 which has a key focus to identify solutions to improve the implementation of MC programmes, adopted the Expert Recommendations for Implementation Change (ERIC) compendium (Powell et al. 2015) to produce a series of systematic recommendations on particulars that can be taken to improve the implementation and sustainability of MC interventions. In Chapters 6 and 7, the development of the implementation trial follows the PRACTical planning for Implementation and Scale-up Guide (PRACTIS guide; Koorts et al., 2018) to address key considerations in planning. The PRACTIS guide was developed to guide the research translation process (Koorts et al. 2018). The guide describes four iterative steps: Step 1) Characterise the parameters of the implementation setting; Step 2) Identify and engage key stakeholders across multiple levels within the delivery systems; Step 3) Identify contextual barriers and facilitators to implementation, and Step 4) Address potential barriers to effective implementation. The PRACTIS guide has been used to examine barriers to implementation (Cooper et al. 2021) and retrospectively evaluate the implementation process (Teychenne et al. 2021). Its use has been recommended for closing the research-to-practice and policy gap (Klepac Pogrmilovic et al. 2020).

3.4 A conceptual framework for this PhD

This PhD research was designed as applied research, by utilising research techniques, procedures, and methods to collect information about various aspects of a problem (Kumar 2019). The conception of the research design can be presented in a conceptual framework (see Figure 3.2), as proposed by Berman and Smyth (2015). This framework shows an overview of

the links between the ontology, referred to as the research context defined by the narrative review of literature in Chapter 2; research objectives; methods used in each chapter; and the epistemology, defined as the new knowledge and implications expected from each chapter.

As depicted in Figure 3.2, mixed methods were applied throughout the PhD. Mixed methods refer to a research approach that uses two or more methods, processes, and philosophies in undertaking a research study (Creswell and Clark 2017). It is based on the belief that combining the strengths of the different methods will result in improving the depth and accuracy of the findings. Inquiries in implementation science are dependent on the function and benefits of a mixed methods approach to understanding: the processes required to induce change, the outcomes of the change, potential barriers and facilitators to that process, and how the context can influence everything (Landsverk et al. 2012). Specifically, Chapter 4 presents a mixed methods systematic review that examines process evaluation of MC interventions, aiming to examine if and how previous MC interventions evaluated the intervention process and functioning. Chapter 5 involves the application of a systems science method (i.e., Collective Intelligence) to conduct group consultation with multiple groups of stakeholders, aiming to map out the barriers to the implementation and sustainability of MC interventions and their interrelationships. Collective Intelligence was chosen over other common approaches for stakeholder consultation such as focus groups and the Delphi method, because it is an applied method to systems thinking, namely, it offers an opportunity for stakeholders not only to map out the barriers but also create solutions in a systematic manner (Ma et al. 2020). The problem-solving feature of this method is highly aligned with the research paradigm of this PhD. More information on its applicability and benefits are outlined in Chapter 5. Findings from preceding chapters contributed to the development of strategies to improve the implementation of a MC intervention and the design of an implementation trial to evaluate the

effectiveness of these implementation strategies (Chapter 6). Chapter 7 then reports on a mixed

methods implementation evaluation.

The overall PhD aim is to improve understanding of the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice, and provide suggestions to evaluate the implementation of MC interventions.

Ontology (What)	Research objectives	Methods (How)	Epistemology (Why)
Motor skill competence interventions • The gap between effective interventions and the persistent low MC levels observed globally • A need to translate effective MC interventions to practice, thus providing opportunities for youth motor development	1. To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	<u>Systematic review</u> (**Chapter 4**): systematic search and data extraction, mixed methods analysis (meta-regression and qualitative synthesis)	Identification of limitations in use and reporting of process evaluation in MC interventions. Improved understanding of: - influences on MC intervention process(es) and outcomes. - typology on evaluation outcomes and measures to enhance the reporting of implementation evaluation
Evaluation • Effectiveness of MC interventions are often established with outcome evaluation, with an inadequate understanding of contextual influences on intervention process(es) and outcomes • Implementation evaluation provides a pathway to access information relevant to the ecological validity of an intervention	2. To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.	<u>Collective Intelligence (CI) Study:</u> Rationalising and piloting the application of CI (**Chapter 5 Part 1**) Identifying barriers and solutions to the implementation and sustainability of MC intervetnions (**Chapter 5 Part 2**)	CI provided a tool and process to understand the implementation and sustainability of MC interventions. The barrier systems provided help to navigate through the complex influences on MC intervention implementation. Provided a roadmap of actions to address barriers identified.
	3. To develop strategies intended to improve the implementation of a MC intervention. 4: To plan, design, and conduct an implementation evaluation of a MC intervention using strategies developed.	Building on the understanding of barriers from the CI study: <u>development of strategies</u> to improve implementaiton of a specific MC intervention and a <u>protocol for implementation evaluation</u> (**Chapter 6**)	Demonstrated a rigorous process to develop implementation strategies, as well as plan, design, and conduct of an implementation evaluation of a MC intervention.
Implementation and sustainability • Translating effective research to practice requires an understanding of implementation and sustainability • A range of theories and frameworks exist to facilitate the understanding	5. To report on the effectiveness of strategies intended to improve the implementation of a MC intervention. 6. To understand the process(es) and factors impacting the implementation and sustainability of a MC intervention.	Reporting on a <u>mixed methods evaluation</u> of a specific MC intervention to examine the implementation process and impact of implementation strategies on outcomes (**Chapter 7**)	Improved understanding of contextual influences on and implications for improving implementation and sustainability of a MC intervention

FIGURE 3. 2 A CONCEPTUAL FRAMEWORK FOR THIS PHD RESEARCH

3.5 The research process (thesis map)

As outlined in Figure 3.2., this PhD presents a series of chapters that include studies that are inextricably linked. Findings and information gained from Chapters 4 and 5 were used to inform the research questions and methods chosen to evaluate the implementation of a MC programme in Chapters 6 and 7. Therefore, for the readers' ease, at the beginning of each chapter, a thesis map is provided to describe the objectives, key findings, and their implications of each chapter. Within the tabulated thesis map, the focus of each chapter is shaded in grey.

3.6 Ethics

By the requirement of the Cotutelle studentship agreement, all studies in this PhD research were approved by both Coventry University and Deakin University Research Ethics Committees (full ethics application forms are provided in Appendix 24). For the evaluation study reported in Chapter 6 and 7, an additional ethics approval was obtained from the Social Research Ethics Committee of University College Cork. Detailed information on approvals for each study is provided in the subsequent chapters. Certificates of approvals were attached at the beginning of this thesis, as stipulated by the thesis submission guideline.

Chapter 4. A systematic review of process evaluation of MC interventions

Thesis Map

Chapter	Objective(s)	Key findings and implications
4. A systematic review of process evaluation of MC interventions	Objective 1: To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions		
6. Developing implementation strategies and a protocol for implementation evaluation of a MC intervention		
7. Outcomes of implementation evaluation of a MC intervention		

A version of this chapter has been published in Sports Medicine:

Ma, J., Lander, N., Eyre, E. L. J., Barnett, L. M., Essiet, I. A., and Duncan, M. J. (2021). It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence. *Sports Medicine*, 51(12), pp.2547-2569. https://doi.org/10.1007/S40279-021-01519-5

Chapter context

The narrative review of the literature in Chapter 2 established that outcome evaluations of MC interventions under controlled settings provides insufficient understanding of contextual influences on MC intervention processes. Figuratively speaking, what is in the 'black box' is unknown. Process evaluation may assist in gaining this understanding but its use in MC interventions is under researched. The need to explore process evaluation in published MC interventions and uncover contextual influences on interventions process(es) underpins this chapter.

Introduction

Based on the theoretical underpinning of motor learning, motor development is a multifaceted process where an individual's biology (e.g., sex, age) interacts with the surrounding physical and social environment (e.g., exposure to appropriate learning and practice opportunities) (Clark 2005). It is therefore expected that effects of interventions may vary as a response to this complex developmental process. Characteristics of participants may influence how they receive interventions and external factors such as socioeconomic environment may also influence the effect a MC intervention may have. Some reviews have delved into specific intervention characteristics to determine which characteristics moderated intervention outcomes, and to what extent. For example, Logan et al. (2012) and Morgan et al. (2013) were not able to establish a statistically significant association between intervention dose/duration and MC outcomes. Jiménez-Díaz et al. (2019) conducted an exploratory analysis to ascertain the effectiveness of interventions of different types and concluded motor skill interventions were more effective than statutory PE and free play to improve MC. However, further analyses to identify potential moderators was not possible due to data unavailability. All three reviews reported difficulties in analyses due to inadequate intervention description and data reported

(Jiménez-Díaz, Chaves-Castro, and Salazar 2019). Furthermore, two other reviews synthesised qualitative evidence on characteristics of teacher training and pedagogy in MC interventions (Lander et al. 2017a, Tompsett et al. 2017), finding that whilst teachers and pedagogical approaches are important to the effectiveness of interventions, the limited depth and consistency of reporting of these characteristics posed challenges for being able to identity elements critical to optimise MC interventions (Lander et al. 2017a, Tompsett et al. 2017).

On account of this, improved understanding of factors that influence MC intervention effectiveness is needed (Engel et al. 2018). One approach which may help is conducting and reporting process evaluations. Process evaluations investigate how and why interventions are effective or not, and for whom and under what circumstances (Moore et al. 2015). Inclusion of process evaluations is encouraged to clarify the causal pathways and functioning of interventions, assess intervention delivery, investigate contextual variance, and ultimately inform intervention effectiveness and dissemination (Craig et al. 2008). This might be particularly relevant for motor development research, since very few interventions have reported on the translation of research into routine practice, in the longer term (Lai et al. 2014).

Given the observed low MC levels and little understanding of how interventions operate for optimal and sustainable effects, there is emerging interest in conducting process evaluations in MC interventions (Rudd et al. 2020). In the broader context of motor development research, investigating the intervention process not only leads to a more comprehensive interpretation of the outcome efficacy, but it also echoes the historical examination on processes for motor behaviour changes as to "*why and how that particular outcome occurred*" (Clark and Whitall 1989, p.184). Therefore, exploring process evaluation evidence in MC interventions is necessary and important (Tompsett et al. 2017). Building the evidence base of process

evaluation in MC interventions is required to inform and prompt better practice in their development and evaluation, as well as to inform their future scalability and sustainability.

In light of this, the primary aim of this systematic review was: a) to investigate whether process evaluations have been reported in MC interventions and if reported, which process evaluation measures have been used (process evaluation methods); b) to explore the association of intervention characteristics and process evaluation findings (outcomes of process evaluation measures) with intervention outcomes both quantitatively and qualitatively, in search for what process evaluation measures may impact on intervention functioning and outcomes.

Considering reviews of interventions to date have only used a single-method approach (i.e., focus on either quantitative or qualitative data synthesis), this review employed a mixed methods approach whereby both narrative syntheses and meta-analyses were performed to analyse quantitative and qualitative data attempting to provide comprehensive and balanced findings (Pearson et al. 2015).

Methods

The process of conducting and reporting this review adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Liberati et al. 2009) (see Appendix 1 for the PRISMA checklist). The review protocol was registered with PROSPERO (CRD42019124412).

Study Selection Criteria

Inclusion and exclusion criteria were defined a priori, and outlined in Table 4.1

TABLE 4. 1 STUDY INCLUSION AND EXCLUSION CRITERIA

	Included	Excluded
Population	Primary/elementary (approximately 5-12 years old), middle (approximately 12-14 years old) and/or secondary/high school (12-18, or 14-18 years old) students Typically developing children or adolescents, which could include overweight or obese or socio-economically disadvantaged students as per the criteria used in a previous review (Morgan et al. 2013)	Target participants were from specific populations (e.g., children with disabilities such as cerebral palsy or identified as having developmental coordination disorder or conditions such as intellectual, psychological or cognitive disabilities)
Intervention	Interventions aimed at improving MC with any delivery/instruction method, duration or setting (school-, community- or home-based etc.)	Interventions conducted in early childcare, preschool or kindergarten
Study design	Randomised controlled trial (RCT), Cluster randomised controlled trials, non-randomised trials, quasi-experimental trials with a pre-post design	Systematic review
Comparator	Interventions included a comparison/control group that was identified as no treatment, usual care or wait list control	Interventions compared two active intervention arms without a comparison/control group
Outcomes	Intervention reported statistical analyses of MC at both pre-intervention and a minimum of one other post-study time point; Reported process or product assessment or a global MC score or at least one skill (e.g., run, jump, throw, catch, balance), or categorised in groups of commonly described similar skills such as locomotor, object control skills, or balance	Interventions assessed only fine motor skills, or skills unique to a particular sport (e.g., climbing, dribbling)
Publication type	Peer reviewed journal articles	Conference abstract, dissertation and book; Not published in the English language

Information Sources and Search

Relevant studies were identified through systematic searching of seven electronic databases and scanning reference lists of subsequently identified articles. Searched databases include MEDLINE (via EBSCOhost), Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, Academic Search Complete, Education Database, SPORTDiscus and Scopus. No

publication date restrictions were imposed. The search was originally completed in February 2019 and updated in September 2020.

Search strategies used in the databases included combinations of key text words and indexing terms where applicable (e.g., MeSH) as recommended by the Cochrane handbook for Systematic Reviews of Interventions (Higgins et al. 2019). The search terms were divided into three groups: (1) population (e.g., child* OR student* OR adolescen* OR child[MeSH Terms] OR adolescent[MeSH Terms]); (2) intervention (e.g., "Fundamental Movement Skill*" OR "FMS" OR "fundamental motor skill*" OR "motor skill*" OR "motor ability" OR "motor learning*" OR "motor competence" OR "motor proficiency" OR "motor development" OR coordination OR co-ordination OR "motor pattern*"); (3) study design (e.g., Intervention* OR "intervention stud*" OR evaluat* OR effect* or clinical trial as topic [MeSH Terms]). The Boolean phrase "AND" was used between groups, and phrases "OR" was used within groups. An example search syntax has been provided in Appendix 2.

Following the initial search, JM removed all duplicates and screened the titles and abstracts of remaining records in a non-blinded standardised manner via a web-based application Rayyan (Ouzzani et al. 2016). In the cases of uncertainty as to whether a study met the inclusion criteria, studies were reviewed and discussed between JM and IE. Any disagreements were resolved by discussion with EE or MD. Full-text articles were then retrieved for all remaining records. All full-text articles were further evaluated separately for relevance by JM and IE via an online-based systematic review tool Covidence (Veritas Health Innovation 2019). Cases of disagreements following full-text review were reviewed and discussed by both reviewers to reach consensus. The reference lists of included articles were scanned to identify additional relevant articles.

Data Extraction

Given the scope of the current review, extraction on process evaluation measures was guided by a comprehensive evidence-based process evaluation framework published by the UK Medical Research Council (MRC) (Moore et al. 2015). As defined in this guidance, a process evaluation is *"a study which aims to understand the functioning of an intervention, by examining implementation, mechanisms of impact, and contextual factors"* (p. 10). The MRC guidance provides a "lens" to review process evaluation measures of MC interventions in a systematic and exhaustive way. Specifically, we used three evaluation domains (as summarised in Table 4.2 from the MRC guidance as a coding framework for data extraction and synthesis purposes.

Data of each included study were extracted relating to: the general study characteristics (i.e., author, date, country, sample, study design, intervention theory and content, intervention duration, measures and outcomes), and the reporting of process evaluation measures as coded by the MRC framework. Data on process evaluation measures in the domains of implementation, mechanism of change and contextual factors were extracted relating to their evaluation questions, collection methods and findings. Extraction was conducted by JM with 15% of the randomly selected subsample checked by IE on Covidence. JM developed and set up a data extraction form on Covidence. The form was piloted and refined prior to data extraction. No significant discrepancies were found in the subsample. All key findings were checked by IE for accuracy.

TABLE 4. 2 SUMMARY OF EVALUATION DOMAINS OF PROCESS EVALUATION ACCORDING TO THE UK MEDICAL RESEARCH COUNCIL (MRC) FRAMEWORK (MOORE ET AL. 2015)

Risk of Bias

Each of the included studies was independently analysed by JM and MD using a 10-item tool adapted from the Consolidated Standards of Reporting Trials statement (Moher et al. 2010) and previously used quality criteria (Morgan et al. 2013) (see Table 4.3). The risk of bias assessment tool was set up on Covidence to obtain consistent data across all studies, as well as to enable two assessors to independently extract quotes and add comments to support their judgements. As recommended by the PRISMA statement (Liberati et al. 2009), items of risk of bias assessment were not summarised to provide final scores, instead each criterion was considered in isolation. Each item on the scale was coded as "explicitly described and present"

(+), "absent" (-) or "unclear" or "inadequately described" (?). Interrater reliability for the assessors was calculated on a dichotomous scale (+ = 1 vs. – or ? =0) using percentage agreement and Cohen's *k*. Some items were coded as not applicable (N/A) due to study design and therefore not included in agreement calculations. Disagreements were discussed and resolved between assessors.

TABLE 4. 3 RISK OF BIAS CHECKLIST

Item	Description
A	Randomisation
B	Valid and reliable measures of FMS used
C	Blinded outcome assessment
D	Participants analysed in group they were originally allocated to, and participants not excluded from analysis because of non-compliance for treatment or because of missing data
E	Covariates accounted for in analysis
F	Power calculations reported for FMS outcome
G	Presentation of baseline characteristics separately for treatment groups (age, sex, and >1 FMS outcome)
H	Drop out for FMS measure described with <20% drop out for studies with follow-up of 6- months and <30% drop out for follow-up with >6 month follow-up
I	Summary results for each group and estimated effect size (difference between groups) and precision
J	Adequate description of the intervention: number of intervention components/aspects, type of intervention, frequency of sessions, intensity of intervention

FMS fundamental movement skills

Data Synthesis and Analysis

A two-phase data analysis was conducted according to review aims. Phase 1: To ascertain whether process evaluation has been reported in MC interventions (Primary Aim), we reviewed all included studies to determine a numerical value of how many studies reported process evaluation. Phase 2: Intervention studies that reported process evaluation measures were analysed in Phase 2. Written summaries and tabulation of extracted data in relation to process

evaluation were presented in a narrative form. Collection methods for process evaluation measures were synthesised by evaluation domains to describe what and how process evaluation measures were used (process evaluation methods). To achieve the secondary aim (i.e., if intervention characteristics and process evaluation findings of studies are associated with intervention outcomes), outcomes of process evaluation measures were analysed in relation to the magnitude and direction of intervention effects both quantitatively and qualitatively. A convergent segregated mixed methods approach to analysis was used (Lizarondo et al. 2020).

Qualitative synthesis

Qualitative research findings related to process evaluation were categorised by three evaluation domains to provide overarching descriptions on the implementation, mechanism of change and context of interventions. Where applicable, results were thematically assembled to produce sets of factors that affect intervention implementation, mechanism and outcomes. To provide a clear summary to describe contextual influences, these factors were grouped according to the Durlak and DuPre framework (Durlak and DuPre 2008). We chose this framework for its established usability to compare facilitators and barriers in school-based physical activity interventions (Cassar et al. 2019a, Naylor et al. 2015), which the MRC framework does not offer.

Quantitative synthesis

Firstly, DerSimonian-Laird inverse variance random-effects meta-analysis was conducted in R environment (package: *metafor*) (R Development Core Team 2011, Viechtbauer 2017) to determine the association of the interventions with improved intervention outcomes (overall MC outcomes) compared with controls. Intervention effects were calculated as standardised mean differences (SMD) using Hedges *g* (Durlak 2009). For studies that include post-test and follow-up assessments, the assessments completed closest to the intervention endpoint were included in meta-analyses. When studies reported outcomes using other statistical analyses

such as ANOVA and regression rather than the raw difference, statistical results (e.g., F value, coefficients) were used to calculate SMD (Lipsey and Wilson 2001) in R using *esc* package (Lüdecke 2019). Statistical heterogeneity was assessed using forest plots and the χ^2 and I^2 statistics. By convention, I^2 values of 25% were considered low, 50% moderate, and 75% high (Durlak 2009). The potential for publication bias was assessed using funnel plots and Egger's test. A baujat plot was used to identify studies contributing significantly to the heterogeneity. A sensitivity analysis was conducted after excluding highly influential studies.

Secondly, a series of random effects univariable meta-regressions were performed. Extracted quantitative data were, where available, included as study-level covariates in meta-regression analyses to examine their associations with intervention outcomes and if they explained heterogeneity in effect sizes (if $I^2 > 50\%$). Investigated moderators (also used in a previous meta-analysis (Jiménez-Díaz, Chaves-Castro, and Salazar 2019)), were: duration (total length of intervention in terms of weeks), intensity (session frequency per week), mean age of study sample, and sample size of each study. These were coded into binary variables based on the calculated median (i.e., above or below the median). Other included binary variables coded according to extracted qualitative data were: whether studies included a process evaluation aim, the use of a theoretical concept, provision of lesson plans, involvement of family, and teacher training. Sex was also included as a moderator (two groups; interventions targeting boys or girls only, or where both sexes were targeted) as it was reported to have influenced intervention outcomes in process evaluation findings included in our review.

Integration of quantitative and qualitative evidence

Meta-regression results and synthesised qualitative findings were juxtaposed and organised into a line of argument to produce an overall configured analysis (Lizarondo et al. 2020) of the links between interventions and process evaluation findings, in an attempt to achieve the

secondary aim. Studies with insufficient data were excluded from meta-regression or qualitative synthesis. This information is outlined in Appendix 3.

Results

The initial search identified 7278 abstracts. The updated search in September 2020 identified 4565. In total, 11843 records were identified. The PRISMA flowchart for the screening is shown in Figure 4.1. This resulted in the inclusion of 67 publications, which covered 60 interventions. All 60 interventions were analysed in Phase 1. In Phase 2, due to data availability, 37 interventions were included in the quantitative synthesis. For example, some studies did not provide sufficient data for standard effect sizes to be calculated. This therefore limited the number of studies that could be included in the meta-regression. Thirty interventions that reported process evaluation measures were included in the qualitative synthesis.

Identification

Records identified through database searching (Performed Feb 2019) (n=7265)

Updated Search (Performed Sep 2020) (n=4565)

Additional records identified through other sources (n=13)

Title and Abstract screening: Records after duplicates removed (n=5709)

Screening

Records excluded (n=5510)

Eligibility

Full-text articles assessed for eligibility (n=199)

Full-text articles excluded (n=132):
Population (n=12)
Intervention (n=5)
Control (n=8)
Study design (n=10)
Outcome (n=65)
Duplicates (n=6)
Protocol or review paper (n=4)
Could not access (n=22)

Papers included in final analysis (n=67)

Protocol, process evaluation, follow-up papers condensed under original intervention outcome paper (n=7)

Included

Independent intervention studies in Phase 1 analysis (n=60)

Independent intervention studies in Phase 2 mixed methods analysis
Quantitative: n=37
Qualitative: n=30

FIGURE 4. 1 SYSTEMATIC REVIEWS AND META-ANALYSIS (PRISMA) STATEMENT FLOWCHART

Study Characteristics

Study characteristics of all included 60 studies are shown in Appendix 3. Most interventions were school based, with five studies in secondary schools examining adolescents (13-15 years), and 49 studies in primary schools examining children (5-12 years). The remaining studies were

conducted in after-school, community, and family settings. The vast majority of interventions (n=38) used PE as delivery medium and 12 interventions used a whole-school approach or included multiple components that involved a wider target audience such as parents. Three interventions targeted boys only, four targeted girls only, the remaining 53 targeted both sexes. The median sample size was 150. The duration of interventions ranged from two weeks to four years with a median of 12 weeks.

Risk of Bias

Table 4.4 summarises the results of risk of bias assessments for the 60 included studies. Interrater reliability for the assessment indicated consistent agreement across 450 items (percentage agreement 90%, k=0.60). Information on power calculation for MC was only presented in 15 studies (25.0%) and dropout rate was unclear in 21 studies (35.0%). Assessor blinding information was not clearly reported in more than half of studies (n=37, 61.7%). Intervention descriptions were not clear or adequate in 19 studies (31.7%)

TABLE 4. 4 RISK OF BIAS ASSESSMENT

Study	Blinded outcome assessment	Covariates analysed	Dropout described	Intervention description	Participant analysed	Power calculations	Baseline characteristics	Randomisation	Summary results	Reliable and Valid FMS measure
Akbari et al. (2009)	?	✗	?	✔	?	✗	✗	?	✗	✔
Andruschko et al. (2018)	✔	✔	✔	?	✔	✔	✔	✔	✔	✔
(Azeem et al. 2015)	?	✗	?	✗	?	✗	✔	✗	✗	?
Bakhtiari et al. (2011)	✗	✗	?	✗	?	✔	✗	✔	✔	✔
Bardid et al. (2017)	✔	✔	✔	✔	✔	?	✔	✔	✔	✔
Barnett et al. (2009)	✔	✔	?	?	✔	?	?	N/A	✔	✔
Barnett et al. (2015)	?	✔	✔	✔	✔	✔	✔	✔	✔	✔
Boyle-Holmes et al. (2010)	?	✔	✔	✔	✔	✗	✗	N/A	✔	✗
Bolger et al. (2019)	?	✔	✔	✔	✗	✗	✔	N/A		
Capio et al. (2015)	✔	✔	✔	✗	✔	✗	✔	N/A	✔	✔
Chagas et al. (2018)	?	?	?	✗	✔	✗	✔	N/A	✔	✔
Chan et al. (2016)	✔	✔	?	✔	✔	✔	✔	✔	✔	✔
Cliff et al. (2011)	✔	✔	?	✔	✔	✗	✔	✔	✔	✔
Cohen et al. (2015)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Costello et al. (2020)	?	✗	✔	✔	✔	✗	✔	N/A	✔	?
Colella et al. (2019)	?	✗	✔	✗	✔	✗	✔	N/A	✗	✔
Dalziell et al. (2019)	✗	✗	✔	✔	✗	✔	✔	N/A	✔	✗
Duncan et al. (2018)	?	✔	?	✔	✔	✔	?		✔	✔
Ericsson (2008)	?	✔	?	✔	✔	✗	✔	✔	?	✔
Fahimi et al. (2013)	?	✗	?	✗	?	✗	✗	?	✗	✔
Foweather et al. (2008)	?	✔	?	✔	✔	✗	?	?	✗	✔
Gallotta et al. (2017)	?	✔	✔	?	✔	✔	✔	✔	✔	✔
Graf et al. 2008)	?	✔	✔	✗	✗	✗	✔	?	✗	?
Gu et al. (2018)	✔	?	?	✔	✔	✗	✔	✔	✔	✔
Guerrero et al. (2018)	✔	?	✔	?	✔	✗	✔	N/A	✔	✔

Hajihosseini et al. (2016)	?	✗	✔	?	✔	✗	✔	✔	✗	✔
Invernizzi et al. (2019)	?	✔	?	✔	?	✔	✗	✔	✔	✔
Jarani et al. (2016)	?	✔	✔	?	✔	?	✔	✔	✔	✔
Johnson et al. (2016)	✔	✔	✔	?	✔	?	✔	✔	?	✔
Johnstone et al. (2017)	✔	✔	✔	✔	✔	?	✔	✔	✔	✔
(Johnstone et al. (2019)	✗	✔	✔	✔	✗	✔	✔	N/A	✔	✗
Kalaja et al. (2012)	?	✔	?	✔	✔	✗	✔	N/A	✗	✔
Karabourniotis et al. (2002)	?	✔	?	✔	✔	✗	✔	N/A	✗	✗
Matvienko et al.(2010)	?	✔	✔	✔	✔	✗	✔	✗	✗	✗
McGrane et al. (2018)	✔	✔	✔	✔	✔	✗	✔	✔	✔	✔
McKenzie et al. (1998)	?	✔	?	✔	✗	✗	✔	✔	✔	✔
Miller et al. (2015)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Miller et al. (2016)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
McGann et al. (2020)	?	✔	✔	✔	✔	✗	✔	N/A	✔	✔
Nathan et al. (2017)	✔	✔	?	✔	✔	✗	✔	N/A	✔	✔
Nobre et al. (2017)	?	?	✔	✔	✔	✗	✔	N/A	✔	✔
Okely et al. (2017)	✔	✔	✔	✔	✔	✗	✔	N/A	✔	✔
Oppici et al. (2020)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Pesce et al. (2016)	?	✔	✗	✔	✔	✗	✔	✔	✔	✔
Platvoet et al. (2016)	?	✔	✔	✔	✔	✗	✔	N/A	✔	✔
Rudd et al. (2017)	?	✔	✔	✔	✔	✔	✔	N/A	✔	✔
Rudd et al. (2017b)	?	✔	✔	✔	✔	✗	✔	N/A	✔	✔
Salmon et al. (2008)	✔	✔	✔	✔	✔	?	✔	✔	✗	✔
Silva Silveira et al. (2018)	?	✔	?	✔	✔	✗	✔	✔	✔	✔
Skowroński et al. (2019)	✗	✗	✔	✗	✔	✗	✗	N/A	✗	✔
Sollerhed et al. (2008)	?	✔	?	✗	✔	✗	✗	N/A	✗	✔

Top et al. (2020)	?	✗	✔	✗	✔	✗	✔	N/A	✗	✔
Telford et al. (2021)	✗	✔	✔	✔	✔	✗	✔	✔	✔	✔
van der Fels et al. (2020)	?	✔	✔	✔	✔	✔	✔	✔	✔	✔
(Vernadakis et al. 2015)	?	?	?	✔	?	✗	✗	✔	✗	✔
Ye et al. (2018)	?	✔	✔	✗	✔	✗	✔	?	✔	✔
Zhang et al. (2019)	?	✔	?	✗	✔	✗	✗	N/A	✔	✔

? unclear or inadequately described, ✔ explicitly described and presented, ✗ absent, *N/A* not applicable, *FMS* fundamental movement skill

Primary Aim: The extent of reporting on process evaluation

This and the next section describe results pertaining to the primary aim of the review, that is, to investigate the extent to which process evaluations have been reported in interventions and which process evaluation measures have been used if reported. Of all 60 included studies, 30 (50.0% out of 60) included process evaluation measures and were carried onto Phase 2. Among these 30 studies, 26 studies (86.7% out of 30) reported measures in the domain of implementation, 15 (50.0%) reported in the domain of mechanism of change and 12 (40.0%) reported in the domain of context.

In total, there were 82 process evaluation measures reported across 30 studies. A summary of measures by studies is provided in Table 4.5. There were 17 (20.7% out of 82 measures) in the domain of context, 42 (51.2%) in the domain of implementation, and 23 (28.0%) in the domain of mechanism of change (see Figure 4.2). In the domain of implementation, 42 measures were reported including fidelity (42.9%), reach (23.8%), dose delivered (14.3%), implementation process (7.1%), recruitment and retention (7.1%) and adaptation (4.8%). In the domain of mechanism of change, 23 measures were reported including participant responses (60.1%), mediator/s (13.0%), dose received (13.0%) and unintended consequences (13.0%). In the domain of context, recorded factors (n=17) include moderator (35.3%), barriers (23.5%), facilitators (17.6%), cross-contamination (11.8%) and other contextual factors (e.g., difference between intervention sites) (11.8%). Figure 4.3 provides a summary of all reported measures by evaluation domains.
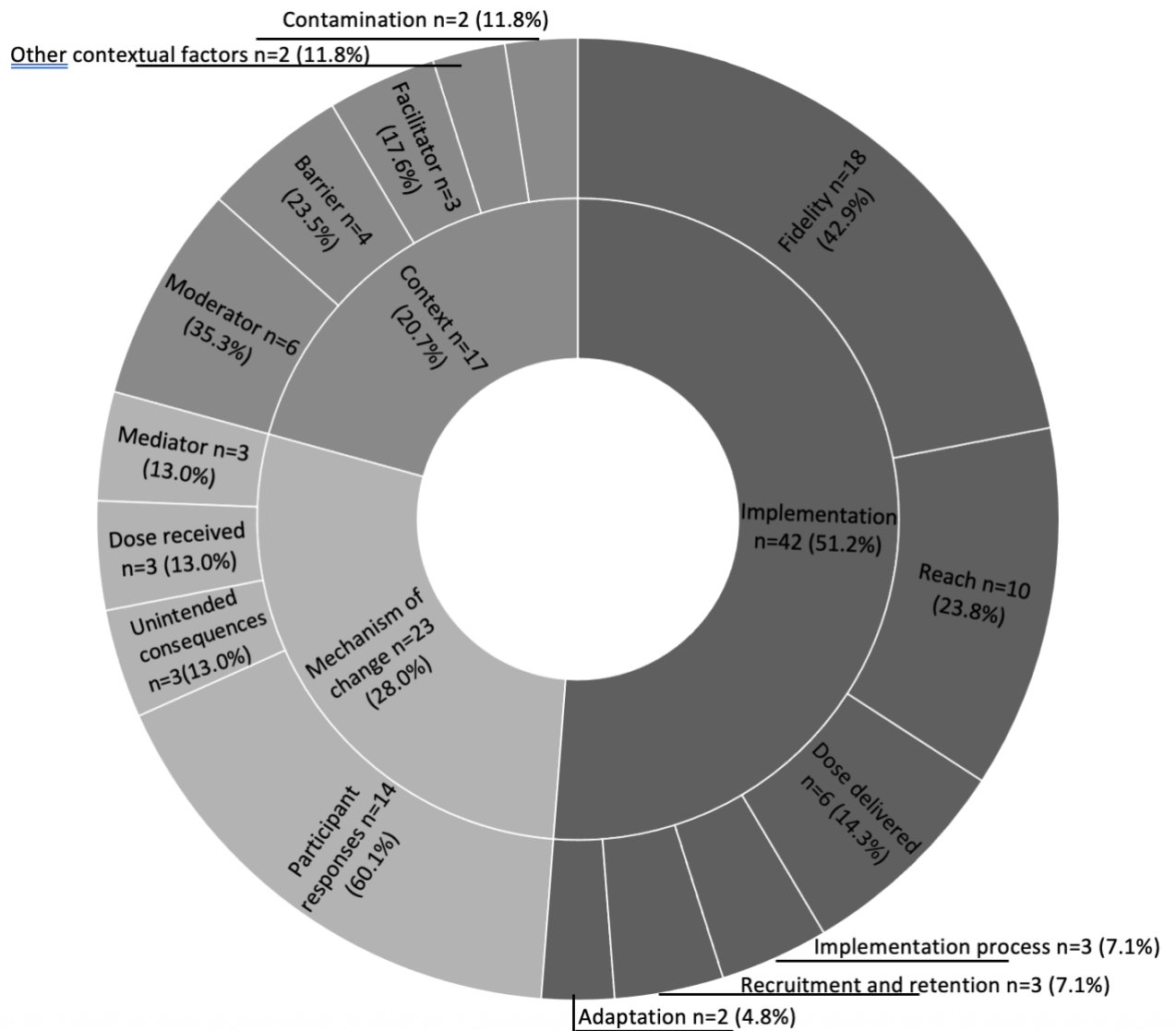
FIGURE 4. 2 AN OVERVIEW OF REPORTED PROCESS EVALUATION MEASURES ACROSS 30 INTERVENTIONS
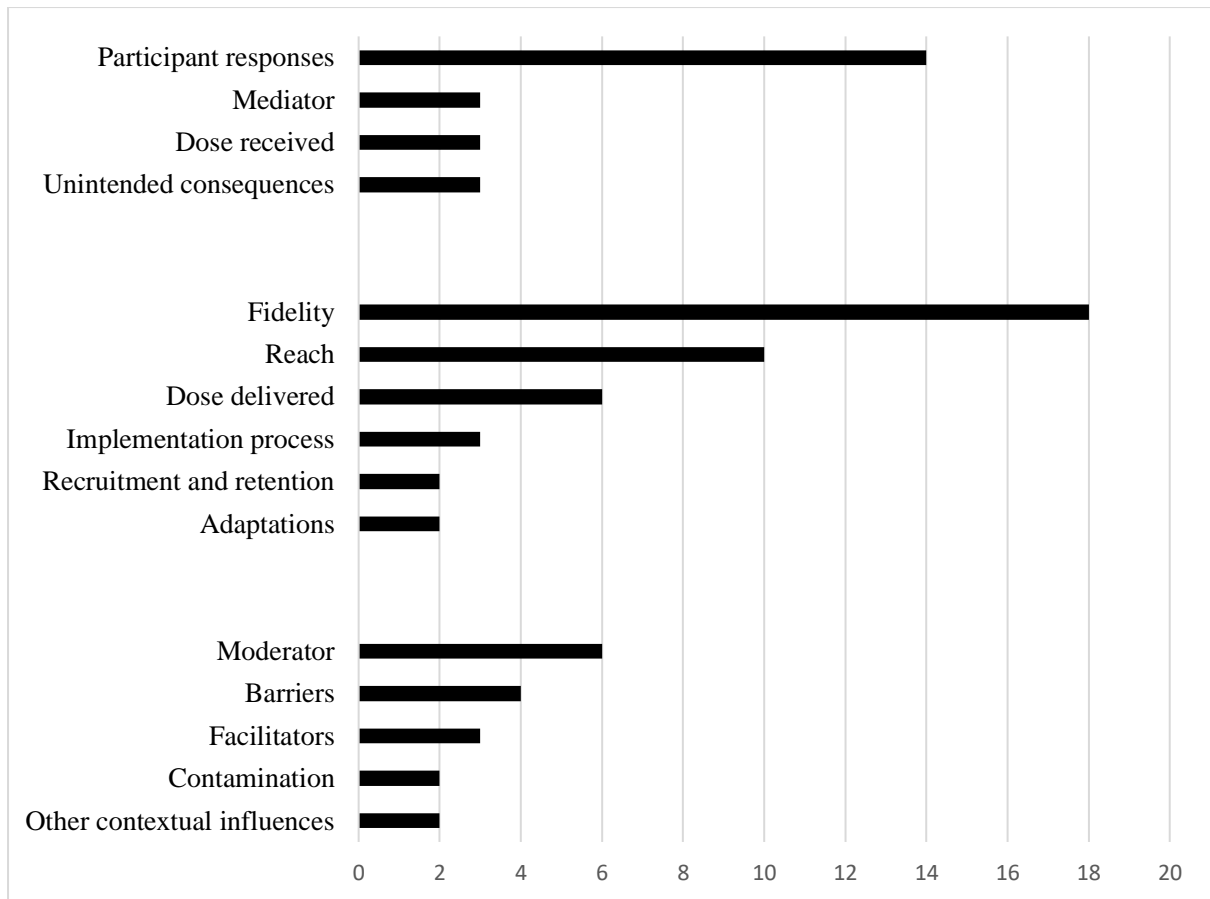
**FIGURE 4. 3 FREQUENCY OF PROCESS EVALUATION MEASURES REPORTED ACROSS 30
INTERVENTION**

Study	RQ	Implementation process	Fidelity	Dose delivered	Reach	Recruitment &retention	Adaptation	Dose received	Participant responses	Mediator	Unintended consequence	Contextual factors
		Implementation						**Mechanism of change**				**Context**
Andruschko et al (2018)	✔			✔	✔	✔			✔			✔
Barnett et al (2009)		✔										
Barnett et al (2015)	✔							✔	✔			✔
Boyle-Holmes et al (2010)	✔	✔	✔	✔								✔
Chan et al (2016)[a]	✔		✔	*			✔		✔			
Cliff et al (2011)	✔		✔	*	✔				✔			✔
Cohen et al (2015)[a]	✔		✔	*	✔			✔	✔		✔	
Duncan et al (2018)				*	✔							
Daziell et al (2019			✔						✔			
Graf et al (2008)			✔									
Gu et al (2018)				*					✔			
Invernizzi et al (2019)	✔		✔	*					✔			

Study									
Jarani et al (2016)			*	✔					
Johnson et al (2016)			*			✔			✔
Johnstone et al (2017)		✔	*	✔	✔				
Kalaja et al (2012)		✔	*						
Karabourniotis et al (2002)	✔	✔	*						
Lander et al (2017)[a]	✔	✔	*		✔		✔		
Laukkanen et al (2015)	✔		*	✔			✔		✔
Miller et al (2015)		✔	*						
Miller et al (2016)	✔	✔	*					✔	
Nathan et al (2017)	✔		✔	✔			✔	✔	✔
Okely etl al (2017)	✔						✔		✔
Pesce et al (2016)	✔	✔	*						
Rudd et al (2017a)		✔	*						

Rudd et al (2017b)			✔	*								
Salmon et al (2008)[a]	✔		✔	✔				✔	✔	✔	✔	✔
SilvaSilvera et al. (2018)					✔							
Telford et al (2021)[a]	✔	✔	✔	✔			✔		✔		✔	✔
van der Fels et al (2020)	✔			✔	✔							✔
Total	17	3	18	6	10	3	2	4	14	3	3	11

[a]Studies had an explicit design of process evaluation (i.e., explicitly reported the design in the "Process Evaluation" section in the article or in a separate publication), *RQ,* research questions related to process evaluation , * Studies reported dose prescribed but not the actual dose delivered

Primary Aim: Process evaluation methods

Research aims

Of 30 studies which included process evaluation measures, 17 (56.7%) proposed a priori research aims in relation to the process evaluation (see Table 4.5). These aims covered a range of process evaluation questions regarding how the intervention was anticipated to work, including feasibility and acceptability of intervention components (Andruschko, Okely, and Pearson 2018, Nathan et al. 2017, Johnstone et al. 2017), contextual variations (Boyle-Holmes et al. 2010), implementation completeness (Miller et al. 2016), participant perception (Salmon et al. 2008, Chan et al. 2016) and hypothesised moderators (Laukkanen et al. 2015) and mediators (Nathan et al. 2017). Five interventions (16.7%) (Lander et al. 2017b, Salmon et al. 2008, Chan et al. 2016, Telford et al. 2021, Cohen et al. 2015) had an explicit design of process evaluation (i.e., explicitly reported the design in a "Process Evaluation" section in the article or in a separate publication). None of these 30 studies reported (or employed) theoretical frameworks to guide process evaluation.

Data collection methods

A wide range of collection methods were used to collect process evaluation data. Table 4.6 summarises all methods and their applications in studies by evaluation domains. Most common methods used to measure implementation were documentation and on-site observation, whereas for mechanisms of change the most common methods of data collection were self-report questionnaires.

Collection Methods	Application	References
Implementation		
Documentation	Using trial logs, routine records, attendance sheets and written lesson plans to determine quantity and quality of intervention delivery, mainly reported by researchers or deliverers	(Silva Silveira et al. 2018, Duncan, Eyre, and Oxford 2017, Andruschko et al. 2018, Nathan et al. 2017, Lander et al. 2018, Jarani et al. 2016, Laukkanen et al. 2015, Salmon et al. 2008, Boyle-Holmes et al. 2010, Cliff et al. 2012, Chan et al. 2016, Telford et al. 2021)
On-site observation	Structured and unstructured (random) observations by researchers or independent trained assistants against standardised checklists	(Rudd et al. 2017, Rudd et al. 2017, Lander et al. 2018, Miller et al. 2016, Cliff et al. 2011, Miller et al. 2015, Graf et al. 2005, Kalaja et al. 2012, Barnett et al. 2009, Karabourniotis et al. 2002, Cohen et al. 2015a, Chan, Ha, and Ng 2016)
Video analysis	Retrospective analysis of video recordings of intervention sessions against standardised checklists to quantify the qualitative characteristics of PE teaching or skill sessions	(Invernizzi et al. 2019, Pesce et al. 2016)
Interview	Interviews with deliverers and school staff to get in-depth perceptions on quality of intervention delivery	(Graf et al. 2008, Cohen et al. 2015b, Telford et al. 2021)
Ongoing consultation	Researchers providing feedback and reinforcement during the intervention period and allowing for ongoing adaptations	(Chan et al. 2016, Lander et al. 2018)
Mechanism of Change		
Self-report questionnaires	Questionnaires administered to: Deliverers, assessing competence, self-perception, programme satisfaction; Participants, assessing programme satisfaction, enjoyment, peer leadership skills; Parents, assessing their involvement and engagement with the	(Cohen et al. 2015b, Chan et al. 2016, Cliff et al. 2011, Andruschko et al. 2018, Invernizzi et al. 2019, Nathan et al. 2017, Lander et al. 2018, Laukkanen et al. 2015, Miller et al. 2016, Salmon et al. 2008)

	programme, satisfaction	
On-site observation	Using standardised observation forms to document children's responsiveness during intervention sessions, including on-task time and responses to different skill trainings	(Cliff et al. 2011, Chan et al. 2016, Johnson et al. 2016, Barnett et al. 2015)
Documentation	Having routine records or logs to document hypothesised an unintended intervention mechanism	(Cohen et al. 2015b, Salmon et al. 2008, Telford et al. 2021)
Interview and focus group	Interviews and/or focus groups with participants to obtain in-depth perception of interventions and intervention deliverers	(Invernizzi et al. 2019, Okely et al. 2017, Barnett et al. 2015)
Video analysis	Retrospective analysis of video recordings of intervention sessions to gather knowledge on children's engagement both quantitatively and qualitatively	(Okely et al. 2017, Laukkanen et al. 2015, Boyle-Holmes et al. 2010, Cliff et al. 2011, Salmon et al. 2008, Telford et al. 2021)
Context		
Interview	Interviews with participants and deliverers to gain knowledge on barriers and facilitators during the intervention implementation	(Johnson et al. 2016, Barnett et al. 2015)
On-site observation	Informal researcher observations on causes for contextual variations	(Nathan et al. 2017, Laukkanen et al. 2015, Salmon et al. 2008)
Self-report questionnaire	Questionnaires administered to parents to collection information on socioeconomic status, gaming and ball sports experience	(Silva Silveira et al. 2018, Duncan et al. 2017, Andruschko, Okely, and Pearson 2018, Nathan et al. 2017, Lander et al. 2018, Jarani et al. 2016, Laukkanen et al. 2015, Salmon et al. 2008, Boyle-Holmes et al. 2010, Cliff et al. 2012, Chan et al. 2016, Telford et al. 2021)
Secondary data analysis	Analysing routinely collected data such as sex and seasonal variation as potential moderator of intervention effects.	(Rudd, et al. 2017, Rudd et al. 2017, Lander et al. 2018, Miller et al. 2016, Cliff et al. 2011, Miller et al. 2015, Graf et al. 2005, Kalaja et al. 2012, Barnett et al. 2009, Karabourniotis et al. 2002, Cohen et al. 2015a, Chan, Ha, and Ng 2016)

Secondary Aim: Process evaluation findings

Reported process evaluation measures and their findings in each study are detailed in Appendix 4. Results in this and next section are concerned with the secondary review aim, that is, to describe the findings from process evaluation and intervention characteristics and explore their associations with intervention functioning and outcome.

Implementation

In 26 studies that reported implementation measures, the general reach of school-based activities to students were high, ranging from 79% (Andruschko et al. 2018) to 100% (Cohen et al. 2015). In comparison, the reach of extracurricular activities to students and parents were low (e.g., 44% attendance rate for after school sports club (Andruschko et al. 2018)) and tended to be lower in intervention maintenance periods (e.g. 54% phone calls received during follow-up (Laukkanen et al. 2015)). The reach to teachers were more varied, ranging from 69.2% (Cohen et al. 2015) to 100% (Lander et al. 2018). In terms of intervention dose, prescribed dose was generally reported across studies, but not the actual dose delivered (see Table 4.5).

Results suggests that, despite the various focus of different prescribed intervention activities, skill-based sessions or PE lessons were successfully adhered to (e.g., teachers successfully adhered to using a game centred approach to teach FMS (Miller et al. 2015)). Few interventions documented modifications and adaptations of intervention activities (Chan et al. 2016, Telford et al. 2021). Studies that assessed fidelity at different time points reported teachers and deliverers' adherence to the intervention protocol increased over time (Miller et al. 2015, Miller et al. 2016, Cohen et al. 2015, Lander et al. 2019). Difference of implementation between intervention arms were also found regarding teaching styles (Invernizzi et al. 2019, Pesce et al. 2016) and use of teaching resources (Boyle-Holmes et al. 2010)

Mechanisms of change

In 15 studies that reported measures related to the intervention mechanism, student enjoyment of intervention activities was the primary focus of process evaluation (10/14, 71%). Across different interventions, student participants found programmes enjoyable when programmes comprised one or more of the following components: active video games (Barnett et al. 2015), assessment-based skill learning (Chan et al. 2016), group sports or game sessions (Andruschko et al. 2018, Invernizzi et al. 2019, Cohen et al. 2015, Cliff et al. 2011), home challenges (Cohen et al. 2015, Cliff et al. 2011) and student peer-led sessions (Nathan et al. 2017). Only one study reported children's enjoyment by subgroups and found boys preferred games and sports while girls enjoyed specific and varied physical activities (Salmon et al. 2008). Children's enjoyment of physical activity were quantitatively examined as mediators in two interventions (Miller et al. 2016, Salmon et al. 2008) with authors of one study reporting enjoyment in the intervention group increased over the intervention period and to a larger extent than that of control group. Students' leadership skills were found to be a significant mediator in one study (Nathan et al. 2017).

Teacher's engagement with interventions was assessed when teachers were intervention deliverers. High satisfaction was reported towards the provision of teaching resources and professional learning opportunities provided by the research team (Chan et al. 2016, Telford et al. 2021, Lander et al. 2019, Cohen et al. 2015). This was reported to increase teachers' knowledge, motivation, and confidence as well as decrease perceived barriers on teaching and assessing FMS, which was evidenced in one intervention study where teacher's competence and self-efficacy were assessed pre- and post-intervention (Lander et al. 2019). One study collected qualitative data with teachers but did not report their findings (Miller et al. 2015).

Parental engagement was assessed in four multi-component interventions and suggested parents perceived the intervention programme to be helpful for their children (Salmon et al. 2008, Cohen et al. 2015, Cliff et al. 2011, Laukkanen et al. 2015). Compared to other participant groups, parents were less involved in intervention activities (Cohen et al. 2015).

Contextual factors

A total of 72 findings related to intervention context were reported to have influenced intervention implementation, mechanism functioning and therefore intervention outcomes. Given the large number of findings and our wish to provide a clear summary to describe these contextual influences, these findings were thematically grouped into 34 factors under the five domains relating to the Durlak and DuPre framework (Durlak and DuPre, 2008; See Table 4.7). 19 factors were associated with implementation (10 barriers and 9 facilitators) and 15 factors were linked to mechanisms and outcome (one barrier and 14 facilitators). Descriptive summary is given here and detailed discussions on these factors are to be discussed in later sections.

TABLE 4. 7 REPORTED CONTEXTUAL FACTORS THAT INFLUENCED INTERVENTION IMPLEMENTATION, INTERVENTION MECHANISM AND OUTCOME CATEGORISED BY DURLAK AND DUPRE DOMAINS (DURLAK AND DUPRE 2008)

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A total of 37 studies were included in the meta-regression. Medium effect sizes for overall MC was revealed (SMD=0.82, 95% CI 0.63-1.00, p<0.01). There is large heterogeneity between studies (I^2=93.4%). A Baujat plot was used to identify studies contributing significantly to the heterogeneity. A sensitivity analysis was conducted after excluding these highly influential studies, and the results still indicated a moderate effect for overall MC (SMD=0.72, 95% CI 0.57-0.87, p<0.0001) and the heterogeneity was significantly lower (I^2=60.00%). A funnel plot was used to assess publication bias; there was considerable asymmetry of the plot. Eggers test for asymmetry of the funnel plot was significant (Coef: 4.71, p<0.01), indicating evidence of smaller studies without statistically significant effects remaining unpublished.

The results of univariable analyses are shown in Table 4.8. The p < .15 threshold was conservative to avoid prematurely discounting potentially important explanatory variables (Hodkinson et al. 2019). Short intervention duration (≤12 weeks) and smaller dose (shorter duration per session) seemed to be related to larger intervention effects. Inclusion of process evaluation aims, provision of lesson plans as well as small sample size and mixed sex population were also potential factors associated with improved overall MC.

TABLE 4. 8 UNIVARIABLE META-REGRESSIONS FOR MOTOR SKILL COMPETENCE

Covariate of Interest (Univariable)	n	β (95% CI)	P Value	I^2, %	R^2, %
Implementation					
Duration (≤12weeks vs >12weeks)[a]	23 vs 23	-0.86 (-0.74 to -0.08)	**0.02**	93.24	1.22
Dose (mins)	41	-0.01(-0.02 to 0.00)	**0.05**	92.17	0.00
Intensity (≤2 sessions per week vs >2 sessions per week)	11 vs 25	0.27 (-0.21 to 0.76)	0.27	92.47	0.00
Mechanism of change					
Use of theoretical concept (no vs yes)	16 vs 28	-0.28 (-0.66 to 0.11)	0.16	92.63	0.00
Provision of lesson plans (no vs yes)	17 vs 15	0.41 (-0.06 to 0.88)	**0.08**	93.24	0.00
Involvement of family/parents (no vs yes)	11 vs 36	-0.03(-0.49 to 0.43)	0.90	93.49	0.00
Teacher training (no vs yes)	10 vs 15	-0.17 (-0.47 to 0.12)	0.25	82.84	8.07
Context					
Sample size (≤150 vs >150)	24 vs 23	-0.70(-1.07 to -0.33)	**0.0002**	93.01	5.73
Sex (targeted sex vs mixed sex)	6 vs 41	-1.35(-1.92 to -0.77)	**<0.0001**	92.31	15.26
Age (yr)	45	-0.06(-0.15 to 0.03)	0.20	92.32	0.00
Process evaluation aim (no vs yes)	8 vs 16	0.32(-0.09 to 0.72)	**0.12**	90.98	0.00

n, number of studies included in the regression model in each category R^2, amount of heterogeneity accounted for. I^2, heterogeneity. [a] reference categories are those on the left for binary variables

Discussion

Principal Findings

This is the first systematic review that has attempted to comprehensively investigate the extent to which process evaluation has been conducted and reported in MC interventions. We identified 60 MC interventions and only 30 (50%) reported process evaluation measures. Given process evaluation can help identify characteristics that optimise intervention functioning and effectiveness, our findings highlight that process evaluation is under-used and/or under-

reported in MC interventions. The limited reporting suggests missed opportunities to identify intervention elements that can be optimised and generalised.

Reporting process evaluation with greater methodical rigour is also needed. Of the 30 studies in which process evaluation measures were reported, only five explicitly stated a process evaluation component (i.e., written out as a section in the paper or reported in a separate publication) and no study mentioned the use of an evaluation framework. In this review, the lack of consistency in reporting and depth in analysing process evaluation measures hindered the comparability of interventions and the understanding of causal pathways underpinning the intervention functioning. This may be explained by the lack of presence of evaluation frameworks within motor development literature, given the guidance on process evaluation began to emerge in the early 2000s as MC interventions were gaining traction. On the other hand, the ad hoc reporting of process evaluation measures in these interventions surfaced as early as in 2002 (Karabourniotis et al. 2002). This suggests researchers have the intuitive understanding of the necessity of process evaluation, that is, to understand how the intervention brings about changes that lead to the hypothesised outcomes. This understanding can be harnessed by a systematic, comprehensive, and consistent reporting of process evaluation measures.

What and how was process evaluation conducted and reported

There was considerable variability in what was measured and reported, and types of methods used in evaluating intervention processes. Notably, across all three evaluation domains, measures relating to implementation were most commonly assessed and reported. Half of the implementation measures were related to intervention fidelity, and as such, it was the most prevalent of all reported process evaluation measures. Intervention fidelity refers to the degree to which an intervention is delivered as intended (Carroll et al. 2007). The wide spread of

fidelity theories in health intervention literature makes fidelity a putative essential element that needs to be assessed. Indeed, among the studies reviewed, fidelity was measured to ensure the internal validity of the study and help researchers to interpret outcome effectiveness accurately (Borrelli et al. 2005). As an example, in one study that reported teachers' instruction approaches in both arms, the use of intended teaching approach increased over time among teachers in the intervention group but not in the control group (Miller et al. 2016). Supported by the findings on fidelity, when interpreting the outcome that favoured students in the intervention group, researchers could confidently conclude the prescribed teaching approach was one key contributor to the intervention success. While skill and curriculum-based interventions can be successfully adhered to, fidelity to non-sessional intervention components (e.g., school policy, recess activities, community sports events) can be low (Cohen et al. 2015) and may decrease over time (Graf et al. 2008). Interpretations of these results were not reported which exposes the ambiguity in describing the purposes of fidelity assessment. This may be explained by researchers' poor knowledge and understanding of how fidelity is conceptualised and operationalised (McGee et al. 2018). Within our review this issue was also reflected in the collection methods and analyses pertinent to fidelity. We found the assessment of fidelity often employed a standardised intervention checklist that codifies delivery characteristics of the intervention. While documenting intervention delivery is essential and a checklist may be a practical decision to record and report fidelity in a way that can be quantified, there are other aspects that are equally important but more challenging to measure.

Fidelity is a multi-faceted concept that comprises more than intervention delivery (Toomey et al. 2019). Apart from the fidelity to the intervention content, there is also theoretical fidelity that measures whether the delivered intervention was congruent with the logic that underpinned the intervention design (Haynes et al. 2016). Measuring theoretical fidelity is vital for validating intervention theories and translating interventions for other contexts (Carroll et

al. 2007). It may also offer a solution for the 'fidelity/adaptation dilemma' (Bopp, Saunders, and Lattimore 2013), whereby the intervention effectiveness is contingent on the balance between intervention standardisation and its contextual adaptations (Haynes et al. 2016). Hawe et al. (2004) further argued that allowing contextual changes may even induce greater fidelity (which may be referred to as theoretical fidelity). This could be particularly pertinent for MC interventions given their reported responsivity to contexts (Lander et al. 2020b). However, measuring theoretical fidelity was rarely done within the reviewed studies; except for two successful interventions which measured fidelity to teaching principles over time and provided ongoing consultation to deliverers (Chan et al. 2016, Lander et al. 2019), in order to enhance intervention consistency. Additionally, a lack of clarity in intervention mechanism and its evaluation thereof is evident–only 68% of studies provided adequate intervention description according to our quality assessment. Without a strong understanding and clear description of intervention theory, it is unlikely that a meaningful assessment of implementation will occur (Fynn et al. 2020, Moore et al. 2015). Documenting the actual implementation process and capturing adaptation may also contribute to a better evaluation.

While fidelity is a fundamental area requiring attention in process evaluation, it is too narrow a concept to cover a whole range of implementation of interventions (Montgomery et al. 2013). Focusing solely on fidelity could leave unanswered the questions about whether the intervention reached its intended participants. In this review, we found intervention reach can vary depend on types of activities and target group and may decrease over the intervention period. This suggests that even if the programme is implemented in full, its functioning can still depend on how intended participants actively interact and engage with the intervention (Steckler and Linnan 2002). Additionally, the actual dose (e.g., time participants spent on skill practice) was only recorded in four interventions limiting the comparability of true intervention effects. In a real-world setting, prescribed intervention doses are not always delivered in full

(Moore et al. 2015). It has been continually underscored to record actual 'on-task' time in MC interventions (Morgan et al. 2013), so that researchers can establish dose-response relationships in interventions.

Within our review, participant responses was the second most reported measure. Mostly it was examined through quantitative measures, including satisfaction, acceptability, self-efficacy, and enjoyment. Despite its suitability for the direct comparison of engagement among heterogeneous participants, only one study in our review compared participant responses by subgroups (Salmon et al. 2008), limiting our understanding regarding for whom the intervention worked most effectively. Exploring gender differences in response to interventions can provide valuable information. Boys showed favourable intervention outcomes compared to girls in one study in our review, and this was attributed to gender differences in children's preference for different intervention components–girls preferred varied physical activity whereas boys preferred games and sports (Salmon et al. 2008). These findings may provide important intervention implications for future interventions, hence a more thorough analysis of participant responses is encouraged.

Conversely, quantitative measures can be limited as they are less likely to capture the interactive nature of how participants respond and may overlook negative experiences of participants (Craig et al. 2013). Lack of qualitative measures were identified within our review (Nathan et al. 2017). For example, some target groups (e.g, parents) were less involved in the intervention and reasons for this could have been explored qualitatively. For studies that reported qualitative findings, interpretations were not explicit as to how these findings contributed to the learning of the intervention. Overall, by undertaking qualitative research, researchers can gain more in-depth understanding about the intervention which feeds back into optimising external validity of the intervention (O'Cathain et al. 2013, Hamilton and Finley

2019). In a recent implementation research exploring maintenance of a teacher-led MC intervention, through focus groups with teachers, several drivers for sustained engagement (including those of students) with the intervention were identified and recommended for future trials (Lander et al. 2020b). With the majority of included interventions being school-based, unsurprisingly, deliverers (e.g., teachers) were surveyed, since they were considered as one key driver of the intervention success. A variety of assessments were used to measure deliverers' responses, including satisfaction of training workshops, perceived use of intervention content and knowledge and competence of teaching and assessing MC. As identified by Lander et al. (2017), teachers' engagement with interventions and values of physical activity and MC determine the effectiveness of their role of as facilitators. However, we were not able to gather sufficient information to conclude on the optimal strategies to enhance engagement. Consistent with previous reviews, reporting on teacher's roles and pedagogy remains poor (Lander et al. 2017, Tompsett et al. 2017).

Intervention functioning can be also explored by formally examining mediators with statistical tests (Moore et al. 2015). Mediators are termed as intervening causal variables that are necessary to complete a causal pathway between an intervention and its outcome (Bauman et al. 2002). Despite several calls to test mediations in the context of an intervention (Brown et al. 2013, Barnett et al. 2008), only three studies within our review did so (Miller et al. 2016, Nathan et al. 2017, Salmon et al. 2008). Surprisingly, perceived motor competence that was theorised and reported as a specific mediating variable to improve children's actual motor competence (Barnett et al. 2008; Stodden et al. 2008) was not tested in any study. Given the multifactorial nature of motor development (Robinson et al. 2015), it is imperative to investigate and report mediating variables so that effective intervention strategies can be identified.

The relationship between an intervention and its outcomes can also vary depending on the surroundings that may influence intervention implementation or outcomes, known as *Context* (Saunders, Evans, and Joshi 2005). The breadth and variety of reported contextual factors and moderators within our review confirm motor development is a complex entity. These factors are further expanded in the next section.

In summary, although we identified 82 process evaluation measures across 30 intervention studies, the heterogeneity (or absence) among the reporting and interpreting of their findings prevented the data from being reviewed fully. Moreover, some measures were collected but not analysed, defeating the purpose of conducting process evaluation in the first instance. It is also noteworthy that most of the studies did not set out a priori evaluation aims to assess the link between process evaluation measures and intervention outcomes. This can be problematic since evaluation without raising questions for investigation can increase the tendency to collect excessive data that are beyond intervention and research capacity (Moore et al. 2015). Our review is therefore timely, highlighting the paucity of process evaluation evidence in MC interventions and the need for further research to expand and support the suggested findings in this review.

Factors that influenced intervention functioning and outcome

We adopted a mixed methods approach to review the links between intervention related factors and MC outcomes. As a first step, we collated contextual factors arising from process evaluation findings and categorised them under the Durlak and DuPre framework (Dulak and DuPre 2008). We then tested intervention specific covariates in meta-regressions. We made attempts to compare and integrate both qualitative and quantitative findings to explore where they converge, diverge, or relate (Creswell 2013). As aforementioned, we encountered a

meagre literature base that explicitly described the link between process evaluation measures and outcome; therefore, limiting our interpretations of findings.

As shown in Table 4.7, more factors emerged in relation to intervention implementation, which confirms researchers' emerging interests and perceived challenges of implementation. Most reported barriers were related to delivery system (e.g., school environment). Challenges include time constraints and competitive demands that overload teacher's schedules (Chan et al. 2016). Our meta-regression identified shorter intervention duration can lead to larger intervention effects (see Table 4.7). Aligned with findings with a recent meta-analysis on the association of PE and MC, it may be the quality of PE, rather than quantity, that is associated with the increase in MC (García-Hermoso et al. 2020). Our speculation is the longer the intervention is, the more likely that intervention implementation is disrupted and therefore less sustained due to lack of organisational support. These findings reflect the need for a supportive school climate/environment, which aligns with findings from previous reviews (Cassar et al. 2019b, Naylor et al. 2015, McGoey et al. 2016). The importance of schools and the support of change agents in the delivery of interventions is well documented in implementation research (Cassar et al. 2019b, Lyon et al. 2018). In motor development, involving teachers in decision making in order to adjust programmes to school and curriculum configurations for ongoing implementation has been recommended (Lander et al. 2020). The organisational support also includes those from managerial level (e.g., school's administrative supports) and other agencies (e.g., community clubs, local councils), as identified barriers are also concerned with staffing, resources and communications between school, home, and local community (as shown in Table 4.7).

Facilitators that can enhance adoption and implementation of interventions were mostly associated with characteristics of provider (e.g., self-efficacy) and innovation (e.g., contextual

fit). Specifically, several intervention characteristics that appeared to optimise intervention implementation were identified, including compatibility with existing curriculum (Okely et al. 2017), self-assessment (Chan et al. 2016) and increased active time (Invernizzi et al. 2019, Cliff et al. 2011). Further elements that make interventions more appealing to participants include a competitiveness component (Gu et al. 2018, Telford et al. 2021, Barnett et al. 2015), novice and transferable skill component (Invernizzi et al. 2019, Cliff et al. 2011), quality resources (Salmon et al. 2008, Laukkanen et al. 2015), and adaptability (Boyle-Holmes et al. 2010, Telford et al. 2021, Lander et al. 2019). Interestingly, even though high fidelity was reported to support intervention functioning, having flexible delivery and malleable elements seem to augment the intervention mechanism. This could be because adaptation may have encouraged programme ownership by the deliverers' (Lander et al. 2020). Deliverers' characteristics and engagement with the programme was another identified facilitator. Teacher's understanding of the intervention and assessment as well as pedagogical approaches were direct influences on intervention outcomes. Consequently, the training offered to teachers could increase intervention effectiveness. Although we did not find statistical significance of teacher training as a moderator, training was reported to be a critical intervention component and comprehensively discussed in previous reviews (Lander et al. 2017, Tompsett et al. 2017).

Additionally, our meta-regressions found inclusion of a process evaluation aim significantly moderated the overall effectiveness and reduced study heterogeneity. This is consistent with previous reviews on implementation which revealed that programmes with monitored implementation obtained larger effect sizes than those which reported no monitoring (Durlak and DuPre 2008). Combining with the fact that reported contextual factors can be interpreted with the broad literature on implementation sciences (i.e., Durlak and DuPre framework), our findings underline the need to consider the valuable role of process evaluation data in explaining the variability and 'real-world' implementation issues in MC interventions.

Finally, the majority of included studies presented statistically significant intervention effects in overall MC, which could be the publication bias found in our meta-analysis. Our analyses suggest publication bias favoured effective interventions with large sample sizes. This further presents the need to conduct and report process evaluations that can help understand and learn from negative findings. This also requires researchers to conduct thorough evaluation planning, taking account of the selection of evaluation measures.

Strengths and limitations

Major strengths of this study include the comprehensive review (with no date restrictions) and mixed methods analysis of quantitative and qualitative process evaluation data in MC intervention literature, using an established framework of process evaluation. The review expanded the literature base regarding the issues faced in evaluating MC interventions and optimal intervention characteristics. As one of the first studies to introduce implementation science literature in motor development research, this review provides an overarching summary on critical evaluation domains/measures for researchers' considerations with an ultimate aim to promote better reporting and evaluation practice. Table 4.7 provided information that can be considered by researchers to reinforce intervention mechanisms and enhance 'buy-in' of target stakeholders and participants to optimise interventions.

Limitations of this review include the limited scope of mixed-methods findings. Due to data availability, some aspects of the quantitative results could not be explored in qualitative findings and some variables identified in qualitative findings could not be tested quantitatively (e.g., we could not ascertain if increase in activity time has induced larger intervention effects due to absence of activity data). Additionally, a small number of studies in category groups (e.g., targeted sex) in meta-regressions affected our confidence in ascertaining moderating effects. This also serves as a call for researchers to conduct more and consistent process

evaluation and the analytic interpretation of process evaluation findings should be in-depth and where possible, supported by quantitative analysis. A further limitation is that we did not investigate the intervention effects by skill subcategories. This may have provided further intervention implications; however, this was not practical to do within one single review.

Conclusion

Process evaluation in MC interventions is in its infancy. We view our findings as a call to action to consider the valuable role of process evaluation in understanding intervention effectiveness and functioning. The persistently found variation in intervention strategies and outcomes suggests that perhaps the optimal intervention programme is not just about *what is being done*, but *the way* a theoretically sound and contextually appropriate programme can be well implemented. We need to appreciate evaluation of interventions puts forward an opportunity to observe motor behaviour changes and what causes these processes for changes. Furthermore, our findings suggest a mandate for better reporting of interventions. To achieve the ultimate goal of scaling up and sustaining effective interventions that benefit population health, we need more robust evidence to help build the scientific case on what works and what does not in practice.

Chapter 5, Part 1. Rationalising the use of Collective Intelligence to understand barriers to the implementation and sustainability of MC interventions

Thesis Map

Chapter	Objective(s)	Key findings and implications
4. A systematic review of process evaluation of MC interventions	Objective 1: To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	- Process evaluation is not sufficiently used or adequately reported in MC interventions when used. - Influences on MC intervention processes and outcomes are wide-ranging and include intervention characteristics, and individual, organisational, and system-level factors. - A wide range of typologies of process evaluation outcomes and measures were identified, along with their collection methods. These include measures relating to implementation, mechanism of change, and contextual influences on an intervention. However, it was insufficient to fully understand the implementation of MC interventions given process evaluation is underused. Further experimental studies are warranted.
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions	Objective 2: To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.	
6. Developing implementation strategies and a protocol for implementation evaluation of a MC intervention		
7. Outcomes of an implementation evaluation of a MC intervention		

A version of this section has been published in Journal of Sports Sciences.

Ma, J., Hogan, M.J., Eyre, E.L., Lander, N., Barnett, L.M., and Duncan, M.J. (2021). Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skill interventions: A rationale and application example. *Journal of sports sciences*, 39(6), pp.691-698. https://doi.org/10.1080/02640414.2020.1841395

Chapter context

Chapter 4 highlighted that the use of process evaluation assists in 'unpacking the black box', i.e., uncovering contextual influences on the MC intervention processes. Due to the inconsistency in the reporting of MC intervention processes, as was identified in Chapter 4, it was difficult to gain a comprehensive understanding of the influences on intervention processes. Furthermore, it was unclear how characteristics of intervention processes may translate into the improved implementation and sustainability of an intervention. Therefore, this chapter aims to empirically address this topic by applying a systems science approach- Collective Intelligence (CI). Given the novelty of this approach in the context of PA and MC research, Part 1 of the current chapter details the rationale, procedures, and benefits of applying CI, and part 2 will report the CI study with an increased sample, along with a meta-analytical process to synthesise outcomes from multiple CI sessions and propose solutions to the barriers identified.

Introduction

Implementing and sustaining interventions is challenging yet feasible (Rabin et al. 2006); a review on sustained intervention effects on PA, fitness and MC suggested that with theory-informed intervention design and sufficient dose, MC and PA are likely to be sustained outcomes in children and adolescents (Lai et al. 2014). The review attributed the lack of sustainability to the absence of research planning for sustained programme implementation and assessment. Nevertheless, there are copious theoretical frameworks available to guide researchers for implementation and sustainability of health interventions (Nilsen 2015). A review on physical activity and sedentary behaviour trials (which included some MC interventions) reported that even among the limited intervention trials that utilised implementation theories, the widespread seemingly ad hoc application of implementation

models signifies that implementation and sustainability are not considered by researchers across the intervention life cycle (Cassar et al. 2019a). This is likely partially due to researcher's insufficient knowledge and appreciation of real-world research methodologies (Koorts et al. 2020). By the same token, adopters and users in the real-world sometimes find interventions incompatible with their routine practices owing to the need for understanding of intervention functioning (Glasgow, Lichtenstein, and Marcus 2003). This continued inadequate collective understanding of the issues in an intervention faced by both researchers and end-users (Bopp, Saunders, and Lattimore 2013) makes addressing implementation and sustainability in MC intervention research a significant priority.

The challenges of planning for implementation and sustainability are grounded in complex interactions between interventions, practice settings, and a broader ecological system (Chambers, Glasgow, and Stange 2013). This is of relevance for MC interventions targeting children and adolescents, since intervention settings are often schools where various agents and factors operating at individual, organisational, and system levels moderate the intervention process and outcome (Cassar et al. 2019a). Furthermore, these elements are not to be considered in isolation due to their interactive and dynamic nature (Littlecott et al. 2019). The complex nature of MC interventions (and many other health interventions) requires researchers to view interventions as 'events' within complex systems (Hawe 2015), where a range of characteristics of interventions can be examined to understand what works and will continue to work, for whom and under what circumstances (Moore et al. 2019). As such, it is essential that investigations in MC interventions account for multifaceted contextual challenges and understand what ingredients make intervention implementation sustainable – ingredients which can be further compiled and translated into measurable indicators to show the progress of implementation (McKay et al. 2019).

Increasing awareness of the complexity and multitude of influences on interventions has put a spotlight on systems thinking as a means of understanding intervention scenarios and dynamics. Systems thinking is an approach to problem solving, where the problem is viewed as part of a system of interrelated component parts (Northridge and Metcalf 2016). A recent WHO bulletin commissioned by a group of PA experts advocate that the application of systems thinking can demonstrate the interconnectedness of key components in PA research (Rutter et al. 2019). Yet, there is limited awareness on how modelling approaches can be integrated to advance understanding of intervention functioning in the field of MC or PA research. The nascent application of systems thinking are predominantly in community-based obesity preventions where techniques such as network analysis and agent-based modelling are utilised to visualise the dynamic complexity of a system (Bagnall et al. 2019, Hayward et al. 2020). In the field of MC or PA research, this could be utilised to investigate how interventions potentially reshape the system (Rutter et al. 2019), which may include analysis of systems of barriers that constrain intervention success. This could be beneficial if implemented to facilitate contextual understanding of intervention system scenarios, and pathways to improve intervention design and evaluation that ultimately uphold intervention implementation and sustainability success. Such practice could yield substantial information if incorporated in a collaborative research context working with a team who have a stake in implementation and sustainability of an intervention, such as researchers, practitioners (e.g., teachers), and beneficiaries (e.g., students) (Johnson et al. 2019).

This study reports on the initial testing of an applied systems science approach – Collective Intelligence (CI), designed to facilitate systems thinking and collective problem-solving relevant to MC intervention implementation and sustainability. By illustrating the rationale and utility of CI methodology and presenting a case example of applying CI, this part

of the chapter aims to (a) test CI as a potentially valuable approach in the context of MC intervention research and (b) provide future directions of where CI could be beneficial.

Methods

CI aims to generate, clarify, and structure interdependencies between problem elements, and further develop options to address the system of interdependent problems (Warfield and Cardenas 2002, Groarke and Hogan 2016, Hogan. et al. 2015, RezaeiZadeh et al. 2017). It utilises a set of methodologies to understand a complex issue and to map actions in response to a problem field by integrating inputs from individuals with diverse views and perspectives in the context of a facilitated and computer-supported workshop structure (Warfield 2006).

To facilitate the CI process, the facilitation team derives a systems model from group member's reasoning and consensus-based voting on problem relations using a computer-supported methodology, *Interpretive Structural Modelling* (ISM; Warfield and Cárdenas 2002). Using ISM, group members collaboratively construct a structural map to illustrate the interdependencies between problems in a problem field. The structural map provides a launch pad for the group to conduct action mapping to solve the problem in an efficient manner, focusing on logical interdependencies between problems and designing actions that help to address key drivers of negative influence.

CI is a context free tool that can be applied in any complex situation (Janes and Milee, 1998). It was validated using Structural Equation Modelling (SEM) for its function of group decision making (Chang 2010). In the field of health sciences, CI has been applied to identify challenges in improving health and wellbeing for Irish citizens (Hogan et al. 2015b) and for the design of personalised nutrition services for older adults in Europe (Hogan et al. 2015). In the context of MC interventions, CI offers a potential way for stakeholders, researchers, and leaders to reach consensus as regards the nature of the problems they face in implementing and

sustaining interventions and solutions to address these problems. We envisage CI to be added into the 'toolbox' of methods to address research and practice challenges in the early stage of the intervention life cycle and in planning to address barriers to intervention implementation.

The operationalisation of CI involves four stages, summarised in Figure 5.1.
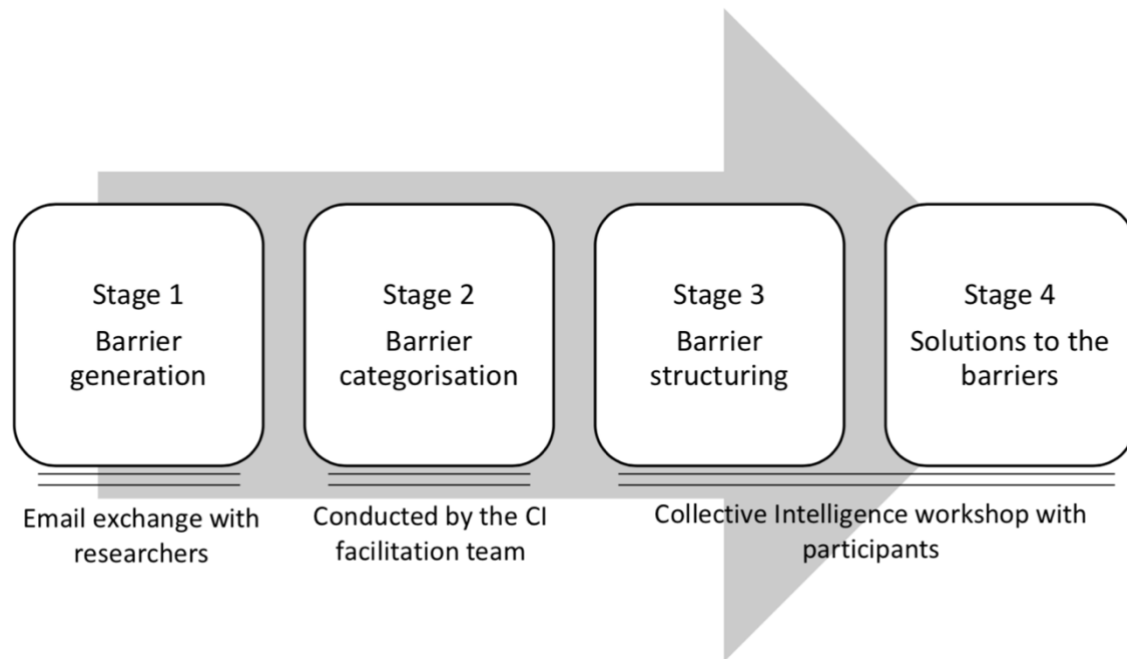
The first stage involves individual barrier generation. In Stage 2, all barriers are categorised by the CI facilitation team prior to the CI workshop. Stage 3 involves a closed voting process and structuring selected barriers using ISM software during the CI workshop (Broome and Hogan 2012). This workshop process is visually described in Figure 5.2. The four steps of ISM are: (i) identification and clarification of a 'relational question' for exploring relationships among the barriers generated in the previous stage; (ii) using the relational question to explore connections between pairs of ideas, the software presents 2 barriers each time for pair-wise relational mapping. The group engages in reasoning on each relational question and a vote is taken to determine the group's judgement about the relationship. A "yes" vote is entered in the

ISM software (and coded as '1' in the underlying matrix) only if a majority consensus (>=70%) is reached, otherwise, a "no" vote (0) is entered; (iii) graphical display of full matrix of decisions and group interpretation of the structural model and amendment to the model by the group, if needed. The structural map generated is a representation of how barriers are related. The facilitators remain impartial and only facilitate member's reasoning and communication.
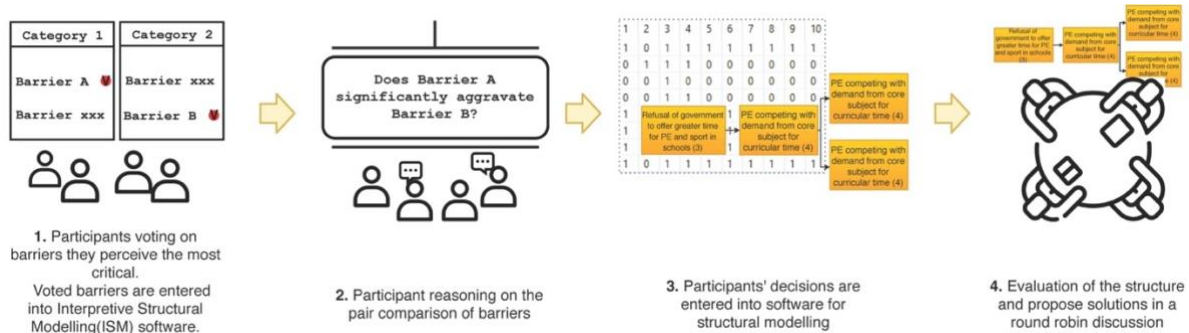
FIGURE 5. 2 A SIMPLE VISUAL DESCRIPTION OF KEY STEPS IN THE CI WORKSHOP

In Stage 4, participants engage in a process of generating options for overcoming the barriers. The idea writing (Warfield and Cárdenas, 1993) technique is used. This technique involves five steps: (i) presentation of a stimulus question to the group (e.g., what are options for overcoming the barriers in the category [x]?); (ii) silent generation of ideas in writing by each member working alone; (iii) exchange of written sheets of ideas among all members in a group, with opportunity for individuals to add ideas as they read others'; (iv) discussion and clarification of ideas; (iv) an oral presentation of the ideas generated and prioritised as most impactful by the working group. When generating solutions, action plans are aimed at resolving problems in a logical and orderly manner according to the structural map.

A Case for Using Collective Intelligence in MC intervention research

This section identifies how CI is operationalised and what outcomes CI can generate in investigating issues in MC intervention research by presenting a case example from a pilot study. In this study, CI was employed to (a) elicit expert perspectives on the barriers associated

with the implementation and sustainability of MC interventions, (b) map interdependencies between these barriers, and (c) generate solutions to overcome barriers.

Methods of the Pilot Study

Participants

20 researchers/practitioners in the United Kingdom (n=14, 70%) and Ireland (n=6, 30%) who have designed/implemented/evaluated MC interventions (identified through peer reviewed publications) were invited to participate via an invitation email (see examples of email invitations in Appendix 5). They were considered to have specialised knowledge and a stake in the issues related to MC intervention implementation and sustainability. Among them, 18 (90%) are current university lecturers/researchers and two are working in local sports associations. In the invitation email, all 20 were informed of the nature of the project and further phone discussions were held with participants who had inquiries. All 20 researchers/practitioners indicated their interest to participate by replying to the invitation email. For pragmatic purposes of this pilot study, wider stakeholders (e.g., teachers, parents) were not recruited. These wider stakeholders will be considered and included in future CI applications. Nevertheless, among researchers included, some can provide insights into broader stakeholder perspectives given their diverse roles and experience. All researchers were considered as content specialists in the topic being discussed. In particular, as researchers, they had extensive experience and prolonged engagement with the settings that were the focus of the current work. Additionally, the nature of the researchers' activities through observations of evidence-based interventions positioned them in a way to provide valuable insights. This information was prompted in each stage of CI. Table 5.1 provides a summary of perspectives the recruited participants represent.

Participants required for CI to yield optimal outcomes*	Participants information (n, % of total numbers of participants)
Stakeholder	All participants had experience in MC research (20, 100%); these researchers also had background knowledge in PE teaching (12, 30%), Health Promotion (2, 10%), Sports coaching (5, 25%), Parenting (1, 5%)
Content specialist	Motor development researchers (20, 100%), all had experience in in-field intervention delivery

* Based on Warfield (2006), the following groups are needed to reach the optimal outcome of CI: a) Stakeholders who have a stake in the issues being considered (e.g., target group of the intervention); b) Content specialist who has specialised knowledge that is relevant to the issue (e.g., intervention developer and implementer)

Procedure

In Stage 1, all 20 participants were invited to generate five barrier statements in response to the following triggering question via email: *"From your understanding and previous involvement in MC interventions, what do you consider are the key barriers to the adoption, implementation and institutionalisation of effective MC interventions targeting children?"* A number of starter phrases (e.g., failure to, lack of, conflicts between) were provided to facilitate barrier generation. In Stage 2, the CI facilitation team (JM and MH) collated all responses and performed a paired comparison of all barrier statements (Warfield and Cárdenas, 1993) in a face-to-face meeting. Specifically, after immersing in the data and obtaining the sense of whole, the facilitation team conducted open coding and category creation. Pairs of barriers were systematically assessed for conceptual similarity in turn, during an exhaustive process of comparative analysis. These conceptually similar barriers were then grouped under higher order categories. In Stage 3, from the 20 initial participants, five were invited (using convenience sampling) to take part and form the panel of experts in the CI workshop. The workshop was held on 16th December 2019, at a meeting room on university campus that was

accessible to all participants. After the introductory presentation on the CI workshop goals and overview of categorised barriers (lasting 15mins approx.), the panel of experts were asked to (a) review the barriers arrayed on display walls and handouts so that each member of the panel had a clear understanding of the barriers, and (b) use a voting method to select the most critical barriers across all categories. Each member was given votes (red stickers) to cast on the barriers on the display wall that they identified as most critical. This involved a process of silent and independent review and selection lasting approximately 20 minutes. The facilitation team then analysed voting patterns and a set of ten barriers which had the most votes were selected for structuring and entered into the ISM software. Only the results of voting were noted on the record and voting decisions were not traceable. Given our focus on examining interdependencies between barriers to the implementation and sustainability of MC interventions, we focused on aggravation relations, specifically, by asking the following question: "*In the context of the adoption, implementation and institutionalisation of effective MC interventions, does barrier A significantly aggravate barrier B?"*. The structuring of 10 critical barriers lasted for 90 mins. In Stage 4, participants focused on the generation of options for barriers as informed by the structural map using the idea writing technique as previously described. Participants spent 90 minutes generating, reviewing, and presenting options in response to the critical barriers. In total, the CI workshop lasted for 4hrs, including coffee breaks.

Results of the Pilot Study

A total of 58 barriers were generated in response to the trigger question. These were organised into 13 barrier categories (see Figure 5.3, and Appendix 6 for the full set of barriers).
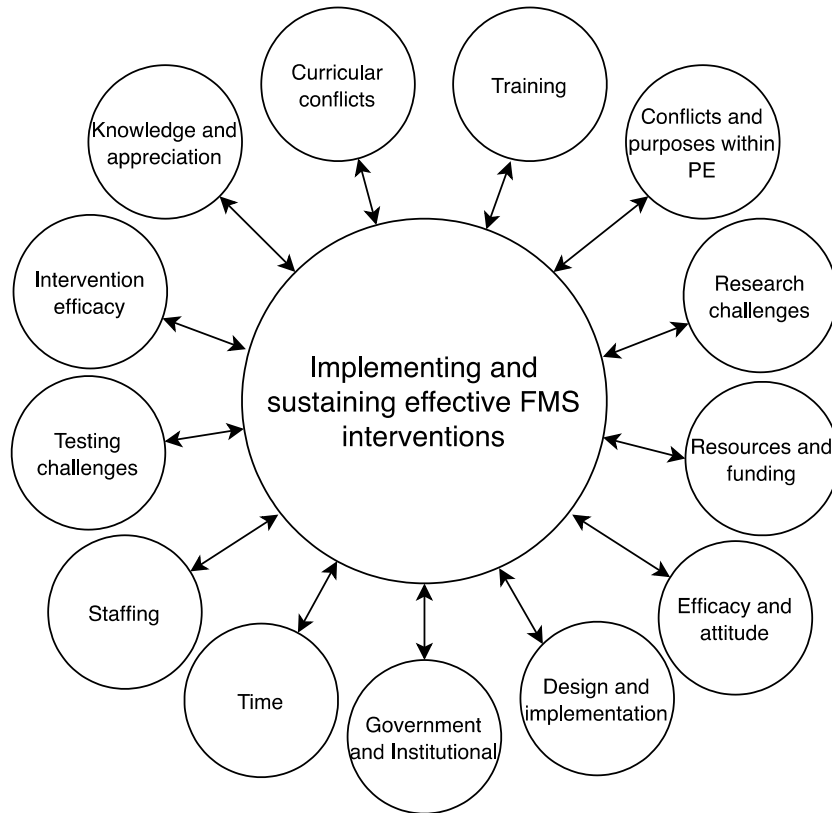
FIGURE 5. 3 BARRIER CATEGORIES

In Stage 3, participants generated a structural map (Figure 5.4) describing the system of relationships between the ten critical barriers. As shown in Figure 5.4, participants argued that 'Refusal of government to offer greater time for PE and sport in schools' is a fundamental driver in the system.

The letter-number combination after each item is derived from Appendix 1.

A. Time
B. Government and Institutional
C. Curricular conflicts
D. Design and Implementation
E. Research challenges
F. Knowledge and Appreciation
G. Conflicts and purposes within PE

H. Resources and Funding
I. Staffing
J. Efficacy and Attitude
K. Training
L. Testing challenges
M. Intervention efficacy

- An insufficient amount of time afforded to us in school setting (A-2)

- Lack of teacher knowledge of FMS and PA in children (F-3)

- Lack of stakeholders knowledge and understanding concerning the benefits for children development derived by FMS interventions (F-5)

- Shortage of school resources and time (H-3)

- Lack of PE teacher or trained expert working in the school continuously (I-2)

- Lack of initial training and continuing professional development (K-1)

- Lack of evaluation to evidence intervention efficacy (M-1)

Refusal of government to offer greater time for PE and sport in schools (B-3)

PE competing with demand from core subjects for curricular time (C-3)

Unwillingness of parents and carers to participate and interact with projects and interventions (F-1)

The arrows indicate that the barriers on the left significantly aggravate (make worse) the barriers to the right. Barriers that are grouped together in one box are reciprocally interrelated and they significantly aggravate one another.

FIGURE 5. 4 EXAMPLE OF A STRUCTURE MAP FROM THE ISM STRUCTURING

As informed by the structural map (Figure 5.4), participants focused on the generation of options for barriers in the Category [B. *Government and Institutional*] and [C. *Curricular Conflicts*] given that selected critical barriers in these categories are seen to drive the system of interdependent barriers. Overcoming these barriers is thus likely to increase our chances of resolving all other barriers in the system and ultimately, improving implementation and sustainability of MC interventions. Table 5.2 gives an example of options the group generated in response to the barriers in the categories. The full set of options generated is provided in Appendix 7.

TABLE 5. 2 EXAMPLE BARRIERS AND OPTIONS

Barrier Category	Example barriers	Option(s)
Government and Institutional	Refusal of government to offer greater time for PE and sport in schools	(a) Build sufficient evidence base to support the greater provision for PE and MC; (b) Set up a task force –multi –education, health to develop, implement and evaluate policy and (c) Promote the evidence/findings from the above task force to change government level policies
Curricular Conflicts	PE competing with demand from core subjects for curricular time	(a) Understand better the school values and ethos to drive shared goals and promote them, and (b) Refine school policies in light of the shared values, ethos and goals through observations, auditing and evaluating.

Discussion

Challenges and recommendations to improve intervention implementation and sustainability are well documented (Cassar et al. 2019b, Koorts et al. 2018a). The current piece of work highlights the utility of the CI methodology to understand and address implementation and sustainability challenges in the context of MC intervention research. In particular, CI assisted in our understanding of barriers to the adoption, implementation and institutionalisation of effective MC interventions, and identifying options and potential solutions to improve and sustain the intervention implementation and effectiveness.

Building upon previous studies eliciting stakeholder perspectives on barriers (e.g., Koorts et al. 2020), CI outcomes reveal both the barriers to improving the implementation and sustainability of MC interventions and how these barriers influence each other, as represented in a structural map that captures the consensus-based logic of stakeholders. The illustrative case example showed that CI assisted in identifying barriers in the problem field and provided a model describing interdependencies between problems (Figure 5.4). Similar to finding from

previous reviews that identified organisational climate and programme coordination as barriers to the implementation of school-based PA interventions (Cassar et al. 2019b, Naylor et al. 2015), the CI process identified Government and Institutional factors and Curricular Conflict as critical barriers to the implementation of MC interventions. CI outcomes also further highlight the aggravating influence of both barriers on all other barriers, and providing a system of logic for the panel experts to design solutions accordingly (Table 5.2). The pilot results are suggestive, and barriers and interdependencies may be replicated in other scenarios. For instance, the case illustrated here will be applied with different MC intervention teams to tackle the issue in more depth and provide context-specific CI supporting intervention implementation and sustainability across the UK and Ireland. MC development is fundamental to population health and lifespan physical development, and broad stakeholder engagement and ongoing systems thinking addressing barriers will be critical for sustainable intervention success in the future.

This system-based understanding of the barrier field and potential solutions in response to the system of barriers are drawn from the multi-disciplinary expertise of the participants and their collaboration during the workshop. In the context of this pilot study, participants underwent the CI process and developed the collective understanding of the problem and identified priorities in resolving the problem, prompting the systematic generation of potentially impactful and feasible solutions matched to the complexity of the problem. As such, gaining knowledge on the intervention levers likely to have the most impact and appreciating the complex barrier system in which interventions are implemented will increase the likelihood of successful implementation (Rabin et al. 2006). CI can also be used to generate prioritisation structures that can potentially inform evidence-based implementation evaluation (i.e., where ISM is used to construct a consensus-based systems model describing how options support one another). If CI is conducted in the early planning of an intervention, structuring potential

barriers, options, or indeed intervention activities, it could potentially help identify drivers of intervention functioning and clarification of key evaluation dimensions. In this way, researchers could propose and devise measuring variables that can track and predict implementation and sustainability in early planning (McKay et al. 2019, Koorts et al. 2019). Engaging in this systems thinking and planning work early on is also recommended as it is in the interest of funders and practitioners to understand whether the planned investment is sufficient to sustain long-term intervention implementation and improved health outcomes (Wolfenden et al. 2019a). The hypothetical pathways and benefits described here will need to be further tested and evidenced in future CI applications, in order to see if CI does, in fact, address the gap between research to practice.

The application of CI aims to engage a group of participants in a democratic, consensus building process (e.g., voting, modelling structural relations collectively) which can enhance the legitimacy of decision-making (Hogan, Hall, and Harney 2017). While alternative computer-mediated system modelling approaches such as 'STICKE' (Hayward et al. 2020) is also purposed to demonstrate stakeholders' interests and perspectives, they do so in a different manner by inviting participants to contribute to the modelling independently and remotely. CI is designed to maximise the potential of group work by integrating and organising the knowledge, experience, and reasoning of participants with a range of diverse backgrounds, perspectives, and values. When used with multiple groups addressing a common societal challenge, one of the key outcomes of CI work—a structural map generated from a standardised real-time modelling process—also allows for CI meta-analysis of multiple models to be conducted (Fauville et al. 2018). Also, the structural maps generated with collective qualitative, deliberative input can potentially be tested quantitatively as they describe casual pathways between intervention levers.

As the first use of CI in MC research, there are further considerations in its future applications. For the pragmatic purpose of the current application, five participants who engaged in the CI workshop all come from the same institution as a result of convenience sampling. This is a limitation of the present pilot study. Although they underwent familiarisation and iterative reviews of barrier categories generated by the initial group of 20 researchers, their established working relationship and shared values could introduce bias into their collective understanding of the problem. This issue was addressed during the workshop through careful facilitation and creation of an environment conducive to learning, reflective thinking, and sharing diverse views (Hogan and Broome 2019). Further uptake in the process of collecting and analysing data from CI may be hindered due to its perceived novelty within the field of MC/PA research. However, the current report provides a detailed account of a feasible CI process adapted to the busy schedule of stakeholders that demonstrates its potential utility in the field. There is also accessible support from literature (referenced in the methods section) and a number of websites (https://www.jnwarfield.com/ism-software.html; https://michaelhoganpsychology.com/collective-intelligence-network-support-unit-cinsu/) if readers would like to know more about the CI methodology and access the modelling software. In the future application of CI, representative stakeholder sampling should be applied to reduce potential biases and to expand stakeholder engagement such that PE teachers, school administrators, parents, leaders, and funders are included. This will increase the scale and depth of stakeholder co-production and bring to light additional practical considerations in research translation efforts that can enhance the application of proposed actions (Estabrooks and Glasgow 2006). Additionally, CI can be combined with scenario-based design (Hogan, Hall, and Harney 2017), which further refines participants' thinking in relation to specific intervention scenarios such that proposed options can be translated into tangible, concrete and specific design solutions that are consistent with stakeholder needs and preferences.

Conclusion

This study is the first to apply CI in the field of MC intervention research. The complex characteristics of implementation settings and understanding the interdependent influencing factors that act as barriers to MC intervention success are key challenges researchers face when translating evidence-based interventions to practice. Those who are interested in translating interventions into sustained practice are encouraged to use the CI methodology detailed in this paper to inform and operationalise their work. This methodology is also relevant for researchers to integrate implementation and sustainability considerations into the life span of an intervention (planning, design, delivery, and evaluation) in efforts to support best practice in the translation of research evidence into practice.

Chapter 5, Part 2. Results of using Collective Intelligence to understand barriers to the implementation and sustainability of MC intervention

Chapter context

The previous Part 1 established the utility and benefit of applying CI in MC intervention research, albeit on a small scale. The advantage of using CI to produce solutions to resolve the barriers identified have not yet been illustrated. The current section, Part 2, details the CI study with an increased sample, along with a meta-analytical process to synthesise outcomes from multiple CI sessions. The study also explored the solutions to the identified barriers to the implementation and sustainability of MC interventions.

Introduction

Lander et al. (2020b) found a variety of barriers and facilitators that influenced the sustained implementation of a school-based programme three years post intervention. Higher levels of teacher's efficacy to teach and assess MC, curriculum alignment, and student's engagement were highlighted as facilitators that support ongoing implementation (Lander et al. 2020b). The breadth of the study findings provides valuable insights into the potential mechanisms to expand MC intervention impact but did not account for the complex interdependencies of the influences on the implementation and sustainability of MC interventions. The need to understand the system of interdependent influences is grounded in the nature of MC

development—a complex and dynamic process, that is characterised by the interaction of a child's maturation with external factors such as physical and social contexts, that support continuous and adaptive experience of movement (Adolph and Franchak 2017). This developmental complexity highlights the need for further examination on the underlying mechanisms and contextual constraints of sustained MC intervention implementation success. This examination needs to be situated in a broader ecological system within which a multitude of influences operate across individual, organisational, community, and systems levels (Chambers, Glasgow, and Stange 2013). These influences are interrelated and dynamic in nature (Littlecott et al. 2019). For instance, despite the recognition of the importance of MC development in PE curricula worldwide (Lopes et al. 2020), the marginal status of PE compared to other core subjects limits the opportunities for children to develop skills needed (Rudd, O'Callaghan, and Williams 2019). The operation of these and other contextual constraints highlights the need for systems-based investigations of MC interventions that account for the contextual complexity within which MC development occurs (Getchell, Schott, and Brian 2020).

Systems thinking is an emerging approach to understand intervention scenarios and the dynamics. It has recently been recommended as a means to enhancing intervention implementation and sustainability (Koorts and Rutter 2021) by examining the interconnectedness of key components in an intervention (Rutter et al. 2019). The application of systems thinking in health interventions is emerging, although this thinking has received critique for its limited reflection on what it might mean for the development and evaluation of interventions (Koorts and Rutter 2021).

One applied systems science approach–Collective Intelligence (CI)–has been widely used to facilitate group-based problem solving, specifically, to both understand a complex issue

and map options and actions relevant to the problem (Warfield and Cardenas 2002; see Hogan et al. 2015b, Hogan et al. 2015, RezaeiZadeh et al. 2017, Groarke and Hogan 2016 for recent social science applications; and see Hogan, Harney, and Broome 2014, Hogan et al. 2015a, Hogan et al. 2017 for further details on methodology and application). The benefits of applying this approach to understand the complexity of MC interventions has been outlined in Chapter 5, Part 1 (also see Ma et al. 2021b). For example, CI helped the stakeholder group to map and understand the relationship between barriers to the implementation of MC interventions. A major strength of the CI method used in the current study is the way in which key systems thinking products can be combined from across multiple group design sessions. Application of the CI method results in the production of a matrix-based structural map (i.e., a systems thinking output) generated from collective, deliberative input from a group, which allows for a meta-analytical examination of multiple structural maps that combine the ideas and reasoning across multiple sessions. This allows for a synthesis of perspectives and the development of an integrated roadmap that can be used to inform practical recommendations and enhance sustainability of strategies to promote MC in children and adolescents in various contexts (Lopes et al. 2020).

Considering the need to translate effective research into practice to enhance MC at the population level, and given the complex nature of MC interventions, the current study sought to understand barriers to the implementation and sustainability of MC interventions, interdependencies between these barriers, and options to address the system of barriers identified. To do so, we used CI with three stakeholder groups in the UK and Ireland who have expertise in MC interventions. To our knowledge, this will be the first meta-analytical examination of MC intervention implementation issues and the first time an applied systems science approach is used to identify barriers and their interdependencies along with options to address these barriers.

Methods

Participants

A purposeful sampling adopting a 'criterion-I' strategy was used (Palinkas et al. 2015). This strategy is commonly applied in studies that seek to engage participants from organisations and systems involved in the implementation process. The criterion used in our study are also consistent with the prerequisites for the optimal outcome of CI sessions (Warfield 2006), in particular, engaging with stakeholders and content specialists who have a stake in the issues being considered (i.e., school teachers, coaches, researcher, public health specialists). This was done by identifying individuals named in publications/reports associated with MC interventions in the UK and Ireland. A snowball sampling technique was also used to identify additional individuals that had a significant role in the intervention setting. Twenty-two participants were conveniently recruited across Location A and B in the UK and Location C, Ireland (Table 5.3). The selection assumed that the individuals and the organisations they are embedded in possess expert knowledge of MC intervention implementation by virtue of their experience in developing, implementing, delivering, and evaluating MC interventions. Most individuals worked across both academic institutions and local intervention practice settings, and thus were in a position to provide information that is both detailed and generalisable across the lifecycle of MC intervention project work. Individuals were contacted via e-mail/telephone and provided with a plain language statement. All participants provided their written consents prior to engaging in the CI process. Ethics clearance was granted by Ethics Committees of Coventry University (P90462) and Deakin University (HEAG-H 173_2020) (see Appendix 8 and 9 for a copy of plain language statement and consent form, respectively).

TABLE 5. 3 KEY STAKEHOLDER CHARACTERISTICS

	Session 1 (UK, N=5)	Session 2 (Ireland, N=6)	Session 3 (UK, N=7)
Proportion (%) of males/females	60/40	50/50	14/86
Proportion (%) of academics as primary profession	100	17	100
Proportion (%) of schoolteacher as primary profession	0	50	0
Proportion (%) of health promotion officer as primary profession	0	33	0
Subject areas participants have expertise/experience in %(N)			
Physical Education	40(2)	83(5)	43(3)
Sports Coaching	60(3)	17(1)	29(2)
MC intervention design and evaluation	80(4)	67(4)	100(7)
MC intervention delivery	80(4)	83(5)	100(7)
Public health specialists	40(2)	33(2)	29(2)
Primary/Secondary school teaching	20(1)	50(3)	29(2)

Data collection

CI is a facilitated group consultation process designed for collective problem-solving (Warfield and Cardenas 2002, Hogan, Harney, and Broome 2014, Hogan et al. 2015b, Hogan, Hall, and Harney 2017). Given the novelty of this approach in the context of MC intervention research, a protocol has been recently published to detail its rationale, procedures, and benefits (see Chapter 5, Part 1 and Ma et al. 2021b). In summary, the same four-stage process (Figure 5.1 and Figure 5.2) as described in the protocol was used in the current study. Overall, three CI sessions each lasted approximately five hours.

Three sessions (including the one pilot session reported in Chapter 5, Part 1) were conducted between December 2019 and November 2020 with three separate MC intervention project teams in the UK and Ireland. These sessions were facilitated by JM and MH. Each session was scheduled at a time that was convenient to the majority in the participant group

and some participants were not present due to unavailability (4/22, 18.2%). CI sessions one (N=5) and two (N=6) were conducted face-to-face on a university campus accessible to all participants, and session three (N=7) was conducted online via Zoom due to pandemic restrictions. The lead author took field notes during and following each session. Field notes are an essential component of rigorous qualitative research and used to capture contextual information of the data collection and aid understanding of the outcome (Phillippi and Lauderdale 2018). Consideration was given to observations of paired comparison that required extended discussions and reflective data including researcher thoughts and ideas relating to the group discussion and reasoning.

Data Analysis

The analysis and reporting process used in the current study follows the standard processes of generating categorised field representations of ideas and for meta-analysis of ISM structure as described in (Van Lente and Hogan 2020). Barrier statements in response to the initial trigger question collated from participants were analysed by barrier categories. For each of the three CI sessions, participants voted to select barriers for structuring from across the category field and were facilitated to generate a structural model through a process of deliberation and matrix structuring in the session. Each structural map was analysed in conjunction with field notes. Additionally, a structural meta-analysis of the three models was conducted to understand the relationship between categories of barriers and to identify high-level structural relations emergent across the three MC intervention scenarios. The meta-analysis process is therefore described in the results section, following presentation of three structural models.

Option statements generated in response to barriers categories were collated and analysed. These option statements were then summarised by JM and MH to generate synthesised options. These options were then thematically categorised based on conceptual

clusters aligned with the ERIC compendium (Powell et al. 2015, Waltz et al. 2015). The ERIC compendium provides a compilation of strategies to improve implementation of interventions and has been used to advance school-based intervention research (Cook et al. 2019). Mapping options generated in this study with the ERIC compendium enables a systematic recommendation on particulars that can be taken to improve implementation and sustainability of MC interventions. This also follows good practice in implementation science by advocating the consistent use of theoretical frameworks and terminology (Moullin et al. 2020).

Results

Category analysis of barriers

The three sessions generated a total of 76 barriers. These barriers were categorised using the paired-comparison method ((Warfield and Cardenas 2002); cf. (Van Lente and Hogan 2020)). The CI facilitation team (JM and MH) conducted open coding and category creation. Specifically, pairs of barriers were systematically assessed for conceptual similarity and conceptually similar barriers were grouped under higher-order categories. This process is continued until all ideas have been placed into final categories. The facilitation team followed this process and identified 13 categories (see Table 5.4). Table 5.4 also provides a description of each category of barriers, along with sample ideas in the category.

TABLE 5. 4 ALL 13 CATEGORIES OF BARRIERS GENERATED FROM THE CI PROCESS

Category	Clarification	Sample statements from CI process
A. Time	Time constraints to integrate the proposed programme	A demand for time in the curriculum, impacting time allotted for interventions
B. Government and Institutional	Factors relating to policy that may support institutionalisation of the programme.	Refusal of government to offer greater time for PE/sports in schools
C. Curricular Conflicts	The contextual appropriateness and congruence with the existing curriculum and schools' priorities	Conflict between school targets and research targets
D. Design and Implementation	The compatibility and adaptability of the proposed programme	Lack of considerations of long-term sustainability and implementation of the programme
E. Research Challenges	Challenges relating to conducting intervention research	Failure to recruit schools/children to interventions
F. Knowledge and Appreciation	Perceived need and benefits of the proposed programme and possession of the relevant skills and knowledge	Lack of teacher knowledge of MC and PA in children
G. Conflicts and Purposes within PE	The contextual appropriateness and congruence with the current PE curriculum and practice	Conflicting interpretations among PE teachers of the aims and the purpose of MC interventions
H. Resources and Funding	Factors relating to funding and resources at the government level and individual organisational level.	Lack of funding to support implementation phase
I. Staffing	Specific considerations on staffing, internal advocates and managerial support necessary for successful implementation	Shortage of staff to support interventions, therefore prevents the 'adoption' of an intervention going forward
J. Efficacy and Attitude	Motivation and self-efficacy to implement the proposed programme	Unwillingness by PE teachers to implement strategies that they are not familiar with
K. Training	Approaches to ensure providers proficiencies in the skills and knowledge required to implement the programme	Lack of Continuing Professional Development for PE teachers (i.e., minimal contact time with PE teachers) and therefore inadequate training
L. Testing Challenges	Challenges relating to conducting outcome assessments	Failure of test subjects to engage with demonstration from researchers
M. Intervention Evaluation	Practice and knowledge on programme evaluations.	Inadequate reporting on interventions, such as intervention process, actual 'on-task' time for motor skill practice, and actual delivered dose of the intervention

When selecting barriers for inclusion in the ISM structuring, participants each voted independently for seven critical barriers, with a total number of aggregate votes at the group level reflecting the perceived importance of barriers. The total number of votes per category received from each session is presented in Figure 5.5. Category [F. Knowledge and

Appreciation], [B. Government and Institutional] and [G. Conflicts and Purposes within PE] received most votes from Group 1, Group 2, and Group 3, respectively. These three categories also received most cumulative votes from the three groups collectively. Group 2 did not identify any critical barriers in Category [C. Curricular Conflicts] and [L. Testing]. Category [L. Testing] received the least votes across three groups.
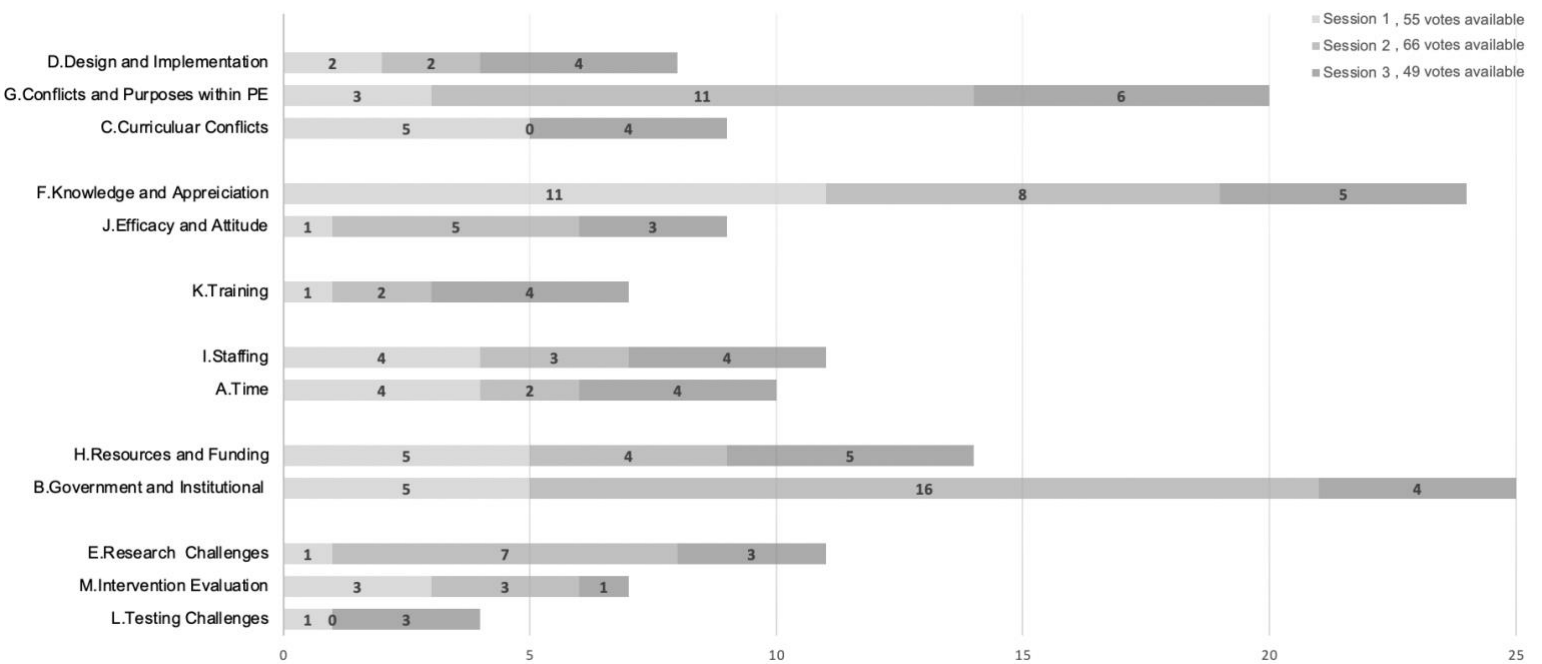
FIGURE 5. 5 VOTES RECEIVED FROM EACH SESSION, BY BARRIER CATEGORY

Structural models generated in each session

A brief description of structural models generated from each session is presented below. Structures are to be read from left to right, with the barriers on the left significantly aggravating (i.e., make worse) the barriers to the right. Barriers grouped together in one box are reciprocally interrelated and they significantly aggravate each other.

Session 1

Five participants attended Session 1 and generated a model of 10 barriers (Figure 5.6). In the model, *"Refusal of government to offer greater time for PE and sport in schools"* was considered to be a fundamental driver of all other barriers. It was argued that this barrier further aggravates *"PE competing with demand from core subjects for curricular time"*, which further influenced all other barriers, including barriers to engaging parents and carers, and seven reciprocally interrelated barriers (i.e., time and resources constraints, insufficient knowledge of teachers and stakeholders, lack of training, lack of continued implementation, and lack of evaluation evidence).

During the pair-wised reasoning, one main emergent theme was challenges associated with practice on school grounds, including teachers' knowledge, time, and resources to support delivery. Notably, participants recognised the cyclical relationship among these factors and also judged these barriers are the result of *"PE not being recognised as a core subject"*. Interestingly, participants also agreed this influences parents and carers willingness to interact with interventions. Participants reasoned that, without continued practice outside the school environment, children would not have sustained improvement of skills from the intervention. Barriers related to Efficacy and Attitude were not perceived as critical, particularly in comparison to barriers related to Knowledge and Appreciation. Participants argued deliverers' (e.g., teachers) attitudes towards the intervention are largely driven by their understanding and subject knowledge of motor skill teaching which influence perceived benefits of the intervention.

The arrows indicate that the barriers on the left significantly aggravate (make worse) the barriers to the right. Barriers that are grouped together in one box are reciprocally interrelated and they significantly aggravate one another.
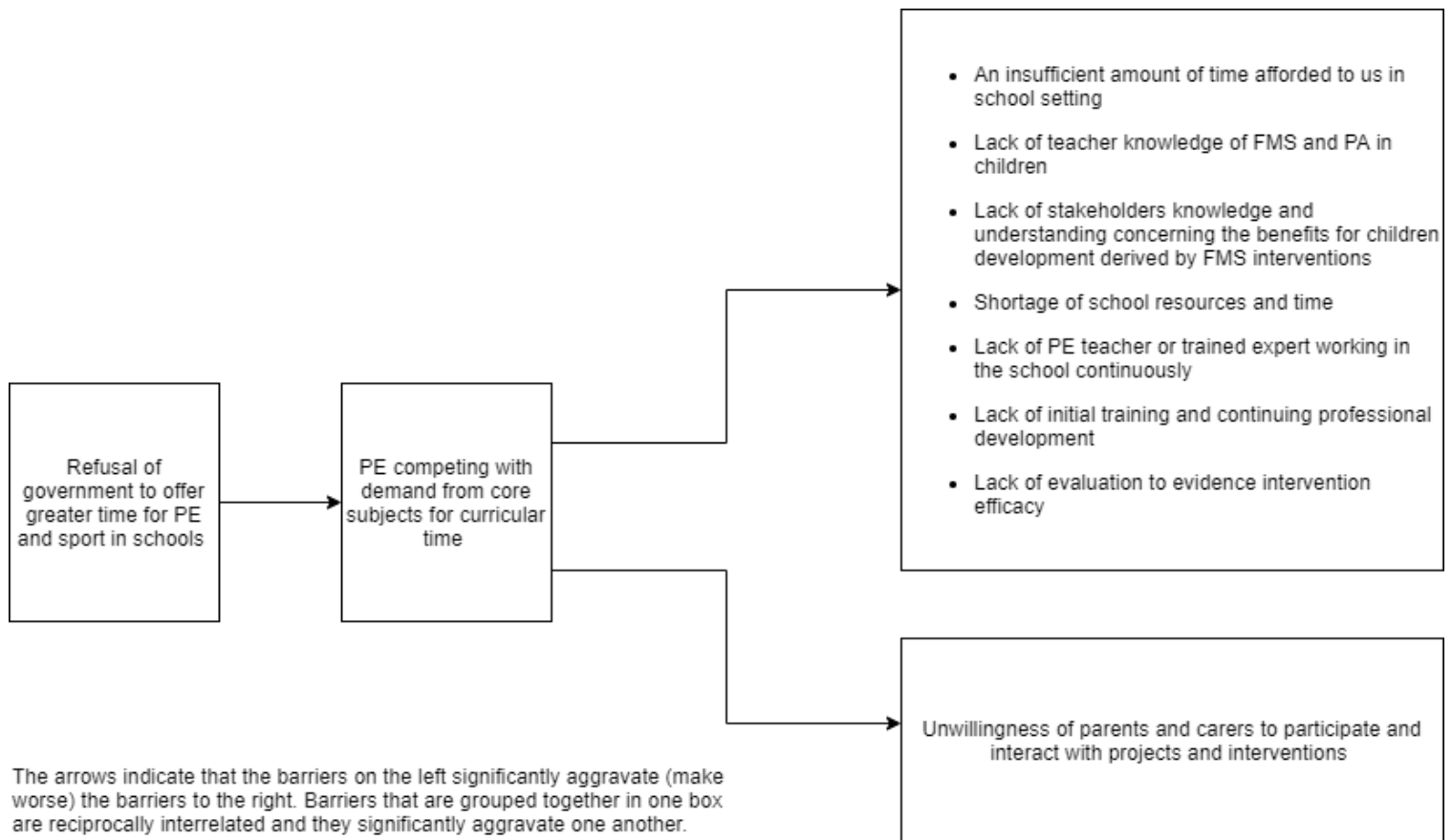
FIGURE 5. 6 BARRIER STRUCTURE FROM SESSION 1

Session 2

Six participants attended Session 2 and generated a model of 12 barriers (Figure 5.7). This group considered the lack of school/community holistic approaches and the misalignment between health, education, and sports as interrelated and critical drivers of the barrier system. Aggravated by these critical drivers are the lack of government supports and motor skill curriculum focus. These barriers spill over into teacher's understanding and appreciation of MC, which, in turn, impact teaching practice and intervention effectiveness. Participants also attributed teacher's unwillingness to focus on MC to teacher's insufficient MC content knowledge and pedagogical content knowledge, as well as poor self-efficacy in this area. These two sets of barriers were considered to be caused by the lack of focus on MC in official documents and curriculum.

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Seven participants attended Session 3 and generated a model of 11 barriers (Figure 5.8). This group identified two barriers as fundamental drivers of negative influence in the system. The first was the *"Lack of PE assessment"*. The group agreed that the absence of PE assessment is central to curriculum conflicts and impacts negatively on stakeholder and teacher's perceived benefits of MC interventions. This barrier further led to the lack of funding and training opportunities to support intervention implementation. The lack of funding was considered to aggravate the time pressure in delivering interventions and providing ongoing support to teachers, as well as to limit availability of resources within schools. Another fundamental driver was "Lack of PE teacher or trained expert working in the school continuously", which resulted in teacher's lack of confidence to continue intervention delivery.

Notably, when participants reviewed the ISM structure, debates emerged as regards other overarching influences. Participants argued that their structure needs to be interpreted "*in the context of a wider system*", specifically, in relation government and policy influences. The group arrived at a consensus that barriers in their structure *"needs to be addressed at the macro level before a meaningful long-term change can be made at the micro level*

The arrows indicate that the barriers on the left significantly aggravate (make worse) the barriers to the right. Barriers that are grouped together in one box are reciprocally interrelated and they significantly aggravate one another.
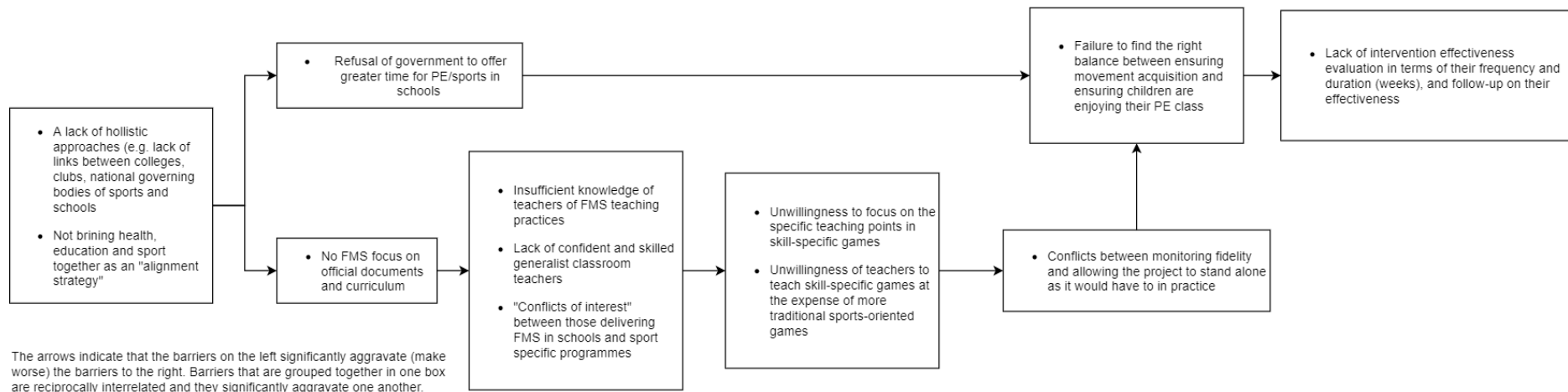
FIGURE 5. 7 BARRIER STRUCTURE FROM SESSION 2

Lack of PE assessment

- Conflicts between PE and major prioritised English and Maths curriculum
- Lack of stakeholders knowledge and understanding concerning the benefits for children development derived by FMS interventions
- Potential conflicts within the aims of PE and therefore what it should be fulfilling in long term

Lack fo funding to support implementation phase

- A demand for time in the curriculum, impacting time allotted for interventions
- Inadequate resources within schools
- Lack of CPD for PE teachers (minimal contact time with PE teachers) and therefore inadequate training

Lack of initial training and CPD (Interventions seen as 'specialist' by teachers and some already lack confidence to deliver curriculum PE)

Lack of PE teacher or trained expert working in the school continuously

Lack of confidence continue to adopt elements of interventions once researchers have left

The arrows indicate that the barriers on the left significantly aggravate (make worse) the barriers to the right. Barriers that are grouped together in one box are reciprocally interrelated and they significantly aggravate one another.

This logic structure needs to be interpreted in a macro-system which each factor is interacting with. The macros system encompasses a range of influences at the government and policy level.

FIGURE 5. 8 BARRIER STRUCTURE FROM SESSION 3

Meta-analysis of three structural models: Influence map of barriers

Barriers from across 10 of the 13 categories appeared in the three ISM structures. A structural meta-analysis of the three models was conducted to understand the relationship between categories of barriers. In order to carry out this analysis, the following scores (i.e., position score, antecedent/succedent score, influence score) were computed to estimate the influence of each category, as per reported process in (Van Lente and Hogan 2020).

Position score

Each structural map places barriers in levels (i.e., the columns barriers are positioned in) (Broome 1995). Ideas to the far right are assigned the lowest position score (i.e., 1), and those in the leftmost position are assigned the highest score (i.e., depending on the number of levels in the structure). For instance, in the structural map generated in Session 1 (Figure 5.6), there are three levels; the idea to the far left is assigned a score of 3, ideas to the far right are assigned a score of 1.

Antecedent and succedent score

The antecedent score is the number of barriers lying to the left of a particular barrier that aggravates it. The succedent score is the number of barriers lying to the right of a barrier in the structure that are aggravated by it. The net succedent/antecedent (net SA) score is the succedent score minus the antecedent score. A positive net SA score indicates the barrier is a net aggravation influence. A negative net SA score indicates the barrier is a net receiver of aggravation (Broome 1995).

Influence score

The influence score is the sum of the position score and the net SA score. Influence scores were calculated for each of the 33 barriers appearing in the three structural models. Total category

influence scores were calculated by summing the individual barrier scores. Average category influence scores were calculated by dividing this total category influence score by the number of barriers in the category. The meta-analytical model arranges barrier categories from left to right based on their average influence scores (see Figure 5.9).

The arrows indicate that the barriers on the left significantly aggravate (make worse) the barriers to the right. Barriers that are grouped together in one box are reciprocally interrelated and they significantly aggravate one another.
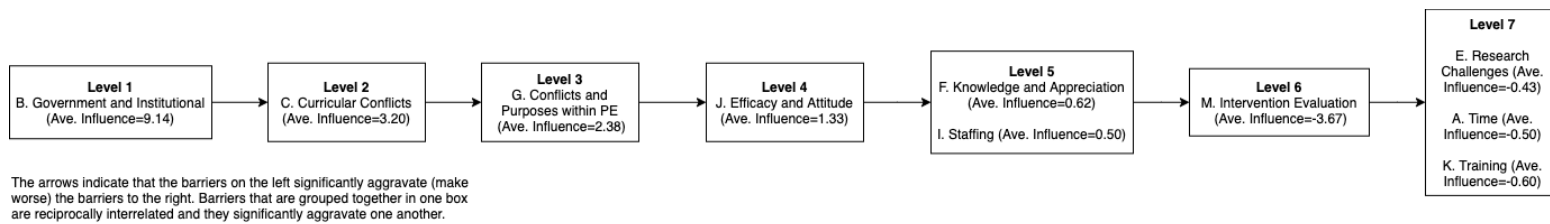
FIGURE 5. 9 META-ANALYSIS OF THREE INFLUENCE STRUCTURES (META-STRUCTURE)

Analysis of options

Based on relationship between barriers in their ISM structure, each CI group generated options to overcome barriers in relevant barrier categories. Participants used the idea writing technique (Warfield and Cardenas 2002) to generate and share ideas. Participants generated option statements on a set of shared sheets, with opportunity to add ideas as they silently read the ideas written by others. Participants generated option statements starting with action verbs, such as *create, develop, encourage, plan*.

In total, 125 option statements were generated across three sessions. Options were generated targeting barriers across Level 1 to Level 5 in the metal-analytical influence map (Figure 5.9). Barriers across Level 1 to Level 5 have positive influence scores, which indicates that they are net aggravation influences in the barrier system that need to be prioritised. All option statements and the associated barrier category they address are presented in Appendix 10. During analysis, these option statements were clustered into 38 higher level synthesised solutions, which were further categorised into nine conceptual clusters linked to the ERIC compendium (see Table 5.5). To adapt to the context of MC intervention research for future

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dissemination, we made surface changes to terminology, which are noted in Table 3. Focusing on Level 1 to Level 5 in the meta-analytical influence map (Figure 5.9), each solution was assigned a score corresponding to the level of the barrier it aims to address in the influence map that represented the solution's potential to address barriers across the field. For instance, solutions designed to overcome barriers relating to [B. Government and Institutional] (i.e., Level 1 in Figure. 5.9, which includes barriers with the highest net aggravating influence) were assigned a score of 5 This high score of 5 corresponds to the high level of potential influence of solutions addressing Level 1 barriers. Following this scoring method and logic, a solution addressing barriers in Level 2 was assigned the next highest score of 4, a solution addressing barriers in level 3 was assigned a score of 3, and so on. After all solutions were scored, and a roadmap representing a hierarchy of actions that corresponds to the barrier meta-structure was developed (Figure 5.10). The roadmap reads from top to bottom with a synthesis of essential activities described on the right in each level. Level 1 actions target barriers at the government and institutional level (Category B) and include activities to create and improve infrastructures. These actions are considered most influential in resolving barriers to implementing and sustaining MC interventions. Level 2 actions correspond to the barriers associated with curricular conflicts (Category C) and purposes within PE (Category G). Actions focus on training and supports provided to multiple change agents, as well as strategies that researchers and practitioners can employ to monitor and evaluate programme implementation. Level 3 actions are designed to overcome various disincentives to engage in interventions (Category J), with emphases on implementation adaptations and stakeholder interrelationships. At Level 4, there are three sets of solutions to enhance intervention user's knowledge and appreciation (Category F) and to alleviate negative influences from practical challenges relating to staffing (Category I).

TABLE 5. 5 STRATEGIES TO IMPLEMENTING AND SUSTAINING MC INTERVENTIONS

Original Label for the Strategy Cluster	Adapted Label Strategy Cluster	Implementation strategies falling under each strategy cluster
Engage Consumers*	**Engage teachers, students, school leaders, researchers**	Report impact from the programme and disseminate knowledge in relation to quality of life, health, and learning outcomes[c]
		Promote publicity and impact of the intervention programme to potential stakeholders and build reciprocal relationships with them to involve them in future research[e]
		Expand programme reach to parents and mobilise parental engagement in interventions[f]
Use Evaluative and Iterative Strategies	No change	In advance of programme implementation, generate shared, measurable goals in a collaboration between schools, researchers and policy makers, and build coalitions and partner relationships to support implementation efforts[c]
		Evaluate, adapt, and create the physical structures, equipment, and school resources to support programme implementation[c]
		Improve and change the current evaluation practice to incorporate more appropriate techniques, change the priority of what determines an intervention success and conduct more long term and follow-up evaluation to monitor sustainability[b]
		Conduct more rigorous and comprehensive evaluation including pilot research, long term follow-up that yields sustainability data, and evaluation of what determines intervention success[m]
		Conduct research on participant understanding of and engagement in intervention programmes and create solutions to overcome perceived barriers and misconceptions[m]
Change Infrastructure	No change	Change school ethos and values around PE through learning workshops and mission documents that promote awareness and understanding of MC and its impact on core school outcomes including cognitive and social skills[c]

		Use and promote a whole-school approach to embed movement opportunities throughout the whole school day, including curricular, extracurricular, cross-curricular, active transport, and homework[c]
		Establish a multi-sector task force to develop, implement, and evaluate child health and development policies and programmes that support PE in schools by directing appropriate funding and resources to local councils[b]
		Develop structures to support programme sustainability, including developing knowledge hub and partner relationships, educating undergraduates, and promoting programme integration into curriculum[b]
		Establish specific, mandated targets on MC and PA and demand these to be achieved and reported by schools, in order to direct intervention time and resources and encourage programme uptake by schools[c]
		Challenge the idea of correct technique in children's movement and encourage children to explore under guidance[f]
		Encourage integration of programmes and interventions with pre-existing school curriculum and syllables[m]
		Integrate intervention science and associated field work in undergraduate teaching programmes[e]
		Create norms of knowledge building and continuous learning to support students, teachers, parents, and coaches[f]
Adapt and Tailor to Context	No change	Develop theory-based interventions and resources as well as adapt pedagogical approaches[b]
		Apply and prioritise PE/skills assessment for children and provide context-specific feedback to allow them to reflect on their progress and performance[g]
Develop Stakeholder Interrelationships		Build collaborations between research, schools and policy holders to promote joined-up thinking[b]
	No change	Conduct stakeholder to clarify intervention aims and results and consult stakeholders on ways to translate intervention findings into practical settings[g]

		Establish cross-disciplinary collaborations in research to access new tools, methods and expertise[e]
		Promote collaborations between research institutes for wider impact[m]
		Create communities of practice among research institutes and consult stakeholders on bids for funding[h]
Utilize Financial Strategies	**Utilise planning strategies**	Create a checklist of essentials for quality PE which guides schools planning on provisions[h]
		Conduct research planning based on available resources including proposing suitable research questions, creating cost-effective solutions in research activities such as training teachers to collect research data[h]
Support Clinicians	**Support policy makers, school leaders, teachers**	Build and communicate robust evidence with stakeholders to encourage uptake of PE and MC at government level[b]
		Establish a feedback method for teachers to report fidelity on programme delivery[e]
		Promote common outcome metrics in PA and MC across all stakehodlers[m]
		Translate evidence base into practical solutions coupled with evaluation techniques and measurable outcomes to create clear MC guidelines, programme methods, and assessments to be embedded in PE curriculum[b]
		Create practical and appropriate resources and build structures to promote continuity of messages following a life span approach and provide practitioners confidence and rewards to carry out ideas[g]
Provide Interactive Assistance	No change	Provide support for practitioners and teachers to co-lead the delivery of projects[g]
		Create a learning collaborative for stakeholders to share their knowledge and experience regarding MC and existing MC resources, as well as to link with researchers to disseminate importance of MC and best practice[f]
Train and Educate Stakeholders	**Train and Educate policy makers, training**	Promote recognition and importance of PE and MC at national and local level through educating policy holders based on evidence drawn from high quality research[b]
		Demand and organise better training for teachers[b]

	providers, school leaders, teachers	Strengthen CPD for teachers and include intervention and educational aims in the training[g]
		Create appropriate resources and disseminate them in different formats to be shared with stakeholders, including guidelines on creating suitable skill learning environments, fun games for children to practice MC, social marketing of programme benefits on children's development and skill specific curriculum programmes[g]
		Plan and implement effective pre-service and in-service teacher training programme to include relevant pedagogies and techniques, learning workshops on knowledge and understanding of MC [f]

*The nine higher-level themes of strategies are based on the conceptual categories of the Expert Recommendations for Implementing Change (ERIC) (Waltz et al. 2015).

Superscripts stand for which barrier categories the solution is generated in response to. b, Government and Institutional; c, Curricular Conflicts; e, Research Challenges; f, Knowledge and Appreciation; g, Conflicts and Purposes within PE; h, Resources and Funding; m, Intervention Evaluation

Level 1 (Government and Institutional):
- Learning workshops and mission documents
- Benefits on core school outcomes including cognitive and social skills
- Whole-school approach
- Knowledge hubs continuous learnings
- Specific, mandated targets on FMS

Level 2 (Curricular Conflicts, Conflicts and Purposes within PE)
- Shared, measurable intervention goals
- School resources audit to support implementation
- Better training for teachers
- Appropriate messaging on PE and FMS importance
- Feedback method to report implementation

Level 3 (Efficacy and Attitude)
- Coproduced intervention aims and translation
- Adaptations of intervention implementation
- Communities of practice

Level 4 (Knowledge and Appreciation, Staffing)
- Programme impact statement
- Expanded programme reach
- Provide ongoing supports for practitioners
- Checklist of essentials for quality delivery
- Research planning based on available resources

Boxes:
- Change Infrastructure
- Use Evaluative and Iterative Strategies
- Train and Educate Policy Makers, Training Providers, School Leaders, Teachers
- Support Policy Makers, School Leaders, Teachers
- Adapt and Tailor to Context
- Develop Stakeholder Interrelationships
- Engage Teachers, Students, School Leaders, researchers
- Provide Interactive Assistance
- Utilise Planning Strategies

FIGURE 5. *10* A ROADMAP OF ACTIONS TO OVERCOME BARRIERS IN IMPLEMENTING AND SUSTAINING MC INTERVENTION

Discussion

This is the first study to use CI methodology to identify, rank, categorise, and structure relations between barriers related to implementation and sustainability of MC interventions, and offer solutions. The study has provided an understanding of needs, expectations, and factors relevant to the implementation and sustainability of MC interventions. Participants identified 76 barriers which were structured and analysed to provide an influence map of barriers and their inter-relationships. The top ranked barrier categories were: Category [B. Government and Institutional], [G. Conflicts and Purposes within PE] and [F. Knowledge and Appreciation]. Analysis of the structural models further revealed other influential barrier categories [C. Curricular Conflicts] and [J. Efficacy and Attitude]. Together, these five barrier categories consistently emerged as influential sources of aggravating influence across all three groups included in the current study and are present in the first five levels in the meta-structure (Figure 5.9). While a number of studies have focused on factors that impede intervention success, less often have solutions been proposed to address a system of barriers in an applied context (Koorts and Rutter 2021). Our study provides solutions designed to address barriers and presents these solutions in the form of a roadmap that corresponds to the system of barriers and associated interdependencies (Figure 5.10). These results are discussed below by reference to their relevance for policy, research, and practice in the implementation and sustainability of MC interventions.

Implication for policy

Our barrier analysis confirms that barriers originated from multiple levels and agents that are important to consider when implementing and sustaining MC interventions in practical settings. Notably, barriers associated with government and institutional policy (Category B) can influence curricular related barriers (Category C) which further aggravates barriers related to

individual knowledge and attitude (Category J and F) (as shown in Figure. 5.6). This is consistent with a previously proposed ecological model of influences on intervention implementation which reported that community/systems level factors (Category B) have overarching influences on practice at an organisational (Category G) and individual level (Category F) (Koorts et al. 2018a). Our findings suggest that the lack of specific and measurable targets for PE and MC in schools makes it challenging to divert the focus from core subjects such as Maths and English. This is a direct consequence of the educational focus of schools which is stipulated by the national education standards. Therefore, mandated changes need to be created for specific school targets on MC and physical activity accompanied by a surveillance and report system, as well as alignment of PE curriculum and assessment. Setting quantifiable and comparable targets is essential to successful health policies (Klepac Pogrmilovic et al. 2020). In the current study context, evaluations on performance related to MC learning and teaching and the accountability system for these to be achieved and reported on may direct the change in school's ethos and values around PE. Via this mechanism (i.e., *Change Infrastructure*, see Figure 5.10), effective motor skill development strategies are more likely to be embedded into the school educational practice.

Government and national strategies need to facilitate this by advocating for a quality assurance system and by providing guidance to ensure PE is accorded the same status as other subjects. The pathway to this policy change presents strategic challenges. As an example, UK policy initiatives produced top-down funding streams (e.g., Pupil Premium for PE) to support this mission. There are official bodies (e.g., Ofsted in the UK) that develop metrics that can hold schools accountable for educational standards, which includes providing judgements on the overall effectiveness on the use of the funding to support school PE (Office for Standards in Education 2005). However, funding were used to employ external sports coaches to deliver PE rather than strategically developing school capacity to deliver quality PE (Jones and Green

2017). Consistent with this, our findings suggest despite the best intentions, the local implementation of policy varies. The recent initiative of UNESCO to promote Quality Physical Education worldwide, reported that policy changes are most effective when accompanied by cohesive and tangible demands (UNESCO 2021). Our roadmap proposes several specifics on setting the agenda to shape the policy process and policy content on PE. Noteworthy is participants' recognition of autonomy at local levels. In the case of MC interventions, creating and showcasing best practice and benefits for teachers, school leaders, and other stakeholders is recommended. Local change agents also need to be mobilised to create joint efforts, including parents, community sports clubs, governing bodies of sports, public health and education specialists, and research institutions. This wider group of stakeholders plays a key role in creating and maintaining social and physical environments that are conducive to children's motor skill development (Daly-Smith et al. 2020a).

Implication for practice

Our findings suggest, in practice, sustainable changes are likely to occur when interventions change the whole-school ethos and values that support intervention missions and PE provisions (Level 1 actions in Figure 5.10). Therefore, central to this set of options is to promote a whole-school approach that embeds movement opportunities in children's school as well as out of school time (i.e., PE, curricular lessons, extracurricular activities, active travel, and homework). This is consistent with the Creating Active School Framework which advocates to establish whole-school practice and ethos that informs beliefs, customs, and practices (Daly-Smith et al. 2020a). Specific to motor skill development, a whole-school approach is a logical step to creating movement culture that comprises multiple forms and purposes (Ward and Griggs 2018).

School leadership (e.g., principals and head teachers) influences the quantity and quality of movement opportunities (Cassar et al. 2020, Daly-Smith et al. 2020b). Identifying what schools are able and willing to do is essential when launching an initiative (Level 2 actions in Figure 5.10). Consistent with literature on implementation of school-based interventions, co-production (i.e., creating and implementing initiatives with schools) is a means to create system changes that has the potential to sustain (Daly-Smith et al. 2020a). Furthermore, our roadmap points out the importance to create a community of practice to enable peer learning and sharing among schools and teachers (Level 3 actions in Figure 5.10). These actions can increase the organisational readiness for change (Weiner 2009), which refers to organisational members' shared resolve to implement a change and shared belief in their collective capability to do so (Shea et al. 2014). Our solutions suggest this community of practice can be developed as a learning collaborative to support knowledge exchange among teachers, students, family, and wider community partners (e.g., coaches, sports clubs).

Our findings suggest that teachers' capacity to develop students' MC is limited due to a gap in their initial education and ongoing professional development, and this gap must be bridged to improve knowledge and appreciation of MC. This is in line with the finding from a recent study that surveyed primary school staff in the UK, in which the majority indicated they have low or no perceived knowledge of MC and do not recall having training on motor skill teaching (Eddy et al. 2021). Our findings highlighted three pillars of quality PE which affects motor skill teaching and learning: curriculum, pedagogy, and assessment, which need to be a priority inclusion in initial teacher education and continuing professional development (Lander et al. 2016). One of the solutions suggests initial teacher education should aim to link theory to practice in a way that offers trainees "in-field" experience for enhancement of knowledge and understanding. The solution set also advises the modality of training should be continuous rather than "one off" for in-service teachers, since long-term practice changes are underpinned

by ongoing training support (Lander et al. 2017a, 2019). Continuing professional development could be offered as an online option to accommodate teachers' timetabling challenges; the positive impact of which has been reported in a scale-up of effective MC intervention (Lonsdale et al. 2021). Although the use of online platform needs to be carefully contextualised to meet the need of teachers (Lander et al. 2020a).

According to our findings, the knowledge and efficacy of intervention users and individual delivering programmes can also be enhanced by supporting their capability to adapt the interventions or recommended practice (Level 3 actions in Figure 5.10). This implies that all participants are active partners rather than passive receivers of an intervention, and it is by adapting to changing circumstances that learning occurs (Holmes et al. 2017). This is also supported by research findings from a long-term follow up of a MC intervention where teacher's sense of ownership of the programme was encouraged by ongoing adaptations (Lander et al. 2020b). In this context, Intervention delivery is allowed to and ideally open and adaptive based on a common understanding of principles. This series of options and actions support a sense of both initiative and belonging among participants, which represents two critical mechanisms for uptake and sustained practice (i.e., improving autonomy and relatedness, as described in Self Determination Theory) (Deci and Ryan 2012). This is further reflected in one of the option statements in the current study, where it is noted that teachers need to get the support to tailor interventions so they can also *"learn new skills without feeling left on their own to deliver a project"*.

Implication for research

A cornerstone of the solution roadmap in the current study is the establishment of a high-quality evidence base, which is needed to frame actions at both policy and practice levels. MC intervention research to date has generated evidence to help physical educators and teachers

plan for successful strategies (Gallahue, Ozmun, and Goodway 2012, Tompsett et al. 2017).

Nevertheless, rarely has this been established, embedded, and sustained in the intended

settings. By directing attention to the ecological context of MC intervention research and

participation, the roadmap provides researchers with a framework of critical components and

players that need to be considered when planning and evaluating an intervention, as well as a

list of strategies to improve implementation. There are notable challenges to conducting

implementation and sustainability research which include funding and resources constraints,

and researcher's lack of knowledge and incentives (Koorts et al. 2020). The use of effective

planning strategies can ensure resources are well allocated (Level 4 actions in Figure 5.10).

Notably, resources are not limited to funding – also included are tools, expertise, and skills, as

well as sufficient time. Review and empirical evidence in physical activity research suggest

that appropriate application of implementation theories/frameworks across the lifespan of an

intervention can support programme implementation and sustainability (Ma et al. 2021c,

Cassar et al. 2019b, Sutherland et al. 2020). Building upon the roadmap and actions identified

in the current study, the CI method can also be used in a local problem situation to identify

implementation and sustainability levers to catalyse available resources in efforts to advance

local project work. The roadmap also identifies multiple strategies which can be employed to

limit the impact of identified barriers, pointing to the importance of implementing solutions at

higher levels that are likely to influence solutions at succeeding levels.

The systems of solutions identified across the roadmap highlight that the research

process needs to be open, emergent, and reflexive with participants treated as active partners

and learners rather than receivers, which includes incorporating participant voices in the

formative planning process (Level 3 actions in Figure 5.10). Intervention evaluation also needs

to consider affective outcomes such as motivation underlying participant engagement in

addition to primary intervention outcomes, to understand more complex affective and

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motivational dynamics as an intervention unfolds. Ultimately, this evidence may contribute to establishing the benchmarks of quality MC programmes which can be considered in future research and practice.

When planning for intervention translation, researchers also need to consider the economic and societal impacts that may be relevant to stakeholders, as these factors are key for sustainability (Level 4 actions in Figure 5.10). The overall impact should be communicated through a variety of channels to spread the word about the benefits of the intervention and new practice. These include preparing intervention champions to demonstrate leadership in the authentic implementation and maintenance of intervention practices (Cassar et al. 2020).

Strengths and limitations

A particular strength of this study is that it is, the first to deploy a meta-analytical CI approach to identify barriers to implementation and sustainability of MC interventions, and a system of options and an action roadmap to address the complexity of the societal issue. By producing a synthesis from experts across three intervention groups using the CI method, the current study highlights options and an action roadmap that is potentially applicable to a broad variety of MC intervention contexts where similar implementation and sustainability issues exist.

In response to the COVID-19 pandemic restrictions, this study is one of the first efforts to implement CI online and thus demonstrates the utility of implementing CI via this mode of delivery. Central to CI is the facilitation of systems thinking in a group and management of group dynamics (Hogan. et al. 2015b). Adaptation of the CI process to an online format has a few implications. One potential in running CI using a video conferencing tool is the partial restriction on a facilitator's ability to regulate discussion flow using the full range of verbal and non-verbal cues possible in face-to-face sessions (Hogan, Harney, and Razzante 2020). Specific to Session 3, to prevent technical difficulties, all participants were asked to turn off

the camera and to contribute their inputs in turn (e.g., reasoning during ISM structuring) upon the facilitator's invite. While this turn-taking and facilitator invitation process is similar to face-to-face CI work, and while the verbal reasoning process is central to systems modelling work, in the absence of seeing participants' non-verbal responses and the associated group dynamic, having the cameras off made it more challenging for the facilitator to 'step in' and steer the conversation. In addition, our study sample, although possessing expertise and experience in the domain of MC interventions (as shown in Table 5.3), were primarily academics. Future research including a broad range of stakeholders (e.g., head teachers, classroom teachers, parents, and students) is encouraged to further understand barriers to implementation and sustainability of MC interventions and options to address barriers.

Conclusions

The current study highlights the complexity of implementation and sustainability of MC interventions and provides a system of options and a roadmap of actions that help navigate through the complexity. This study contributes to building the knowledge base of strategies required to support research-to-practice translation in interventions. Further application of the CI process and emergent action roadmaps will help researchers, practitioners, and policy makers to design and operationalise future projects in more systemic and relational terms and support more robust implementation and sustainability of MC interventions at local and national levels.

Chapter 6. Developing implementation strategies and a protocol for implementation evaluation of a MC intervention

Thesis Map

Chapter	Objective(s)	Key findings and implications
4. A systematic review of process evaluation of MC interventions	Objective 1: To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	• Process evaluation is not sufficiently used or adequately reported in MC interventions when used. • Influences on MC intervention processes and outcomes are wide-ranging and include intervention characteristics, and individual, organisational, and system-level factors. • A wide range of typologies of process evaluation outcomes and measures were identified, along with their collection methods. These include measures relating to implementation, mechanism of change, and contextual influences on an intervention. However, it was insufficient to fully understand the implementation of MC interventions given process evaluation is underused. Further experimental studies are warranted.
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions	Objective 2: To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.	• A total of 76 barriers to the implementation and sustainability of MC interventions were identified, these barriers are related to policy, physical education curriculum, and individuals' self-efficacy, knowledge, and appreciation. • The interrelationships of these barriers were described in barrier systems, which provided help to navigate through the complex influences on MC intervention implementation. • The roadmap of actions revealed the ecological context of MC intervention and provides critical components that need to be considered when designing, operationalising, and evaluating MC interventions.
6. Developing implementation strategies and a protocol for implementation	Objective 3: To develop strategies intended to improve the implementation of a MC intervention.	

evaluation of a MC intervention	Objective 4: To plan, design, and conduct an implementation evaluation of a MC intervention using strategies developed.	

7. Outcomes of an implementation evaluation of a MC intervention

6.1 Chapter context

The systematic review in Chapter 4 highlighted the lack of reporting on intervention processes with the use of a theoretical framework. The review also provided a directory of common process measures used in MC intervention evaluations. Chapter 5 then revealed complex interrelationships between barriers to the implementation and sustainability of MC interventions. The CI outcome, in a format of a barrier system, can highlight the evaluation priorities in a specific intervention context. The CI outcome also provided a list of recommended solutions to overcome the barriers identified. Building on the findings of previous chapters, this chapter aims to develop strategies intended to improve the implementation and document the planning, design, and conduct of an implementation evaluation of a specific MC intervention. By doing so, this chapter presents the process of 'how to' unpack the 'black box' of an intervention.

6.2 Introduction

The MC intervention evaluated in the current study—Project FLAME—is efficacious in improving Irish adolescents' MC (Lester 2020). The Project FLAME research team were participants in the CI study of this PhD (see Chapter 5). As such, they were engaged from that point on regarding the importance, need, and value of evaluating the implementation of Project FLAME. Of note, no process evaluation was included in the previous trials of Project FLAME. Therefore, the candidate and research team reached the consensus that the logical next step was for Project FLAME to become the case study for the development and testing of an

implementation evaluation protocol, and subsequently illuminate the potential adaptations required for Project FLAME to be implemented at-scale. The conception, design, planning, development, conduct and reporting of the implementation evaluation of Project FLAME was led by the candidate, which were documented and reported in Chapter 6 and Chapter 7 as part of this PhD research. By synthesising and building on findings from preceding studies in this PhD, this chapter details the rationale and process of developing strategies, setting evaluation objectives and priorities for the implementation of Project FLAME. Finally, an implementation evaluation protocol is presented.

6.3 Rationale of implementation evaluation of Project FLAME

Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) aims to improve the MC of Irish adolescents (aged 12-16 years old) in post-primary school settings (Lester 2020, Philpott et al. 2021b). The target student group are in junior cycle (first three years of post-primary schooling), in which PE is a key area of learning entitled 'wellbeing' (NCCA 2017). The Project FLAME intervention was designed to be delivered in a naturalistic setting (i.e., delivered by teachers in school settings), with PE being a key avenue for intervention activities. A summary of each intervention component is provided in Table 6.1. In summary, the intervention included movement activities (using external cues), delivered by PE specialists within the weekly PE lesson with supporting physical and digital resources (i.e., project handbook, QR codes linked to YouTube videos), and alongside classroom-based motor skill focussed movement activities. Two efficacy trials have been conducted in Cork, Ireland, including a non-randomised controlled trial in 2017/18 and a randomised controlled trial in 2018/19 (Lester 2020). In these efficacy trials, students' MC was assessed as the primary outcome of the intervention, with PA levels being the secondary outcome. No process evaluation outcomes were examined in these trials. The current implementation evaluation trial

focuses on six motor skills, including throw, skip, dribble, horizontal jump, kick, and vertical jump. These skills were selected based on their low level of mastery among Irish adolescents and critical roles in Irish sporting and PE cultures (O'Brien et al., 2016). The classroom component was not delivered in the current trial, due to various school circumstances post COVID-19 lockdown.

TABLE 6. 1 INTERVENTION DESCRIPTION OF PROJECT FLAME (ADAPTED FROM LESTER 2020)

Intervention component	Intervention Input
Student	Developmentally appropriate movement-based activities in an authentic learning environment in school. Clear and specific process-oriented criteria.
Physical Education	Appropriate PE teacher training (professional development). Comprehensive subject and pedagogy content. Teaching instructional practices, and teaching quality. External cues.
Digital resources	Digital resources (QR codes/YouTube videos/Posters) to provide activities and games for each skill, as well as visual external learning cues.
Classroom	Kinaesthetic classroom (motor skill focused movement breaks). By delivering movement breaks, all teachers, particularly non-specialists (i.e., generalist classroom teacher), improve student knowledge in and become facilitators of motor development and PA promotion.

Project FLAME was originally developed in response to the worrying low levels of Irish adolescents' MC and PA (Lester 2020). As an efficacious MC intervention, Project FLAME had not been formally tested to see if and how the intervention could be sustainably implemented over time and in different school contexts (Lester 2020). As previously reviewed, the lack of measuring and reporting regarding the implementation of MC interventions hinders the translatability of research into practice (see Chapter 4). Given the intention of Project FLAME to be rolled out in naturalistic settings, it needs to be tested with real-world implementation in mind (see Chapter 5, Part 1).

As identified in Chapter 2 and 4, there is a lack of a systematic application of theoretical frameworks during the implementation planning stage in MC interventions, specifically, during

the design of implementation strategies and planned evaluation of implementation outcomes. Furthermore, the intervention process of Project FLAME had not been examined in any of the efficacy trials. Therefore, the current study aims to address the aforementioned gaps by following the PRACTIS guide (Koorts et al. 2018b), particularly its principles in the early planning stage that include the identification of key implementation determinants and outcomes (as introduced in Chapter 3), to (a) develop implementation strategies for Project FLAME, (b) design an evaluation protocol to investigate the implementation of Project FLAME and test the effectiveness and feasibility of implementation strategies. The following sections detail the development process and protocol for the evaluation.

6.4 Methods and design

6.4.1 Development of implementation strategies

The development of the implementation trial was aligned with the four iterative steps of the PRACTIS guide. Step 1 involved characterising the parameters of the implementation setting. The information gained from this step resulted in describing who would be involved in implementation (i.e., People); what settings would be involved (i.e., Place); how the implementation process would occur (i.e., Process); what resources may be necessary to achieve implementation (i.e., Provisions); and the underlying mechanisms of the implementation process (i.e., Principles). Outcomes from Step 1 are outlined in Table 6.2.

TABLE 6. 2 SUMMARY OF STEPS INVOLVED IN DEVELOPING IMPLEMENTATION STRATEGIES AND EVALUATION OF PROJECT FLAME, USING THE PRACTIS GUIDE

PRACTIS guide steps	Operationalisation in the current study
Step 1: Characterise parameters of the implementation setting	Place: Post-primary schools People & Process: Intervention targeting to improve student's MC. Weekly PE lessons with a motor skill focus delivered by trained PE teachers. Provisions: Project resource handbook, website, and QR codes to access videos of games/activities Principles: Use implementation strategies to improve the implementation of the programme
Step 2: Identify and engage key stakeholders	Engaged researchers, PE teachers, and local health promotion officers who have an overarching responsibility or 'ownership' for Project FLAME.
Step 3: Identify implementation barriers and facilitators	Critical barriers identified from the CI as shown in **Fig 6.1**
Step 4: Address/assess potential barriers to implementation	A concurrent process to develop implementation strategies, harmonising options proposed by the CI stakeholders and ERIC.

CI: Collective Intelligence ERIC: Expert Recommendations on Implementation Changes

In Step 2 and Step 3, by engaging with the research team of Project FLAME and relevant stakeholders during the implementation planning, the contextual barriers and facilitators to the implementation of Project FLAME were identified. This was done using a co-production approach, involving researchers, teachers, and local health promotion officers who have an overarching responsibility or 'ownership' for Project FLAME (see Chapter 5, Part 2; Session 2 of the three workshops). This approach (i.e., Step 2 and Step 3) was also purposed to facilitate buy-in and enhanced implementation of the intervention, which in the long-term, could help effective knowledge exchange between the research team and the public with an ultimate aim to scale up the strategy to the wider community (Koorts et al. 2020). The outcome of the CI workshop (see Chapter 5, Part 2) identified and structured the barriers that were perceived as critical to the effective implementation of Project FLAME, as well as to propose options/solutions to address these barriers. These critical barriers to the implementation of the

Project FLAME were meta-analysed (as per the analysis process reported in Chapter 5, Part 2) to reflect their interdependent relationship among one another (Figure. 6.1).
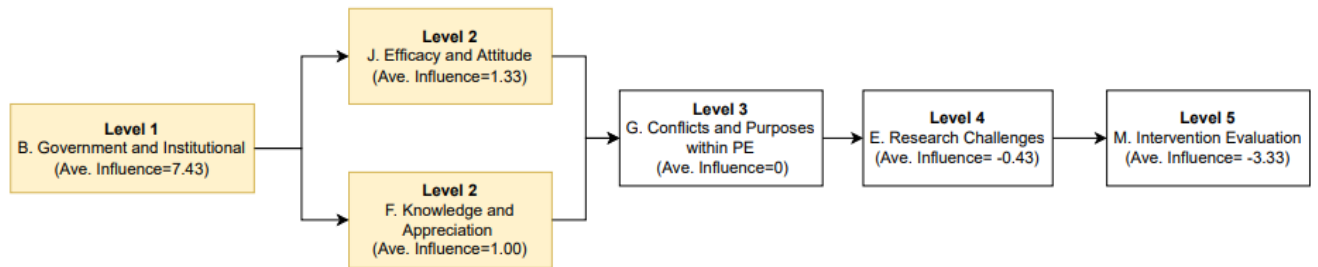
FIGURE 6. 1 META-STRUCTURE OF BARRIERS INFLUENCING IMPLEMENTATION OF PROJECT FLAME (HIGHLIGHTED ARE THE BARRIER CATEGORIES THAT HAVE NET AGGRAVATION INFLUENCES)

The prior use of the CI assisted in overcoming a key barrier to implementation studies–that is–the identification of key implementation determinants that need to be prioritised in evaluations (Moullin et al. 2020). Specifically, the meta-structure of barriers (Figure 6.1) was used to inform a) the development and selection of implementation strategies, which corresponded to the identified barriers, and b) the selection of evaluation outcomes corresponding to the barrier structure. In Step 4, to guide the selection of implementation strategies, a concurrent process was framed by the meta-structure of barriers (Figure. 6.1) and ERIC compendium (Powell et al. 2015). The meta-structure revealed the key factors that influence the implementation process and outcome of Project FLAME, relating to [Category B. Government and Institutional], [Category F. Knowledge and Appreciation], and [Category J. Efficacy and Attitude], given their net aggravation influences (as highlighted in Figure 6.1). The identified critical barriers were mapped onto the roadmap of actions developed in Chapter 5 (Figure 5.10, Table 5.5) to render a list of strategies endorsed by MC intervention experts that are most influential in overcoming these barriers. This list was harmonised with the options the participant group created in the CI session (Session 2) to select and tailor implementation strategies to Project FLAME and local contextual needs. The harmonisation resulted in four

implementation strategies that were translated to the four main adaptations to the original intervention activities. Table 6.3 provides an explicit description of critical barriers, the mechanism(s) linking barriers, selected strategies, and outcomes, following the format of the implementation research logic model (Smith, Li, and Rafferty 2020). The key resource is a website designed to be a medium where four implementation strategies are applied. Screenshots of the website are provided in Appendix 11 and 12 and are referred to when outlining the proposed implementation strategy in the logic model below (Table 6.3).

TABLE 6. 3 THE IMPLEMENTATION LOGIC MODEL OF THE MODIFIED PROJECT FLAME, INCLUDING DESCRIPTIONS OF IDENTIFIED BARRIERS AND IMPLEMENTATION STRATEGIES

Barrier description (identified during the CI workshop)	Corresponding options to overcome barriers in the category (identified during the CI workshop)	Proposed Implementation Strategy	Proposed Mechanisms	Implementation outcomes
B. Government and Institutional				
A lack of a holistic approach to bring health, education, and sport together	Build collaborations with policy makers, training providers, school leaders, and teachers to promote joined-up thinking	***None proposed*** N.B. As the current PhD research does not have access to policy levers, and involvement with external partners such as sports clubs was not feasible in light of the pandemic situation, the relevant suggested solutions were not adopted.		
No MC focus on official documents and curriculum **Refusal of government to offer greater time for PE/sports in schools**	Change policy priorities to promote recognition and importance of PE and MC at the national and local level through educating policy holders based on evidence drawn from high quality research Improve and change the current evaluation practice to incorporate more appropriate techniques, change the priority of what determines an intervention success and conduct more long term and follow-up evaluations to monitor sustainability			

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A lack of infrastructure to support the institutionalisation of the programme	Develop infrastructure to support programme sustainability, including developing a knowledge hub and partner relationships, and promoting programme integration into the curriculum	Strategy A. Develop an online knowledge hub (hosted on a website) to inform teachers, school leaders, students, and parents of the programme (a screenshot of the corresponding website content is provided in Appendix 11). **Justification:** The website sections introduce the project aim, benefits, and alignment with the national curriculum (Junior Cycle Wellbeing Guideline 2021), which aims to promote teachers, students, parents, and school leaders' knowledge and understanding of Project FLAME. The website was designed as a digital infrastructure (an online knowledge hub) to host project resources permanently to support sustained use.	Strategy A will <u>build teachers' awareness and knowledge</u> of Project FLAME, thereby influencing the adherence to the intervention aim	**Fidelity (consistency)**: the consistency of what is implemented

J. Efficacy and Attitude

A lack of self-efficacy of teachers to implement the proposed programme	Prepare teachers to be active participants, and provide support for them to co-lead the delivery of projects Create appropriate resources and disseminate them in different formats to be shared with stakeholders, including guidelines on creating suitable skill learning environments, fun games for children to practice motor skills, social marketing of	B. Include detailed intervention delivery process on the website and training and involve teachers in discussions on options to engage students in the programme (the corresponding website screenshot is provided in Appendix 11). **Justifications:** All project resources and a step-by-step guide for teachers' involvement in the project were posted on the website, aiming to provide a 'one-stop-shop that is easily accessible for teachers, thereby increasing their confidence in delivering the project. Additionally, teachers were involved in the	Strategy A, B, and C will <u>improve teachers' perceived fit</u> of and <u>confidence in</u> delivering the intervention, by clarifying the intervention aims and benefits and allowing for flexibility in delivery.	**Fidelity (adaptation):** alterations made to the project delivery to achieve a better contextual fit, while preserving consistency to the project aim **Teacher's self-efficacy**

		ongoing discussions about the project delivery to increase their levels of 'ownership' of the project. C. Encourage teachers to adapt the programme to meet the local needs and record the adaptations. **Justifications:** Teachers have the flexibility in delivering the project and are allowed to alter/adapt according to their own experience and school context, hence increasing their self-efficacy in delivering the project.	Strategy C will <u>use explicit communication</u> to induce teachers' adaptations to the delivery while preserving the core aim of the project, thus resulting in more fidelity-consistent adaptations	**Participants' responsiveness**: Degree to which the project stimulates interest in and level of satisfaction among students and teachers
programme benefits on children's development, and skill-specific curriculum programmes.				

F. Knowledge and Appreciation

Insufficient knowledge of the perceived need and benefits of the proposed programme and possession of the relevant skills and knowledge to implement the programme	Create a learning collaborative for stakeholders to share their knowledge and experience regarding MC and existing MC resources, as well as to link with researchers to disseminate the importance of MC and best practice Plan and implement an effective pre-service and in-service teacher training programme to include relevant pedagogies and techniques, learning workshops on knowledge and understanding of MC	D. Capture and share local knowledge through the website on how teachers made something work in their setting and share with other sites, and encourage students to leave comments and questions regarding skills for continuous learning (via the website comment and Q&A section as shown in Appendix12) **Justifications:** Experience is exchanged among the teacher group, fostering a 'community of practice' rather than a 'delivery template' prescribed by the research team, aiming to increase teachers' engagement in the project.	Strategy D, <u>by building a community of practice and learning collaborative</u>, has the potential to encourage teachers' and students' engagement	**Teacher's self-efficacy** **Participants' responsiveness**: Degree to which the project stimulates interest in and level of satisfaction among students and teachers

Create norms of knowledge
building and continuous learning
to support students, teachers,
parents, and coaches

6.4.2 Implementation outcome

As per the described mechanisms in Table 6.3, the proposed implementation strategies have the potential to impact teachers' self-efficacy, participant responsiveness, fidelity to the project delivery, and its adaptation. In addition, feasibility and teachers' perceived sustainability of implementation strategies were also investigated. This is in line with the recommendation to optimise the applicability of implementation strategies for future applications (Pearson et al. 2020). In the current study, sustainability is operationalised as the likelihood the project will be delivered over the long-term, rather than the extent to which the project is being delivered over the long term (sustainment) (Chambers, Glasgow, and Stange 2013). The current study was prospectively designed and therefore the emphasis was placed on participants' perceived sustainability to gain knowledge on how to leverage existing resources, structures, and practice to maintain the long-term use of Project FLAME. The evaluation objectives were to a) describe and compare two modes of implementation of Project FLAME, b) investigate the impact of implementation strategies on the implementation outcomes, and c) explore the feasibility and sustainability of Project FLAME. The two groups compared were: i) The Original FLAME group: an active comparison group delivering the original Project FLAME for six weeks; and ii) The Modified FLAME group: a group delivering Project FLAME incorporating the additional / newly developed implementation strategies for six weeks. Detailed descriptions of intervention activities in two groups are provided in Table 6.4. Table 6.5 then outlines the implementation outcomes assessed and measures taken for each outcome. Descriptions for each data source and its measurement are provided in the following sections.

TABLE 6. 4 INTERVENTION DESCRIPTION OF PROJECT FLAME IN THE CURRENT IMPLEMENTATION TRIAL

Intervention component	Intervention description
Student	Developmentally appropriate movement-based activities in an authentic learning environment in school. Clear and specific process-oriented criteria. **Access to the project website (project-flame.com); Students are encouraged to leave questions and comments on the website regarding skill learning.**
PE	Appropriate PE teacher training (online). Comprehensive subject and pedagogy content. Teaching instructional practices, and teaching quality. External cues. **Access to the project website that includes all project resources, project aims, and benefits.** **Teachers are encouraged to adapt the project delivery, and document and share local knowledge among the group.** **Teachers are consulted regarding the project delivery to increase student engagement.**
Digital resources	Digital resources (QR codes/YouTube videos/**Website**).
Classroom	This component was not delivered in the current trial, due to various school circumstances post COVID-19 lockdown.

*The additional modifications are bolded.

TABLE 6. 5 SUMMARY OF OUTCOME MEASURES IN THE IMPLEMENTATION TRIAL

Implementation Outcome	Data source	Measure, scale, or interview question examples
PE teacher's self-efficacy[a,b,c]	Teacher survey	Perceived teacher competence questionnaire (Lander et al. 2017b) Rate your degree of confidence by recording a number from 0(cannot do at all) to 100(Highly certainly can do), e.g., "plan effective lessons to achieve motor skills related student learning outcomes"
	Teacher interview	"Do you feel you were able to successfully implement the programme? What makes you feel this way?"
Participant responsiveness[d]	Teacher survey	Acceptability of Intervention Measure (AIM) (Weiner et al. 2017) Indicate the level of agreement on the following item: "Considering the contents/resources of Project FLAME, Project FLAME meets my approval (respond on 5-point Likert scale)" Intervention Appropriateness Measure (IAM) (Weiner et al. 2017) Indicate the level of agreement on the following item: "Considering the contents/resources of Project FLAME, Project FLAME seems like a good match (respond on 5-point Likert scale)"
	Student survey	Satisfaction of the project participation Indicate the level of agreement on the following item: "Project FLAME PE lessons are fun" (respond on 5-point Likert scale)
	Web analytics	Views of the website page, engagement with the online comment section
	Teacher interview	"What sort of impact, positive or negative, do you think the program has/had on your students?"
Fidelity and adaptations[a,b,c]	Teacher logbook	"Were students visually shown the correct performance of the movement skills by you, to the best of your understanding?" If not, please explain how you adapted the project to fit the need of your lesson and students
	Teacher interview	"Can you talk me through the process of planning and delivering a Project FLAME PE lesson?"
	Student survey	"Were you visually shown the correct performance of the movement skills by your teacher? And how often?" (Students' responses were collected to cross-check teacher's self-reported fidelity)
Feasibility	Teacher survey	Feasibility of Intervention Measures (FIM) (Weiner et al. 2017) Indicate the level of agreement on the following item: "Project FLAME seems easy to use" (respond on 5-point Likert scale)

	Teacher interview	"Which do you think are the essential components of the project, what are the non-negotiables in terms of implementing the programme? Why is this?"
Sustainability	Teacher survey	"Would you continue to use Project FLAME resources or contents in your future practice? If yes, please briefly tell us you plan on continuing to use it?"
	Teacher interview	"Do you feel that this program could be sustained in your teaching practice and your school - why/why not"

*Superscripts indicate the implementation strategies impacting the specified outcome

6.4.3 Evaluation design

This study used a mixed method, two-group pre-and-post design. Such a direct comparison of modes of implementation, particularly between the original and modified version (as outlined in Table 6.4), sheds light on how programmes should operate in different school contexts (Durlak and DuPre 2008). This quasi-experimental design was chosen as a flexible approach to compare the implementation process and inform the effectiveness of implementation strategies, and for its advantage to yield findings with a higher external validity (Geldsetzer and Fawzi 2017). The target population remained the same as the original trial, i.e., adolescents aged 12-16 years old in post-primary schools. Schools that had never been exposed to the Project FLAME in previous efficacy trials were eligible.

6.4.4 Data collection

During the 2021/2022 academic year (September 2021-November 2021), data were collected before the trial began, during the trial, and after the trial ended. The measures taken at different time points are presented in Table 6.6. Descriptions for each data source are presented below.

TABLE 6. 6 SCHEDULE OF EVALUATION DATA COLLECTION METHODS

Study Measure	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 8-10
PE teacher survey	x	-	-	-	-	-		x
Student survey	-	-	-	-	-	-		x
Teacher log*	-	←——————————————————————————→						
Website Analytics*		←——————————————————————————→						
Semi-structured Interviews (PE teachers)	-	-	-	-	-	-		x

* Teachers log and website analytics were collected weekly and daily, respectively

As the Original FLAME group did not have access to the online version, web analytics and interviews on the feasibility and sustainability of the intervention were not collected for that group. Following best practice recommended by the PRACTIS guide (Koorts et al. 2018a), implementation strategies and the evaluation plan were reviewed with all participating teachers during the training prior to the launch of the trial to familiarise teachers with the intervention aim to resolve any potential implementation barriers. Teachers did not raise any barriers, however, after the discussion during the training, teachers suggested a WhatsApp group would be helpful in case they needed any ongoing support during the trial. Therefore, two separate WhatsApp groups were created for the Modified FLAME and Original FLAME as a communication channel between the research team and teachers.

6.4.4.1 PE teacher survey

PE teachers were asked to complete an online survey pre- and post-trial. Teachers' self-efficacy was measured using a perceived teacher competence questionnaire (Lander et al. 2017b). The questionnaire is a modified version of The Primary School Physical Education questionnaire (Morgan and Hansen 2008), and was used to collect information about the teachers' competence, experiences, feelings, and practices regarding teaching and assessing MC (Lander et al. 2017b). Teachers were invited to state their level of agreement within 14 self-efficacy

statements, on a 0 (cannot do at all) to 100 (highly certain can do). To obtain the face validity of the scale, the questionnaire was piloted with a group of five non-participating PE teachers working in Irish post-primary settings before the current trial. Suggested minor modifications were made to enhance clarity and relevance.

Teachers' perception on acceptability, feasibility, and appropriateness of the programme (Weiner et al. 2017) were used, including nine items from the Acceptability of Intervention Measure (AIM), Intervention Appropriateness Measure (IAM), and Feasibility of Intervention Measures (FIM). Psychometric properties of three scales were previously assessed with a group of international implementation scientists and health practitioners (n=296) (Weiner et al. 2017). Construct validity exhibited factor loadings that ranged between 0.79 and 0.94, an acceptable model fit, i.e., CFI = 0.98, RMSEA = 0.08, and three-week test-retest reliability coefficients ranged from 0.73 to 0.88. Appendix 13 and 14 provide examples of PE teacher surveys pre- and post-trial, respectively.

6.4.4.2 Student survey

Students were asked to complete an online survey at the end of Week 6. The survey collected sociodemographic characteristics of participants (e.g., age, sex, school, and grade). For students' responsiveness to the project, students were asked if they thought Project FLAME was fun, useful, and introduced them to new activities, as well as the frequency of their access to project resources and skill practice. Students were also asked about their awareness of the performance criteria of the six skills, and to provide text responses about the highlight of Project FLAME lessons. These items were identified as critical to student engagement, as reported in the review in Chapter 4. The survey was also discussed with the Project FLAME research team, comprising two members being experienced teachers working with post-primary school students. A copy of the student survey is provided in Appendix 15.

6.4.4.3 Teacher log

Throughout the six-week programme, teachers were asked to complete a weekly log via a web link to record implementation fidelity and intervention adaptations (see Appendix 16 for a copy of the teacher log). A weekly reminder was sent via WhatsApp messages each week for teachers in both groups to complete the log. To determine the extent to which Project FLAME was implemented as intended, teachers were asked to report against the core principles of Project FLAME (see Table 6.7). The assessment and analysis procedure followed the recommendations for fidelity measurement development (Schoenwald et al. 2011). Relevant components for monitoring (i.e., core principles of Project FLAME, referred to as fidelity component hereafter) were firstly identified, followed by the development of questionnaire items on the weekly log. Table 6.7 describes all fidelity components and how fidelity ratings were defined. A summary score for the rating was created for each fidelity component. Such a coding method for fidelity was previously applied in MC interventions (see Chapter 4, and Famelia, Goodway, and Chen 2019, Brian et al. 2017). In line with the implementation strategy proposed in the current study, teachers in the Modified FLAME group were informed that the fidelity components should not be regarded as the 'gold standards' and they were encouraged to adapt the delivery and document the adaptation in the log. The log also included questions to capture the reason for adaptation, which can be used to infer the contextual fit of implementation strategies. For example, teachers were asked if they demonstrated the movement using QR code during the lesson, and if not, they were asked to briefly explain why. Additionally, wherever applicable, questions that elicited information on fidelity components were included in the student questionnaire, to validate self-report responses as outlined in Table 6.

TABLE 6. 7 FIDELITY COMPONENTS OF PROJECT FLAME AND THEIR DEFINITIONS AND RATINGS

Fidelity Component	Item question on a weekly log	Fidelity rating defined according to response options	Item question on student survey	Fidelity rating defined according to response options
Motor skill focus	Was the lesson focused on MC for this week? (e.g., focused on throw in Week 1)	0 – No/Fidelity inconsistent* adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	N/A	N/A
Integration	Was MC developed further as part of the curricular strand?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	N/A	N/A
Teacher demonstration	Were students visually shown the correct performance of the movement skills by you, to the best of your understanding?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	Have you been shown how to perform movement skills correctly by your teacher?	0 – No 1 – Maybe 2 – Yes
Digital demonstration	Were students visually shown the correct performance of the movement skills by digital resources (e.g., videos accessed by QR codes)?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	Did your teacher use QR codes or YouTube videos to show you how to perform skills correctly?	0 – No 1 – Maybe 2 – Yes
Criteria	Did you share and teach the performance criteria/features of quality, as relevant to the selected movement skills (e.g., when throwing, wind-up is initiated with downward movement of hand/arm)?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	How often were you shown the correct performance of movement skills during the six-week of Project FLAME?	0 – Never 1 – Rarely 2 – Sometimes 3 – Very often 4 – Always

Cue	Did you share and teach the movement through the use of external movement-based cues (e.g., throwing like the NIKE logo)?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	I am aware of the learning cues and criteria to perform movement skills correctly for (tick all that apply in the list of six skills)	0 – 0 out of 6 1 – 1 out of 6 2 – 2 out of 6 3 – 3 out of 6 4 – 4 out of 6 5 – 5 out of 6 6 – all skills
Error identification	Did you identify potential errors among students when they perform the movement?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	How often were you given feedback on your skill performance during the six-week of Project FLAME?	0 – Never 1 – Rarely 2 – Sometimes 3 – Very often 4 – Always
Digital provision	Were students provided with the digital resources (e.g., QR codes) to practice this week's movement skill in their own time?	0 – No/Fidelity inconsistent adaptation made 1 – Fidelity consistent adaptations made 2 – Yes	I have been provided with the resource/QR codes to practice movement skills in my own time (e.g., at home)	0 – No 1 – Maybe 2 – Yes
Duration of Project FLAME activities in one PE lesson	On average, I included Project FLAME for the duration one PE lesson	1 – 0-5 minutes 2 – 5-10 minutes 3 – 10-15 minutes 4 – 15-20 minutes 5 – 20+ minutes 6 – a whole lesson	How long did you usually practice movement skills in one Project FLAME PE lesson?	1 – 0-5 minutes 2 – 5-10 minutes 3 – 10-15 minutes 4 – 15-20 minutes 5 – 20+ minutes 6 – a whole lesson

*Fidelity-consistent adaptations refer to those that preserve core elements of an intervention that are needed for it to be effective in improving student outcomes, identification of this was made in consultation with input from the project developers (UCC research team)

6.4.4.4 Web analytics

Teacher's and student's engagement with the website was explored through usage data collected with Google Analytics throughout the trial period (September 2021 to November 2021). Variables tracked using Google Analytics include sessions (e.g., page views that occur within a single period), page views (i.e., a count of total visits to each page of the website), and average session duration (e.g., the length of time of a session from the first click to the last). These variables were chosen as guided by the Analysing and Measuring Usage and Engagement Data (AMUsED) checklist (Miller et al., 2019). To segregate different types of users (i.e., student and teacher), the teachers' web page was only accessible by using unique login details which were assigned to teachers in the Modified FLAME group before the trial.

6.4.4.5 Semi-structured interviews with PE teachers

Given the study aimed to investigate individual perceptions on the intervention implementation, semi-structured interviews were used which provided a structure (see the interview guide in Appendix 17) to ensure all necessary questions were asked and retained flexibility to have expanded conversations on the experience (Jones, Brown & Holloway, 2012). Interviews were conducted to elicit information on the delivery and adaptation of Project FLAME and self-efficacy; perceived feasibility and sustainability of implementation strategies and intervention components, and perceived project impact on student responsiveness. All interviews began with questions on the school context and teacher's role in the school, which eased participants into the conversation with the topic they are familiar with. The interviewer (the candidate) had no prior involvement in the outcome evaluation of Project FLAME, therefore was able to conduct the interview with objectivity that reduces potential biases arising from analysing outcome data (Moore et al. 2015). Prior to each interview, teachers' responses in the survey and weekly logs were studied to develop prompts used in the interviews, as a

means to connect the analysis of quantitative data with the subsequent qualitative data collection (Creswell and Clark 2017).

6.5 Data analysis

6.5.1 Qualitative data

Firstly, interviews were transcribed verbatim by the candidate. Once transcribed, the transcripts were reviewed to become familiar with content of the data and generate notes for coding. Other qualitative data collected in the trial including interview transcripts and text-based responses in questionnaires were compiled into a word document. Coding processes were dependent on the implementation outcome the data reported on. For qualitative data on sustainability, teachers' quotes were deductively coded using the domains of a framework that assesses capacity for sustainability (Programme Sustainability Framework; Luke et al. 2014). This framework was applied for its comprehensiveness in understanding the potential determinants of sustainability of public health programmes broadly (Luke et al. 2014). To describe the extent, type, and reasons for adaptations of the project, adaptations reported from the weekly logs was collated and coded using the Framework for Reporting Adaptations and Modifications-Enhanced (FRAME) (Stirman, Baumann, and Miller 2019). The framework includes the following categories:

- Were adaptations proactive or reactive?
- Who participated in the decision to adapt? (e.g., research team, individual practitioners such as teachers, student participants)
- What was the goal of adaptation? (e.g., improve feasibility)
- What was adapted? (e.g., context, content)
- Context adaptations were made to what? (e.g., format, setting)
- For whom/what is the adaptation made? (e.g., the whole class)
- What is the nature of the content adaptation? (e.g., adding elements, tailoring)
- Were adaptations fidelity consistent (core elements preserved) or fidelity inconsistent?
- Reasons for the adaptation? (e.g., student motivation and readiness)

The coding was conducted by the candidate. The purpose of the coding was to systematically examine the common adaptations made during the trial using a taxonomy of classifying adaptations that is consistent with the wider implementation research literature. The number of adaptations was reported for each adaptation category.

Students' text responses were analysed using pen profiles, which method was previously used to analyse children's PA experience (Ridgers, Knowles, and Sayers 2012, Knowles et al. 2013). The analysis outcome was presented via a diagram of composite key emergent themes, alongside the number of times each theme was mentioned (Ridgers et al. 2012).

A framework approach to thematic analysis was then used to collate qualitative data and coding clusters corresponding to the implementation outcome (Ritchie et al. 2014). The approach was previously used in a mixed methods implementation evaluation of a school-based running programme (Chalkley 2020). In the context of the current study, this approach was adopted to chart qualitative data by participating teachers/schools into a framework of implementation outcomes as outlined in Table 6.5. All coding clusters were deductively charted into apriori themes based on the implementation outcomes of interest (i.e., fidelity and adaptation, teacher's self-efficacy, participant responsiveness, implementation feasibility, and sustainability). For interpretation, a matrix was generated in a word document with the column representing apriori themes (i.e., implementation outcomes of interests) and each row representing a participating teacher/school. Once all data had been entered, within-case analysis was employed to highlight commonalities and differences between participating teachers/schools.

6.5.2 Quantitative data

Descriptive statistics were employed to summarise the characteristics of continuous variables. Given the small sample size of teachers, self-efficacy data were presented in full for each teacher using a univariate scatterplot to show the data distribution (Weissgerber et al. 2015). For the analyses of the three scales (i.e., AIM, IAM, FIM), responses for each scale item corresponding to the indicator (i.e., appropriateness, acceptability, and feasibility) were presented for each teacher in radar maps, which are a useful way to visualise multivariate data (Nowicki and Merenstein 2016).

6.5.3 Mixed methods data integration

Integrations of quantitative and qualitative data were performed for different purposes (Creswell and Clark 2017). Firstly, quantitative data were connected with qualitative data to inform qualitative interview questions as reported in section 6.3.3. To address the study aims, quantitative data and qualitative data were merged to provide answers (as seen in Figure 6.4). An explanatory parallel analysis process (Creswell and Clark 2017) was adopted. The rationale for this approach is that the quantitative data provide information on the magnitude and frequency of the implementation outcomes (the phenomenon), and the qualitative data provide the meaning and contexts of the phenomenon (Creswell 2013). Results from both quantitative and qualitative data were interpreted by comparing and triangulating to find out where they converge, diverge, or relate (Creswell 2013).
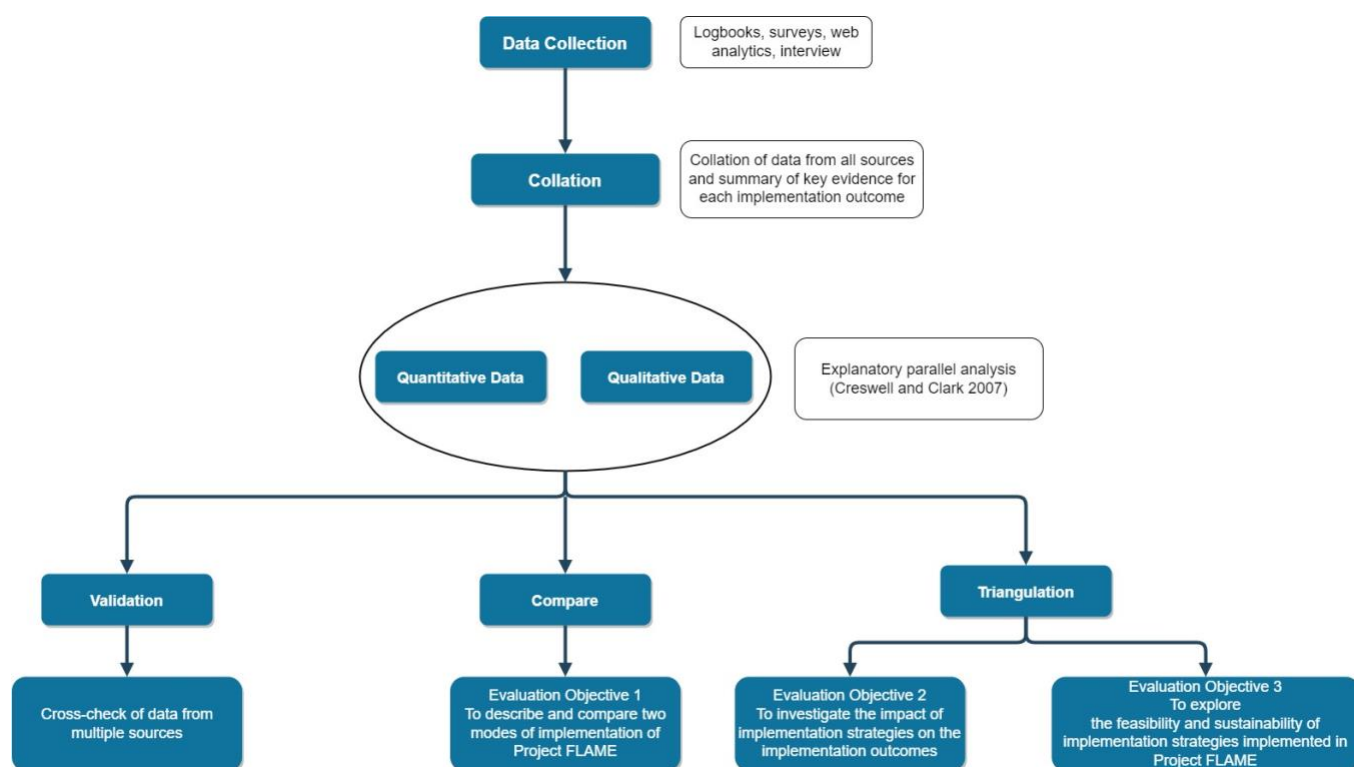
FIGURE 6. 2 MIXED METHODS INTEGRATION OF DATA IN THE IMPLEMENTATION EVALUATION OF PROJECT FLAME

6.6 Strengths and limitations of this evaluation protocol

The prospective design of a comprehensive set of implementation strategies and evaluation plans is a strength of this study. Specifically, the selection of implementation strategies employed a systems science approach which identified leverage points to enhance implementation efforts (Koorts and Rutter 2021). Relevant implementation frameworks (e.g., the PRACTIS guide) were employed to ensure the robustness of the implementation process and relevance to the local stakeholders. The mechanisms underlying the implementation strategies (as outlined in Table 6.3) could have been strengthened by considering behaviour change techniques (Powell et al. 2019), specifically by identifying the synergies between taxonomies of implementation strategies and behaviour change techniques (such as Behaviour Change Wheel, Michie et al. 2009) (Presseau et al. 2021). As this study is the first to explore the implementation process of Project FLAME, the comprehensive evaluation measures would

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contribute to understanding what mechanisms may produce positive changes and this understanding can be further applied in conjunction with behaviour change theories for the future refinement. Another strength is the objectivity the student researcher brings to the evaluation. Given the student researcher is not a member of the research team that developed and delivered the original Project FLAME, participants were less likely to perceive the student researcher as aligned with programme delivery and feel restricted to disclose on the adoption or non-adoption of the intervention. Another limitation of this study is the absence of student MC outcomes. Due to the pandemic-related logistics and restrictions, school-based testing of student physical outcomes was not possible. Assessment of students' physical outcomes would have provided evidence on the impact of implementation strategies on the intervention outcome as tested in the original efficacy trial.

Overall, the implementation evaluation protocol presented in the current study, using robust implementation theories and evaluation frameworks on implementation outcomes, followed a rigorous process of prospectively developing and testing implementation strategies with stakeholders' input. Findings will therefore inform future optimisation of Project FLAME specifically and school-based MC interventions more broadly, by identifying critical elements that may facilitate implementation. This protocol clearly outlines key methodological choices and analysis methods in developing implementation strategies and planning implementation evaluation, which contributes to the valuable learnings on how to conduct such evaluations in MC interventions. There is no one "best" theory or framework for a given project when it comes to implementation studies. This chapter presents a case of "how-to" address the implementation of an intervention by presenting the logical and rigorous process in developing this protocol.

Chapter 7. Outcomes of an implementation evaluation of a MC intervention

Thesis Map

Chapter	Objective(s)	Key findings and implications
4. A systematic review of process evaluation of MC interventions	Objective 1: To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	• Process evaluation is not sufficiently used or adequately reported in MC interventions when used. • Influences on MC intervention processes and outcomes are wide-ranging and include intervention characteristics, and individual, organisational, and system-level factors. • A wide range of typologies of process evaluation outcomes and measures were identified, along with their collection methods. These include measures relating to implementation, mechanism of change, and contextual influences on an intervention. However, it was insufficient to fully understand the implementation of MC interventions given process evaluation is underused. Further experimental studies are warranted.
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions	Objective 2: To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.	• A total of 76 barriers to the implementation and sustainability of MC interventions were identified, these barriers are related to policy, physical education curriculum, and individuals' self-efficacy, knowledge, and appreciation. • The interrelationships of these barriers were described in barrier systems, which provided help to navigate through the complex influences on MC intervention implementation. • The roadmap of actions revealed the ecological context of MC intervention and provides critical components that need to be considered when designing, operationalising, and evaluating MC interventions.
6. Developing implementation strategies and a protocol for implementation	Objective 3: To develop strategies intended to improve the implementation of a MC intervention.	• Findings from Chapter 4 helped frame implementation outcomes in the evaluation protocol.

| evaluation of a MC intervention | Objective 4: To plan, design, and conduct an implementation evaluation of a MC intervention using strategies developed. | • Findings from Chapter 5 helped develop strategies to improve the implementation of a specific MC intervention.
• Informed by the barrier system generated from CI, fidelity/adaptation, teachers' self-efficacy, and participant responsiveness were identified as driving influences on the implementation of this MC intervention.
• The development of implementation strategies and evaluation was in accordance with the PRACTIS guide, which demonstrated a rigorous process to plan and design an implementation evaluation. |
| 7. Outcomes of an implementation evaluation of a MC intervention | Objective 5: To report on the effectiveness of strategies intended to improve the implementation of a MC intervention.

Objective 6: To understand the process(es) and factors impacting the implementation and sustainability of a MC intervention. | |

7.1 Chapter context

This chapter presents the empirical outcomes of an implementation evaluation of a MC intervention (Project FLAME), as per the protocol outlined in Chapter 6. By doing so, this chapter reports on the effectiveness of the strategies intended to improve the implementation of Project FLAME, as well as to understand the process(es) and factors impacting the implementation and sustainability of Project FLAME.

7.2 Introduction

The evaluation objectives were to a) describe and compare two modes of implementation of Project FLAME, as per the implementation outcomes defined in Table 6.6, b) investigate the impact of the implementation strategies on the implementation outcomes, and c) explore the

feasibility and sustainability of Project FLAME. The two groups compared were: i) Original FLAME group: an active comparison group delivering the original Project FLAME for six weeks; and ii) Modified FLAME group: a group delivering Project FLAME incorporating the additional / newly developed implementation strategies and digital resources for six weeks. Detailed descriptions of intervention activities in two groups were provided in Table 6.4. The evaluation was conducted in eight schools over six weeks. Ethics approvals for conducting this trial was obtained from Ethics Committees of Coventry University (P116006), Deakin University (HEAG-H 52_2021), and Social Research Ethics Committee of UCC (Log: 2021-010). Ethics approvals from the first two institutions are attached at the beginning of this thesis, as required by the thesis submission guideline. Appendix 18 provides the ethics approval from UCC.

7.3 Participants and data availability

Subsequent to the approval granted by school principals and teachers, consent forms and information sheets (Appendix 19) were distributed to each respective class group. Informed parental consent (Appendix 20) and child assent (Appendix 21) were required before any adolescents could partake in the student survey. Schools, teachers, and students were informed that participation was entirely voluntary, and they were free to withdraw from the study at any time. The recruitment was overseen by the UCC researchers, who are qualified second-level school specialist PE teachers, as recognised by the Teaching Council of Ireland.

Overall, 12 schools and 13 teachers were recruited for the study, of which 9 returned the consent to participate in the study. Four teachers did not return the consents to take part due to work commitment, personal, and other unknown reasons. The final sample of analysis included data collected from 127 students (consent rate: 72.5%) and 9 teachers' post-trial. Among these teachers, 2 teachers were from the same school delivering the intervention to

different classes. All school teachers were given a choice of two timeslots within the same week to attend the pre-trial training (i.e., Training One and Training Two) in September 2020. Teachers who were available to attend Training One were allocated to the Modified FLAME group (Participant IDs: M-1, M-2, M-5, M-6, M-7), and those who were available for Training Two were allocated to the Original FLAME group (Participant IDs: O-1, O-2, O-3, O-4).

Table 7.1 provides a summary of the characteristics of participating schools. All schools are at post-primary levels but range in size, status, gender, and socioeconomic status. In Ireland, there are different types of post-primary schools, including voluntary secondary schools (privately owned), community schools (financed entirely by the Department of Education), community colleges, and vocational schools (partially funded by the Department of Education). The socioeconomic status of the school was indicated by if they were part of the DEIS plan (*Delivering Equality of Opportunity in Schools)* which was purposed to ensure better educational outcomes for learners in schools from disadvantaged communities and to maximise the chances of every child getting the best possible opportunity to fulfil her/his potential in life.

TABLE 7. 1 SUMMARY OF SCHOOL CHARACTERISTICS

Participating teacher/school ID*	Status	Gender	No. of enrolled students	DEIS indicator
M-1	Community	Mixed	307	Yes
M-2	Vocational	Mixed	307	Yes
M-5	Secondary	All Boys	713	No
M-6	Vocational	Mixed	613	No
M-7	Secondary	All Boys	763	No
O-1	Secondary	All Boys	717	No
O-2, O-3	Secondary	All Girls	562	No
O-4	Secondary	All Boys	231	No

*Teachers ID starts with M are from the Modified FLAME group, O are from the Original FLAME group

Over the six-week trial period, 38 weekly logbooks were returned by teachers (54 expected from nine teachers over six weeks, response rate: 70%). Return of the logbooks decreased over six weeks, with the highest in Week 1 (11 logbooks returned) and lowest in Week 6 (3 logbooks returned). All teachers completed the teacher survey pre- and post-trial (response rate: 100%). Students from seven schools (out of 9) responded to the student survey. Four out of the 9 teachers (who completed the survey which included an invitation to be interviewed) agreed and were interviewed (all males, from three mixed and one all boys school). The other five teachers declined the invitation to be interviewed. A summary of data availability is provided in Table 7.2.

TABLE 7. 2 A SUMMARY OF DATA AVAILABILITY AND CHARACTERISTICS BY PARTICIPATING SCHOOLS/TEACHERS

	School/ Teacher ID	Gender	Years of teaching experience	Logbook Returned/Expected	Teacher survey (pre-trial)	Teacher survey (post-trial)	Student survey*	Teacher Interview
Modified FLAME	M-1	Female	>10	4/6	✓	✓	✓	x
	M-2	Male	1-3	4/6	✓	✓	x	✓
	M-5	Male	1-3	3/6	✓	✓	✓	✓
	M-6	Male	1-3	5/6	✓	✓	✓	✓
	M-7	Male	1-3	4/6	✓	✓	✓	✓
Original FLAME	O-1	Female	1-3	4/6	✓	✓	x	x
	O-2	Female	4-10	4/6	✓	✓	✓	x
	O-3	Female	1-3	6/6	✓	✓	✓	x
	O-4	Male	4-10	4/6	✓	✓	✓	x

*As requested by the principals of M-2 and O-1, students from these schools were not asked to take part in the student survey.

7.4 Results

7.4.1 Data validation

As per the data validation process described in section 6.4.4, teachers' and students' responses were cross-checked for item questions (as presented in Table 6.7) on the weekly log and student survey to establish the data trustworthiness. Table 7.3 below gives a descriptive summary of

the results. There were similarities between teachers' and students' responses across the different sources (i.e., the weekly log and student survey). Consistently high was teacher's demonstration, whereby most lessons (87.5%) included teacher demonstration and in turn, the majority of students (94.1%) reported they recall teachers' demonstration in Project FLAME PE lessons. Similar patterns were found for performance criteria of skills. For external cues, teachers self-reported that in 92.5% of lessons they taught skills using external cues. As a result, more than half (65.3%) of students aware of cues for all six skills. Similarly low was the demonstration using digital resources during class, whereby only 22.5% of lessons included digital demonstration reported by teachers, and consequently, very few students recalled seeing QR codes or YouTube videos during class. This pattern was also found for the provision of digital resources for students to use in their own time. Regarding duration of Project FLAME activities included in one PE lesson, more than half of teachers (63%) reported that Project FLAME was included for 5-15 minutes. The majority of students (65%) reported they remembered practicing skills in a Project FLAME PE lesson for 5-20 minutes. A main variation was found regarding teachers' feedback and identification of potential errors of students' skill performance. While teachers reported they gave feedback and identified errors in vast majority of lessons (90%), only 77.5% of students remembered receiving feedback during class. The positive findings from data validation established trustworthiness of data collated from multiple sources, which gave confidence to its utilisation in the subsequent analysis.

TABLE 7. 3 RESULTS OF CROSS-CHECKING OF TEACHERS' AND STUDENTS' RESPONSES TO ITEM QUESTIONS ON WEEKLY LOG AND STUDENT SURVEY

	Teacher reported[a]	Student reported[b]
Duration of Project FLAME activities in one PE lesson	0-5 minutes 10%	0-5 minutes 3%
	5-10 minutes 38%	5-10 minutes 23%
	10-15 minutes 25%	10-15 minutes 27%
	15-20 minutes 10%	15-20 minutes 13%
	20+ minutes 12%	20+ minutes 11%
	A whole lesson 5%	A whole lesson 23%
Teacher demonstration (delivered/received)	87.5%	94.1%
Digital demonstration (delivered/received)	22.5%	11.7%
Criteria (delivered/received)	82.5%	99.2%
External cue[c]		One 7.6%
		Two 3.4%
		Three 5.1%
	92.5%	Four 11.9%
		Five 6.8%
		Six 65.3%
Error identification (delivered/received)	90%	77.5%
Digital provision (delivered/received)	25%	22.5%

[a]Percentage is relative to the total Project FLAME lessons delivered by teachers

[b]Percentage is relative to the total number of student responses received

[c]Student responses for this item are the number of skills they are aware of cues to perform correctly for

7.4.2 Comparing implementation outcomes

To address the first evaluation objective to describe and compare two modes of implementation of Project FLAME, results are reported by implementation outcomes respectively, as outlined in Table 6.4.

Descriptive statistics in Table 7.4 shows that for teachers in the Modified FLAME group, self-efficacy scores were similar pre- and post-trial (pre-trial median = 86.07, IQR = 66.43 – 90.00; post-trial median = 81.07, IQR = 80.71 – 86.57), with IQR post-trial wider than that of pre-trial. As visually presented in Figure 7.1, self-efficacy of teachers in the Modified FLAME group increased slightly except for one individual that reported the maximum score at pre-trial (i.e., the outlier). This may have skewed the summary statistics in this group overall. As for teachers in the Original FLAME group, all teachers' self-efficacy scores increased from pre-trial (median = 75.04, IQR = 74.32 – 75.75) to post-trial (median = 88.89, IQR = 88.39 – 91.02), as depicted in Figure 7.1.

TABLE 7. 4 DESCRIPTIVE SUMMARY OF TEACHER'S SELF-EFFICACY SCORES IN TWO GROUPS, PRE- TO POST TRIAL

Self-efficacy (on 0-100 scale)	Pre-trial median [IQR]		Post-trial median [IQR]	
	Modified FLAME (n=5)	Original FLAME (n=4)	Modified FLAME (n=5)	Original FLAME (n=4)
a. Planning effective lessons to achieve FMS related student learning outcomes	90.00[85.00-90.00]	74.50[70.50-78.75]	85.00[80.00-87.00]	96.50[93.75-98.50]
b. Apply appropriate FMS content knowledge in my teaching (e.g., motor development and skill acquisition theory) to achieve learning outcomes	90.00[90.00-92.00]	67.50[58.75-75.00]	89.00[80.00-89.00]	94.00[92.25-96.25]
c. Apply appropriate FMS pedagogical content knowledge in my teaching (e.g., teaching models, instructional frameworks to deliver FMS) to achieve learning outcomes	90.00[59.00-90.00]	65.00[63.75-66.25]	80.00[80.00-89.00]	91.00[89.00-94.00]
d. Implement general teaching and learning strategies to meet the needs of PE class	85.00[70.00-95.00]	87.50[83.75-90.00]	91.00[80.00-96.00]	97.00[93.75-100.00]
e. Actively engage students in learning of FMS	90.00[69.00-90.00]	90.00[75.00-91.00]	85.00[80.00-86.00]	91.00[86.25-92.25]
f. Design lesson contents to meet differing student needs (e.g., multiple exposures for FMS learning, differentiated teaching strategies)	80.00[80.00-95.00]	70.50[69.25-72.00]	80.00[79.00-87.00]	91.50[91.00-94.00]
g. Choose developmentally appropriate curricular strand to develop FMS within the lesson	86.00[85.00-95.00]	69.00[67.50-71.25]	80.00[80.00-86.00]	90.00[87.75-93.25]
h. Identify students' varying levels in FMS proficiency	81.00[80.00-95.00]	77.50[73.25-82.50]	85.00[80.00-95.00]	86.00[83.00-91.00]

i. Use FMS assessment as part of the teaching and learning cycle in PE	90.00[86.00-95.00]	75.00[69.50-81.25]	80.00[71.00-89.00]	86.00[82.25-91.75]
j. Report on students outcomes in FMS	50.00[42.00-90.00]	74.00[65.75-82.75]	77.00[70.00-80.00]	85.00[81.50-91.00]
k. Manage the class when teaching FMS (e.g., managing disruptive behaviours)	90.00[71.00-95.00]	86.50[79.75-92.50]	93.00[90.00-95.00]	88.00[84.00-91.75]
l. Integrate reflective FMS teaching practices	90.00[78.00-95.00]	74.00[70.50-75.00]	80.00[73.00-86.00]	82.50[78.25-88.00]
m. Provide feedback to help students develop FMS within the lesson	79.00[76.00-95.00]	89.00[80.00-91.00]	80.50[78.50-83.25]	86.00[84.00-94.25]
n. Access appropriate FMS resources to effectively teach FMS lessons	80.00[60.00-95.00]	80.00[74.00-90.00]	69.00[62.75-78.75]	93.00[86.00-100.00]
Overall Self-efficacy	86.07[66.43 – 90.00]	81.07[80.71 – 86.57]	75.04[74.32 – 75.75]	88.89[88.39 – 91.02]

*IQR narrowed from pre- to post-trial for bolded self-efficacy items c,d,e

Teachers in the Modified FLAME group had more varied scores of self-efficacy at both pre- and post-trial levels, whereas the scores were more consistent among teachers in the Original FLAME group (Figure 7.1).
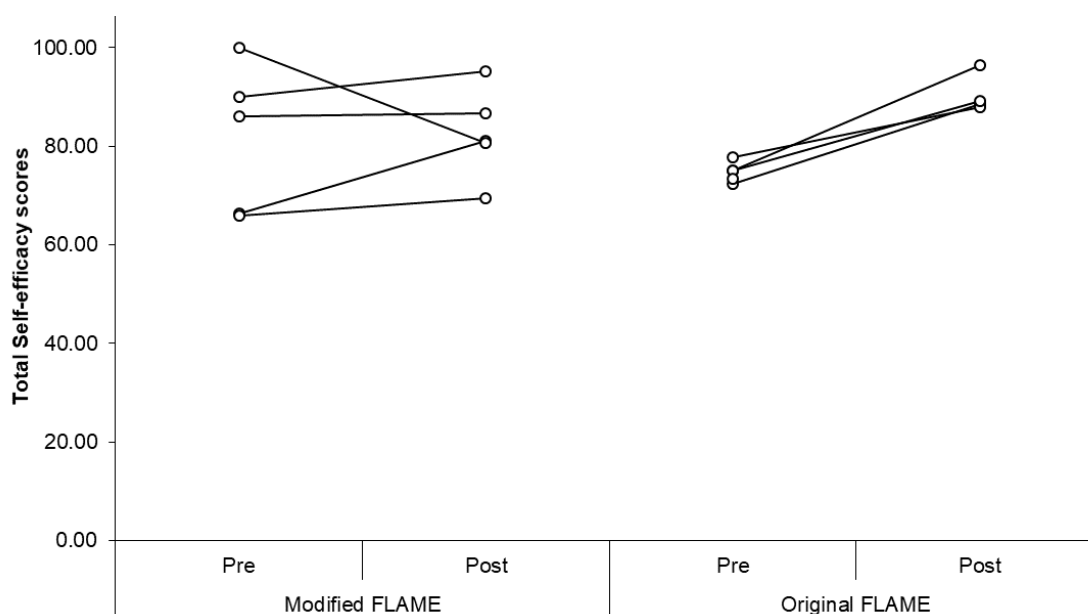
FIGURE 7. 1 COMPARISON OF THE TOTAL SELF-EFFICACY SCORES BETWEEN THE ORIGINAL FLAME AND MODIFIED FLAME, PRE- TO POST-TRIAL

For individual items of the self-efficacy scale, as shown in Table 7.4, self-efficacy of teachers in the Original FLAME group increased in all items pre- to post-trial, except decreased slightly in item m. Teachers' self-efficacy in the Modified FLAME group decreased in all items pre- to post-trial apart from item d, j, k, m. However, this may be due to the outlier who reported

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the maximum scores for all items at the pre-trial. For individual self-efficacy item, a common pattern found between two groups was that the IQR narrowed in items c, d, e, indicating that Project FLAME might have increased the confidence among teachers who had a lower level of self-efficacy in the specified three areas at pre-trial. In fact, across all individual reports, all teachers who reported lower levels of self-efficacy at baseline increased after the trial. During interviews with teachers, even though they had prior knowledge in MC and Project FLAME, teachers perceived the project resources and contents as *'a refresher'*, hence increasing their confidence in delivering the intervention:

> *"I had an awareness of the sort was going to be and the different skills*
> *were involved, but there was no harm to have just kind of a refresher. And*
> *just to get it fresh in your mind because you know everything you're going*
> *(to deliver), it's nice to have the kind of bank of resource" (Teacher M-7)*

Teachers also found certain elements of Project FLAME (cues and games) helped the teaching preparation and increased their confidence in delivering Project FLAME PE lessons:

> *"I found cues really helpful, so just know and have that printed off and*
> *ready to go with me, kind of gave me a bit more confidence in delivering it*
> *as well." (Teacher M-7)*

> *"It would be a useful resource when you are at your planning meetings*
> *where you can identify the different areas that we could potentially focus*
> *on for developing their skills and then say that's a resource that you could*
> *use before your lesson, if you need some ideas around what you're going to*
> *do." (Teacher M-2)*

7.4.2.2 Fidelity (consistency)

Table 7.5 shows that scores were comparable between two groups regarding fidelity to error identification and the use of external cues. All lessons in the Original FLAME group shared the performance criteria to teach movement skills, while some lessons in the Modified FLAME group did not. Both groups reported a low level of fidelity to the use of QR codes for skill demonstration and the sharing of QR codes (and other digital resources) for students' use.

Nevertheless, more lessons in the Modified FLAME group made use of the digital resources, as opposed to the Original FLAME group.

TABLE 7. 5 COMPARISON OF SCORING ON FIDELITY COMPONENTS BETWEEN THE MODIFIED FLAME AND ORIGINAL FLAME GROUPS

Fidelity Component		Modified FLAME n=20 lessons	Original FLAME n=18 lessons
FMS focus	Fidelity consistent	14	14
	Fidelity consistent adaptations	3	4
	Fidelity inconsistent	3	0
Integration	Fidelity consistent	17	17
	Fidelity consistent adaptations	2	1
	Fidelity inconsistent	1	0
Teacher demonstration	Fidelity consistent	17	18
	Fidelity consistent with adaptations	2	0
	Fidelity inconsistent	1	0
Digital demonstration	Fidelity consistent	8	1
	Fidelity consistent with adaptations	0	0
	Fidelity inconsistent	12	17
Criteria	Fidelity consistent	15	18
	Fidelity consistent with adaptations	0	0
	Fidelity inconsistent	5	0
External cues	Fidelity consistent	20	17
	Fidelity consistent with adaptations	0	0
	Fidelity inconsistent	0	1
Error identification	Fidelity consistent	19	17
	Fidelity consistent with adaptations	0	1
	Fidelity inconsistent	1	0
Digital provision	Fidelity consistent	7	3
	Fidelity consistent with adaptations	0	1
	Fidelity inconsistent	13	16

To examine the cause of the variations between two groups, scores for each fidelity component were also determined for each weekly log received for each school. An average of the score was calculated for each school, as summarised in Table 7.6. Consistent with Table 7.5, fidelity to the use of external cues and error identification were high across schools. Teachers' adherence to fidelity components in the Modified FLAME group seemed more variable, while teachers in the Original FLAME group consistently adhered to the intervention.

The inconsistent use of digital demonstration was due to issues related to technology and facilities, backed by what was reported in the weekly logs and interviews. For example, both School M-5 and School M-7 held PE offsite because the PE halls were converted to classrooms (due to social distancing measures) and therefore no technical equipment such as projectors were available. By contrast, as part of the school provision, Teacher M-6 was equipped with a tablet and able to use the digital demonstration during Project FLAME PE lessons.

TABLE 7. 6 SCORES FOR THE FIDELITY COMPONENT OF PROJECT FLAME, BY EACH SCHOOL

Fidelity component (maximum score=2)	Modified FLAME					Original FLAME			
	School M-1	School M-2	School M-5	School M-6	School M-7	School O-1	School O-2	School O-3	School O-4
Motor skill Focus	0.75	2	1.3	2	1.5	1.75	1.25	2	2
Integration	1.5	2	1.3	2	1.5	1.75	2	2	2
Teacher demonstration	2	1.25	2	2	1.5	2	2	2	2
Digital demonstration	0.5	0	0.67	2	0	0	0	0	0.5
Criteria	2	0	2	2	1.5	2	2	2	2
External cues	2	2	2	2	2	2	2	1.67	2
Error identification	2	2	2	2	1.5	1.75	2	2	2
Digital provision	0	0	0	1.2	2	0	1	0	0.5
Total (maximum score=16)	10.7 (67.2%)	9.2 (57.8%)	11.3 (70.8%)	15.2 (95%)	11.5 (71.9%)	11.2 (70.3%)	12.2 (76.6%)	11.6 (72.9%)	13.0 (81.2%)

School M-2 had the lowest level of adherence, mainly attributed to the inconsistent use of teacher demonstration and performance criteria. In the interview, Teacher M-2 reported that a more flexible pedagogical approach was adopted during the delivery by which the teacher guided the students to explore the correct movement pattern themselves:

"I didn't give any prescriptive instructions of how to perform a skill. I kinda let them try it and if a skill was looking some way like it should be like, I might give them an external cue or I could just change the task for them. 'cause like, if they weren't getting the dribble I would make it easier instead of telling them to get the dribble around waist height, I got them to do one where they got it over their head, one down low, and then they kind of got to the area where it worked best for them." (Teacher M-2)

7.4.2.3 Fidelity (adaptation)

A total of 72 adaptations were made during the six-week trial, 43 were reported by teachers in the Modified FLAME group and 28 by teachers in the Original FLAME group. One adaptation was made by the research team in response to the disengagement with the website comment sections by the teachers, after week 1. Instead of teachers posting their delivery experience on the website, the research team collated the information from the logs and shared on WhatsApp groups weekly to enable and encourage the exchange between teachers (Implementation Strategy D). Table 7.6 provides a summary of all adaptations, coded using the FRAME framework (Stirman, Baumann, and Miller 2019).

As shown in Table 7.7, almost all adaptations (n=70) were made by teachers, with one exception involving students' adaptations (i.e., *created their cues*). The vast majority of adaptations (n=67) were made targeting the whole class, with the exception of four adaptations that were made tailoring to individuals with special needs (e.g., *no focus on stance and using softer balls for wheelchair users to practice throw, a Buddy system with students with ASD (Autism spectrum disorder) to help them through the teaching points*). Most adaptations (n=50) were made proactively except some reactive adaptations (n=20) in the Modified FLAME group in response to school shortages of technical resources and equipment (e.g., *skipping the digital demonstration*). Most adaptations were made to the contextual format (n=49) instead of intervention content (n=24), for example, Project FLAME activities with a motor skill focus were often included in the warm-up of PE lessons. In terms of the goals of adaptations, the most common goal in both groups was to improve feasibility (n=47) (e.g., *skill focus was*

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included in the warm-up), followed by increasing student engagement and satisfaction (n=24) and improving fit (n=13) with the students (e.g., *add relays while dribbling to make them more concentrated*). Both groups considered students' engagement when adapting the intervention delivery (i.e., *considering their motivation and readiness to the game*). In terms of the nature of adaptations, teachers often skipped digital demonstration and used teacher demonstration alone in class due to a lack of technology facilities, and substituted skill teaching with a more student-centred approach, rather than sharing performance criteria alone (e.g., *gave the students some freedom to figure out the best way to jump themselves*). Teachers also added elements or refinements to meet the student needs during class, for example, students were matched by their abilities in playing Project FLAME games to ensure '*every student had the opportunity to succeed*'. Another example is showing examples of elite athletes and encouraging students to relate skills to a movement in their chosen sport. Of note, some Project FLAME activities were integrated into the curricular strand that was taught (e.g., *As we were doing Gaelic Football this week it tied in nicely at the beginning of the lesson*).

TABLE 7. 7 AN OVERVIEW OF ADAPTATIONS MADE DURING THE SIX-WEEK PROJECT FLAME TRIAL, CODED USING THE FRAME FRAMEWORK

Adaptation categories	Code (number of adaptations)*	Example adaptations reported in the teacher log (teacher ID)
Who participated in the decision to adapt?	Teacher (70)	*I used the lessons as a warm up activity. It is really useful to identify weakness in 1st year students. (O-4)*
	Student (1)	*I adapted it by using cues that the students came up with themselves. (O-2)*
For whom is the adaptation made?	The whole class (67)	*I created an obstacle course at the end which got the students using all 6 of the movements learned at different stages in teams as a race against the other teams. (O-3)*
	Individuals (4)	*I have one student on wheelchair so her control over the ball was much less than others. We did not do one handed dribble with her instead I focused on catching the ball after each bounce with 2 hands. (M-1)*
Were adaptations proactive or reactive?	Proactive (50)	*I changed it to a more simplified version of dodgeball (Using tennis balls to practise skill) then their engagement was much better. So it*

		was great to be given the initial game and then being able to adapt it to the needs of my group. (O-4)
	Reactive (20)	*Didn't use QR demo due to lack of facilities. (O-2)*
What was the goal	Improve feasibility (47)	*Relay/tag teams were used to compensate for shortage of basketballs. (O-1)*
	Increase engagement and satisfaction (24)	*I made the activities more game like. I find the students engage better and they find it more enjoyable. (M-2)*
	Improve outcomes (15)	*Most students were inclined to not use their legs to get power in the throw at all - forcing them to stand side on enforced this. (O-2)*
	Improve fit with students (13)	*For "catching" the person activity, students were matched according to ability. This ensured that every student had the opportunity to succeed. (M-1)*
What is adapted?	Contextual (format) (49)	*Skip focus was included in the warm—up and linked to the catching/fielding skill in GAA. (M-5)*
	Content (24)	*I didn't use the cone game because it would have taken too long to set up and I thought the students may have found it boring. (M-2)*
What is the nature of the adaptation?	Substituting/skipping (37)	*Didn't use QR demo during the class due to lack of access to phones, the videos have been added to their online class to look at themselves. (O-2)*
	Integrating parts of the intervention into another framework (14)	*I included this as part of the students' gymnastics routines as it hit the area of balance and stability by encouraging a wide base when landing. (M-5)*
	Tailoring/tweaking/refining (13)	*I altered it by asking the students to perform the skip differently, e.g low, high, sideways, backwards, quietly, loudly. (M-2)*
	Adding elements (11)	*Showing students examples of the movements of athletes in sport helps with application and interest. (M-5)*
Reasons for adaptation?	Available time and resources (29)	*Impractical to set up projector/ipads for a video I could demonstrate efficiently myself. (O-1)*
	Student motivation and readiness (20)	*Students seemed to enjoy experimenting with what position enabled them to throw further. We tried throwing the 'wrong way' eg. Wrong foot forward/standing face on/etc. Students could discover themselves what their technique should be. (O-1)*
	Provider competence and experience (18)	*Didn't use QR demon because I can demonstrate efficiently myself. (O-1)*
	Student physical capacity (4)	*Adapted games and personal ques to students due to physical disabilities e.g no focus on stance for wheelchair user, softer balls. (M-1)*
	Existing curriculum (11)	*We were carrying out other small sided games so we used the dribbling activities as a warm*

*The total number of adaptations reported was 72.

7.4.2.4 Participant's responsiveness (Teacher)

Teachers' perceived acceptability seemed consistently high in the Original FLAME group, while in the Modified FLAME group, teachers' perceptions varied. These individual variations are presented in radar maps in Figure 7.2. Each teacher's responses were plotted along each axis that represents the item in the scale and connected to form a square. The visualisation allowed for the comparison of responses to each scale item, and between teachers. When teachers reported the same scores, the squares overlay each other. The overall perceived acceptability of a teacher is represented by the size and shape of the square.
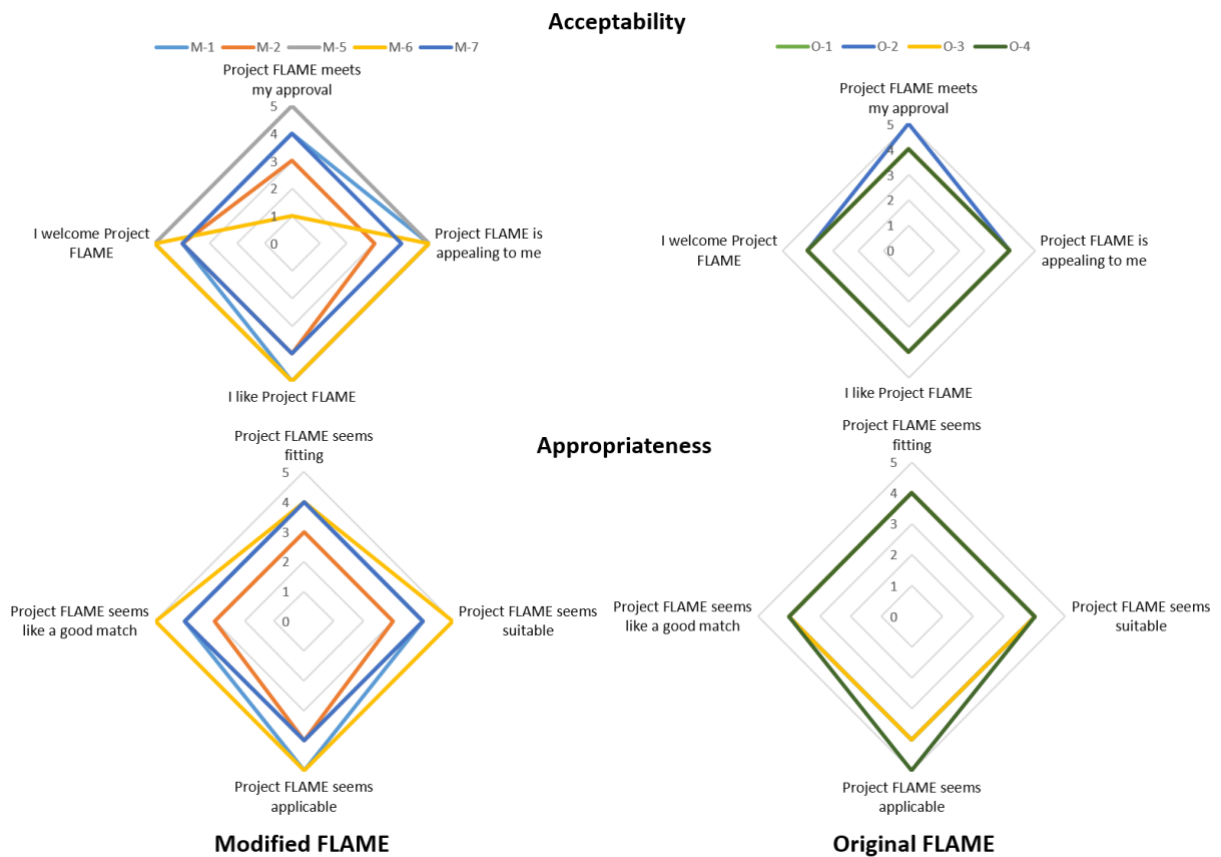

FIGURE 7. 2 TEACHER'S PERCEIVED ACCEPTABILITY AND APPROPRIATENESS OF PROJECT FLAME

The Modified Project FLAME seemed more appealing compared to the Original Project FLAME, with more teachers in the Modified FLAME group indicating the highest level of agreement on "I welcome Project FLAME", "I like Project FLAME" and "Project FLAME is appealing to me". During the interview, when teachers were asked on the appeal of Project FLAME for them to be willing to take part initially, all teachers mentioned the benefits of developing MC:

"I suppose it's the focus on FMS (that appealed to me)... It's something different as well for the guys who are in the class, I think particularly the weaker guys benefited from it." (Teacher M-5)

"Probably being aware that like through all the movements, how transferable they are throughout all aspects of PE and physical activity. I was aware that if the students were able to do with these skills confidently like that, they would be able to do a lot of other things." (Teacher M-7)

Teachers from School M-2 and School M-6 reported lower levels of agreement on "Project FLAME meets my approval", compared to other teachers. This may be explained by the varied perceptions on the project contents and structures:

"It (Project FLAME) was really like kind of too linear. It was kind of isolating the skills away from the games, whereas when I was doing, for example, dribbling and stuff, I was trying to kind of doing through the games that dribbling being a key skill in and to get them to make decisions on when to dribble and how to dribble rather than dribbling for the sake of it." (Teacher M-2)

In comparison, Teacher M-6 appreciated the project contents but had reservations on student's proper use of the website (implementation strategy D):

"I found the website and those QR codes. They were very helpful for me to see (the content and games)... and I could put everything on my tablet." (Teacher M-6)

"I think the website is helpful, but perhaps that it might be a little bit too much for students. 'cause what I find, I wouldn't get rid of it, I think it's a very beneficial thing, but I'm just wondering how many 13,14,15 year old students after PE are so into the Project FLAME and are going to look into it after. You might have one or two in each class...but I think it is definitely

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*not an essential and imperative part of delivering Project FLAME. It's
really more helpful for the teacher to be honest." (Teacher M-6)*

Interestingly, Teacher M-7 commented on the usefulness of resources provided in

Project FLAME, for both teachers and students:

*"And just to get it fresh in your mind because you know everything you're
going (to use during delivery), it's nice to have the kind of bank of resource
there as well just to lean back on, as kind of a tool for the students as well,
they can, if it didn't go well in class they had, they know where to go to get
help or to revise themselves." (Teacher M-7)*

Teachers from both groups tend to agree more on "Project FLAME seems applicable",

which was confirmed by the high fidelity to the project components reported previously. When

teachers' responsiveness was discussed during the interviews, there were differences in

opinions about the perceived fit of the programme. For instance, Teacher M-7 found Project

FLAME relevant and applicable in developing students' skills so that they can benefit from PE

in the long run:

*"I was aware that if the students were able to do these skills confidently
like that, they would be able to do a lot of other things… And I will
hopefully have them (take part in Project FLAME) for the next two years. It
probably makes my life a bit easier as well." (Teacher M-7)*

Similarly, Teacher M-2 commented on the applicability of Project FLAME

(performance criteria) in identifying students' skill proficiency levels:

*"I think it was kind of very important for the teacher to be aware of where
the kids generally struggle with it, or like…what areas they found the kids
didn't perform it too well. So it's kind of nice to know that's an area that
might be a good idea to focus on for which year group. And it kind of help
when you like say I had, it was first year so I didn't know them at all. So it
was nice to identify potential areas where the students where they might
have a bit of difficulty, or where they need improvement." (Teacher M-2)*

By contrast, teachers seem to agree less on "Project FLAME seems fitting", mainly for

its suitability to the existing curricular strands that need to be covered in PE as well as the

school-specific PE planning. For example, Teacher M-5 reflected on how Project FLAME fit into the school curriculum:

> *"I was actually kinda happy with some of them. Some of the ways that it slotted in. There were other aspects that (did) not particularly fit well, that's just because of how we operate the schedule of modules. That might be something worth looking at, how it will fit in with the way that (school) PE department might run." (Teacher M-5)*

Another contributing factor to a teacher's perceived fit, was the teacher's pedagogical preference. For instance, Teacher M-2 reported the overall lower levels of agreement on the appropriateness items (Figure 7.4), due to the misalignment between Project FLAME and his own teaching philosophy and practice:

> *"I suppose over the last few years, I've kind of moved towards more teaching the skills through the games. I've been doing a lot of reading and stuff like ecological dynamics and how you can kind of apply their skills through a given, (for example) with some of the project flame stuff. I was kind of adapting them to make them more games (like) and kind of getting the skills to emerge through the games ordered and kind of teaching them how to do it." (Teacher M-2)*

7.4.2.5 Participant's responsiveness (Students)

For the 127 students who responded to the survey, 74 were from schools in the Modified FLAME group (65 boys, 4 girls, 5 prefer not to say) and 51 were from the Original FLAME group (26 boys, 23 girls, 2 prefer not to say). Student's satisfaction (maximum score 5) was 4.17±0.99 and 4.21±0.75 for the Modified FLAME and Original FLAME group, respectively. Table 7.8 presents the distribution of student survey responses between groups. No differences were found in the items listed between students in two groups, apart from the frequency of skill practice during the week, with students in the Modified FLAME group practicing skills more frequently than those in the Original FLAME group.

TABLE 7. 8 DESCRIPTIVE SUMMARY OF STUDENT SURVEY RESPONSES AFTER THE SIX-WEEK TRIAL

	Modifed FLAME (n=74)		Original FLAME (n=51)	
Project FLAME lessons are fun				
Completely agree		19		13
Agree		30		19
Neither		12		12
Disagree		4		1
Completely disagree		3		1
Missing data		6		5
Project FLAME introduces me to new activities				
Completely agree		16		9
Agree		34		20
Neither		9		11
Disagree		4		4
Completely disagree		5		2
Missing data		6		5
Project FLAME lessons are useful				
Completely agree		20		11
Agree		39		23
Neither		6		8
Disagree		2		2
Completely disagree		1		2
Missing data		6		5
Skill practice outside school hours				
Once a week		15		7
2-3 times a week		24		13
3-5 times a week		10		7
Everyday		10		4
None		7		15
Missing data		8		5
Apply what are learnt in Project FLAME in future				
Definitely will		12		7
Probably will		29		22
Probably won't		23		15
Definitely won't		4		2
Missing data		6		5

*Data bars suggest the percentage of students in the respective group

Students' participation in Project FLAME was further explored by their text responses in the survey. There were 107 out of 127 students who wrote comments regarding their participation highlights. No divergent themes were found between students participating in two

modes of Project FLAME. No responses related to the digital component of the Project FLAME were present in either group.

Across both groups, a common theme was students' reported enjoyment in skill-specific tasks, games, and external cues. In total, 94 students mentioned the specific motor skills in their responses (Figure 7.3) and described what they liked about the motor skill-focussed activities (e.g., "*I liked the Christiano Ronaldo jump.*" *(School O-4, M))*. Horizontal and vertical jumps seemed to be the most preferred lesson by students because they involved a diverse range of games and competitions (e.g., *"I enjoyed horizontal jump because we did a hoola hoop game which I enjoyed." (School O-3, F))*. Students also found Project FLAME useful in terms of learning a new skill (e.g., *"I enjoyed new methods of kicking (School O-3, F))* and improving their skill proficiency levels (e.g., "*I got to learn how to skip properly and fix what I was doing wrong." (School O-3, F))*. Many students highlighted the transferability of skills to their preferred sports (e.g.,*" I liked kicking and throwing because they can be carried out in different activities and sports." (School O-3, F))*. Irish national sports Gaelic football and hurling were the most mentioned in the responses.
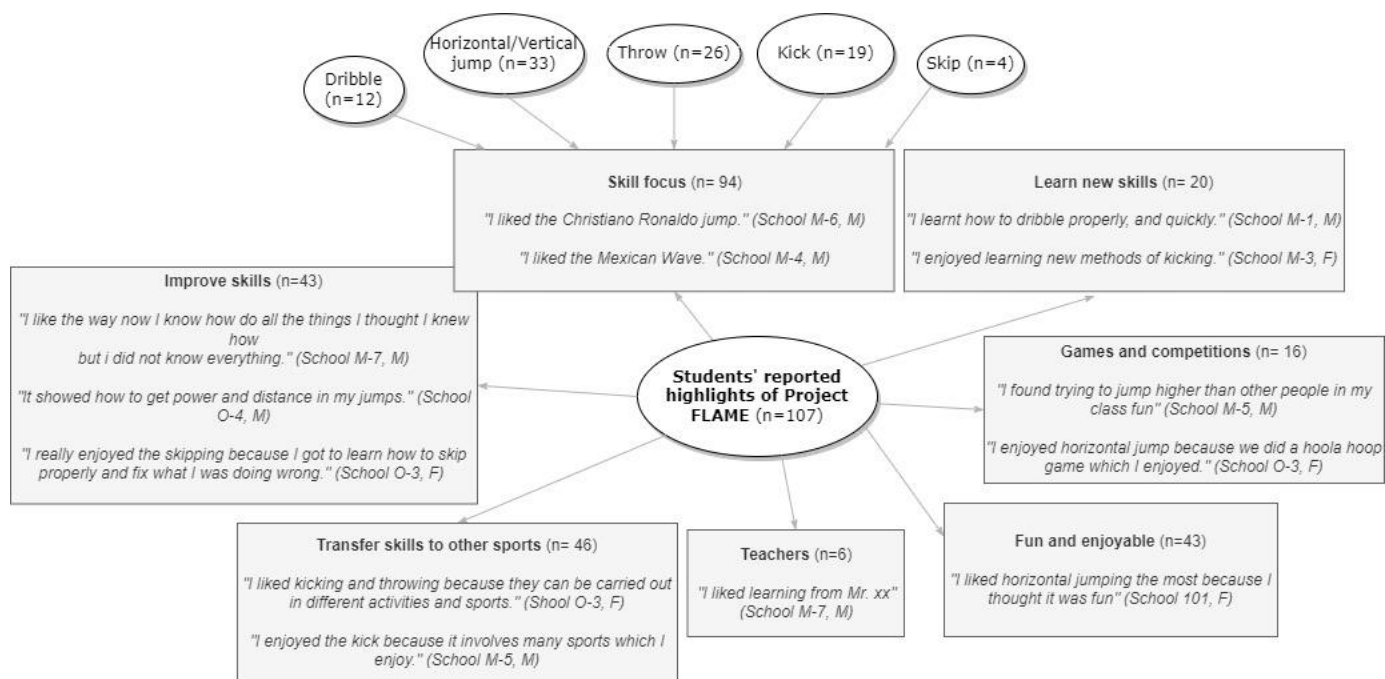
FIGURE 7. 3 STUDENTS' REPORTED HIGHLIGHTS OF PROJECT FLAME

Themes that emerged in the student responses were corroborated by teachers' responses in the interviews when teachers were asked about their observations on students' engagement with Project FLAME. Teachers' responses provided contextual information on what influences students' engagement. In line with students' text responses, teachers reported that students found games and competitions palatable, and their responses differed by skill levels. For example, Teacher M-5 and M-2 found teachings points of Project FLAME worked particularly well with students with lower levels of proficiency:

> *"I suppose having the Project FLAME to break it down into the few different points rather than saying to them 'right, I want you to throw this bean bag into the thing just 30 yards away, they wouldn't have a clue what to do. When you started out small and are able to break it down and I found weaker students were able to improve that better and understand it and be able to take part, which was good." (Teacher M-5)*

> *"Especially some of those students that were struggling with some of the skills, and it helped (them) build confidence." (Teacher M-2)*

However, for students who possessed higher skill levels, more challenging tasks, and the competition element was often needed:

"The guys who are highly developed in skill-wise can get quite bored quickly." (Teacher M-5)

"So if the basketball dribble was too easy for him. And then I gave him a tennis ball and it was a bit harder. So it's kind of challenging him, whereas if I kept him under basketball they would have got bored over." (Teacher M-2)

Additionally, external cues and games in the Project FLAME resource pack were memorable and educational for the students and helped their continuous learning:

"Like a cup of tea on your knee (i.e., the cue for skip), and they would remember that, then the next week I put in a bit of recall into it as well. It seemed to work and that was one of the strategies I used." (Teacher M-5)

"They were saying how they were having a bit of laugh (in kicking games). But then they could also start seeing their transferability to the different things, which was good." (Teacher M-7)

Consistent with students' responses, the skill-focus of Project FLAME motivated students, particularly when they were facilitated to see the improvement and success in their skill levels (via teacher and peer feedback):

"Every student will tell you that they just want to play soccer, but they actually enjoy (learning skills) when you show them the improvements could be made."(Teacher M-6)

"I think they actually did really enjoy seeing which tile they could hit (through vertical jumps) because they were speaking about it on the way down. You know bragging about that, they got the highest tile and all this stuff, so they do enjoy that." (Teacher M-5)

"More (feedback was provided to) the weaker guys. They tell each other because they wanted to improve." (Teacher M-5)

Teachers also found students more engaged when they were provided with rationale on why it is important to develop MC (e.g., encouraging students to reflect on mastering motor skills can help branch out into other sports.). This made students "*realise the point of doing it, which helps the buy-in a lot*" *(Teacher M-5)*. Some teachers used examples of professional athletes that students admire (e.g., "*Roger Federer developed a broad range of skills when younger, not just through playing tennis*") to make students feel "*relatable*" and *"what they were doing were worthwhile" (Teacher M-7).*

Finally, Teacher M-7 commented on the potential impact of Project FLAME on students beyond PE classes:

> *"There are a lot of them playing different sports and stuff. Whether be soccer or hurling, Gaelic football. There is really good uptake in sports, and I'd like to think there is a link between having the skills through Project FLAME." (Teacher M-7)*

7.4.2.6 Engagement with the Project FLAME website (Modified FLAME group only)

There was a total of 23 users of the Project FLAME website during the study period (excluding members of the research team). Five were teachers who registered for the website access and 19 were student users. Table 7.9 provides a summary of website usage. The most frequently viewed pages were the home page (18.8% of all views), teachers' resources (11.5%), teacher's log-in page (11.3%), and introduction to Project FLAME (8.6%). The average count of sessions (2.26) and duration (8.18 minutes) show that teachers engaged with the website content. No teachers engaged in the online forum discussion on exchanging the delivery experience. Considering the contents hosted on the site and top viewed page, it can be extrapolated that most teachers' visits were to log on to the website and browse the project resources. The total page views for the student resources were 37, with an average duration of 1.5 minutes. This indicates minimal student contact with the website. This is consistent with the fidelity findings,

as only Teacher M-6 and Teacher M-7 gave digital resources (web links and QR codes) to students for their use outside of school hours.

TABLE 7. 9 SUMMARY OF PROJECT FLAME WEBSITE USAGE

Usage	All user*
Sessions per user, mean	2.26
Page views per user, mean	19.69
Page views per session, mean	8.71
Session duration (minutes), mean	8.18

* 'All user' group includes teachers and students.

Moreover, as shown in the website traffic recorded throughout the trial period (Figure 7.4). The engagement with the website decreased over time, as only a few users kept returning to the site and accessing the website resources regularly (as indicated by the green line). Page views seemed to have peaked mid-trial when teachers were delivering dribbling and horizontal jump as per the intervention protocol. Websites were mainly accessed via tablets and desktop computers, rather than mobile phones.
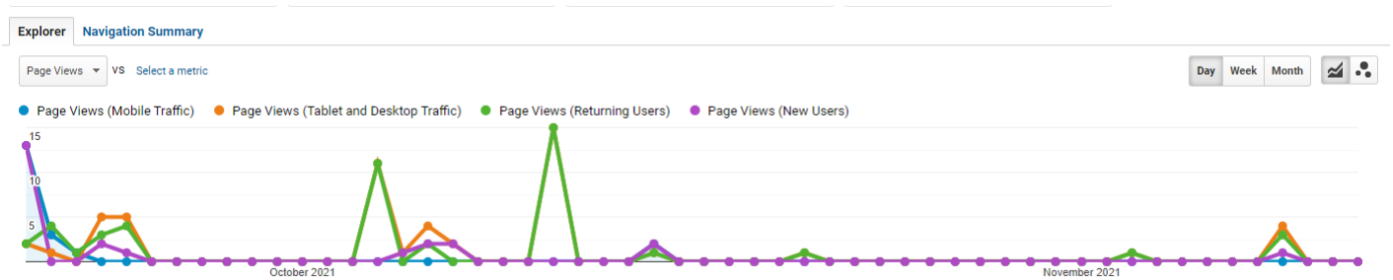
FIGURE 7. 4 WEBSITE TRAFFIC THROUGHOUT THE TRIAL PERIOD (SEPTEMBER – NOVEMBER 2021)

The qualitative data in teachers' interviews support the decline in teachers' engagement with the website. Teacher M-2 commented that initially he logged on to the website to browse the resources but lost the log-in details during the trial and did not request a new one. Teacher M-5 was impressed by the website resources but did not keep engaging with it due to the change to a new device and the tight teaching schedules. He also commented that he preferred hard

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copies to online resources in the teaching preparation. By contrast, Teacher M-6 and M-7 had more frequent access to the website, particularly for the teaching preparation. They saw the website as a *'bank of resources'* (Teacher M-7). Teacher M-6 further outlined its usefulness in his teaching and reflective practice:

> *"I think it's a crutch more than anything. It's something to lean on if you're unsure. And more so in preparation, more than anything else, and then it's helpful for reflection if you want. If you aren't the most competent at delivering Project FLAME, I think it would be quite helpful to look at it after the lesson and reflect after saying how did that go? It's a very good crutch that way. Just say I ticked all the boxes or my teaching cue was good, or I used good examples."(Teacher M-6)*

As for students, teachers seemed to have reservations on the extent the students are willing to engage with the website. Teachers commented that students could benefit from it if they had a regular engagement with the website, however, this is not a common expectation of students to have continuous PE learning outside of school hours. The explanation for this perhaps can be epitomised by this comment: "*It's not a culture of PE as homework. It's not a thing that's done.*" (Teacher M-5).

7.4.2.7 Feasibility of Project FLAME

Teachers found Project FLAME highly feasible, despite the group they were in (Figure 7.5). This finding is corroborated by the high fidelity reported in the previous section.
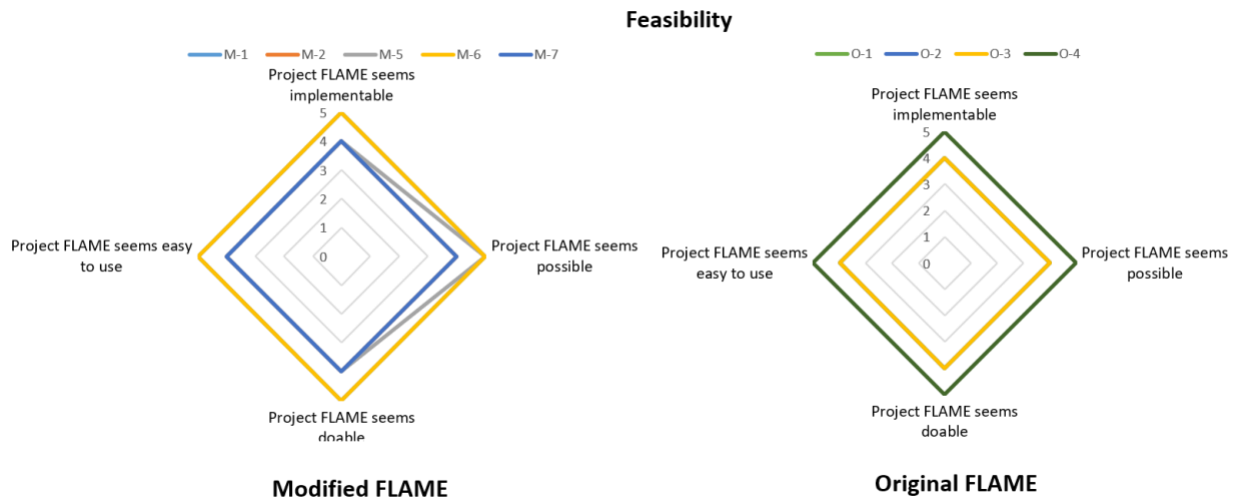
FIGURE 7. 5 TEACHERS' PERCEIVED FEASIBILITY OF PROJECT FLAME

Nevertheless, teachers in the Modified FLAME group reported some barriers, relating to the training and implementation strategies. All four interviewed teachers suggested that in-person training would have been more beneficial, in that more practical examples could have been provided:

> *"I suppose maybe more practical examples or kind of different ways that you could modify it. Like constraints based on the schools you are in. If you were doing dribbling that you could use different types of balls. (Teacher M-2)"*

Teacher M-7 and Teacher M-5 felt that seeing how Project FLAME is delivered would have been helpful in transferring to their practice:

> *"It's all well and good like doing training with you and all PE teachers and everyone knows the skills, when you're there teaching 12 and 13 year old students who have never done these skills maybe having kind of a workshop or something, or even a recorded video of how he (the researcher) would deliver it I suppose or how it's delivered in a practical sense. Maybe also through someone delivering tool kits." (Teacher M-7)*

At the same time, teachers commented on the tasks they had to complete for the current evaluation, including the weekly log and distribution of consent forms. Teacher M-6 preferred the project to be delivered at a different time of the year. At the planning stage, the beginning of the year was chosen as the research team thought it would be an appropriate timing for

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teachers to take on new practice. However, in Teacher M-6's case, the beginning of the year was the most hectic particularly post COVID-19 lockdown. Even though Teacher M-6 found completing weekly logs a reflective practice, he found it challenging to remember completing the logs after each class:

> *"Maybe it would have been more beneficial to do this after midterm in favour or something like that. I just think it's a very busy time of the year to try and implement something new like that as well. Like the first week back." (Teacher M-6)*

The tight and busy work schedules of teachers also created barriers to implementing other activities, such as leaving comments on the website. All four interviewed teachers have teaching responsibilities in addition to PE, the planning and teaching hours for PE and other subjects are usually split in half. PE teachers often need to go from one class to another, if it is PE they would need to prepare and bring equipment and organise students to get to the site which leaves very little time. As Teacher M-5 commented, "*I don't think the online thing really works too well with PE teachers particularly, because we are very active and practical and like to see things being done and how they work.*"

7.4.2.8 Sustainability of Project FLAME

Sustainability of Project FLAME in both groups was explored using survey items, followed by interviews. Teachers were asked if they would continue to use Project FLAME in their future practice and if yes, in what way. All teachers but Teacher M-6 and M-7 reported that the programme could be sustained in their practice. A common theme in their text responses was to integrate the elements of Project FLAME (such as external cues, games) to the relevant teaching strand. Teacher O-3 highlighted that these need to be sustained in the practice for students' continuous learning of motor skills:

"FMS games/activities as warm-ups during lessons to remind the student of the correct technique for the various skills and also to reinforce these skills as they need to be practiced on a continuous basis both in isolation and as part of different games." (Teacher O-3, F)

In line with the weekly log records, teachers reflected that for the continued use of Project FLAME, they would adapt to fit better within their teaching practice. Some suggested that these adaptations could be collected and formalised into regular updates of Project FLAME resources. Teacher M-1 mentioned project resources to include examples for children with special needs:

"Would be great if there were some suggestions for the kids who need to be more challenged. Wheelchair users, only that person cannot do a jump but just videos for relevant FMS and them being done in similar circumstances. If these were available." (Teacher M-1)

Teacher M-5 suggested that the ongoing development of Project FLAME can be done by setting up a liaison between schools and the research team. This person can act as a '*FLAME ambassador*' who collates feedback in the school and regularly meets up with the research team, then brings back the updated resources to the school:

"To be kind of continuously developing new, not only adaptations but advancements, progressions, and different games, different single activities, double activities or paired activities to be replenished maybe once a year. To have a flame teacher who will go to it every year and bring back the knowledge to the department."(Teacher M-5)

This was corroborated by Teacher M-6 who thought the project resources need to be refreshed to sustain students' engagement, which may have explained this teachers' negative survey response on the continued use. He would be open to use the project in the future if alterations can be made:

Just 'cause students like any of us, we need a break from things as well. Probably just needed to change a small bit of it. Like it was very good over the six weeks but they found at the end once we got to midterm, students

had enough of it and so maybe it just needs to be altered a little bit."
(Teacher M-6)

Apart from taking actions on Project FLAME itself to enhance its sustainability, there are other notable contextual factors that demonstrates the capacity for sustainability. These are presented in Table 7.9 below. Notably, three out of four interviewed teachers shared that, during the six-week trial, they were asked by other colleagues when they were seen delivering Project FLAME activities. This demonstrates the potential demand of Project FLAME for PE teachers.

TABLE 7. 10 THEMES AND ILLUSTRATIVE QUOTES IDENTIFIED FROM EACH DOMAIN FROM THE PROGRAM SUSTAINABILITY FRAMEWORK (LUKE ET AL. 2014)

Sustainability Domain	Description	Quotes
Environmental Support and partnership	Having a supportive internal and external climate. Teachers highlighted the importance of building and maintaining the network of teachers who are interested in motor skill development and Project FLAME. Through this network, Project FLAME can be disseminated wider and in longer term.	*"You're going to find teachers who are interested in this, particularly PE teachers. They tend to stay on top of what's going on. I think maybe targeting the PE conference getting a practical demonstration off there would be fantastic. And I think that would be really useful to disseminate it further." (Teacher M-5)* *"There's a good cohort of PE teachers like that. They are committed to doing this kind of stuff, anything that's concrete and have the resources." (Teacher M-6)*
Funding Stability	Establishing a consistent financial base for the project (meeting long-term needs, adjusting to changing trends, having a plan). No funding issues were raised, however teachers mentioned providing equipment may be preferred.	*"I think you would get a lot more interests in teachers around the country if there was FLAME pack delivered." (Teacher M-6)*
Organizational Capacity	Having the internal support and resources needed to effectively manage the programme. Teachers mentioned that having the leadership on board supports the sustained use.	*"So I think it is probably more important to talk to the head of the department of PE. If principal is from a PE background, they trusted department to think this is this is good idea to get involved in my school. And definitely they would say it's a good idea if they don't have to spend money and resource pack." (Teacher M-7)*
Programme Evaluation	Assessing the programme to inform planning and document results (staying on track with goals/outcomes, collecting	*"It's very informal throughout the year, but we are putting in place these kind of milestones throughout the year that we'd*

	data about successes/impact to gain support and funding). There are a mix of existing formal and informal internal exchanges on PE practice among teachers, which could be an infrastructure to build in ongoing evaluation for Project FLAME.	*say. OK, at the end of the first term, what's going right? What's going wrong? And so that's what we do. We do a mix of mostly informal, but then also having formal and evaluation meetings." (Teacher M-5)*
Programme Adaptation	Taking actions that adapt the programme to ensure its ongoing effectiveness. Examples of adaptations were presented in Section 7.4.2.3. Teachers need to adapt the project element to fit within their practice and class needs.	*"I would change some of them to make it more game-like." (Teacher M-2)*
Communication	Strategic communication with stakeholders and the public about the programme (internal and external). Hard copies of Project FLAME resources can be disseminated in PE offices and PE hall, for teachers' and students' use.	*"Maybe having a leaflet or something more physical that they could pin up in the room. As you can see here in the PE offices, we have things like (a white board)... Skill performance. Different stages marked out and then the skill cues just underneath that you know it could be a double-sided thing laminated. And you could put it off in the PE hall. That would be a fantastic resource." (Teacher M-5)*
Strategic Planning	Using processes that guide the programme's direction, goals, and strategies. There are planning meetings of the PE department in each school. In these meetings, teachers can share Project FLAME resources and plan the use of them for different teaching strands. One school is already planning to include Project FLAME in school-wide activities (i.e., wellbeing week).	*"One of our modules that we're thinking of bringing in next year for the first years incoming is fundamental movement skill development as a an opening block. Where we would then use some of the Project FLAME resource." (Teacher M-5)*

7.5 Discussion

The current study was conducted to a) describe and compare two modes of implementation of Project FLAME, b) investigate the impact of implementation strategies on the implementation outcomes, and c) explore the feasibility and sustainability of Project FLAME. Results of the evaluation provide details on the contextual influences on the implementation and offer insights into the potential of the sustained use of Project FLAME. The findings collectively revealed that implementation processes and outcomes, the mechanism of how implementation strategies

work, as well as the participant responsiveness to the intervention all differ. However, commonalities were found regarding fidelity to and engagement with core principles and elements of Project FLAME. Understanding of these contextual influences confirms that there is no 'one size fits all' when it comes to the intervention implementation.

7.5.1 Differences and similarities in the implementation outcomes between two groups

7.5.1.1 Teacher's self-efficacy

One of the major variations found between groups were teachers' changes in self-efficacy in response to the trial. Self-efficacy is a key influencing factor of quality PE delivery and teachers with high self-efficacy are more likely to overcome challenges faced in their teaching (Bandura 1993; Morgan and Bourke 2008). All teachers in the Original FLAME group improved their self-efficacy consistently, whereas teachers in the Modified FLAME group varied individually. This may be owing to that four out of five teachers in the Modified FLAME group were recent graduates with a Bachelor of Education (B.Ed) degree with a PE specialism, in which course motor skill development was a key learning outcome. During this course, they were exposed to the content and structures of Project FLAME in various means which may have given them the initial high level of self-efficacy. This was supported by the corresponding responses from all four interviewed teachers (who are recent graduates):

> *"At the time when I joined my undergrad like one of the big things, those kinds of fundamental movement skills and developing the fundamental movement skills…During my undergraduate, I helped data collection with Project FLAME…so I kind of had a good insight into what was going on before that training " (Teacher M-2)*

> *"And we did some stuff on FMS in our undergraduate degree, and I think it was the focus of one of two modules, so we have had some insights into it…" (Teacher M-5)*

> *"I would be quite familiar with FLAME anyway, but I found the workshop and the information session very good, but I think I had a good enough foundation knowledge on it anyway from being involved in their projects which are very helpful." (Teacher M-6)*

"I actually did it (the final year project) through Project FLAME as well...
It was kind of I had an awareness of the sort was going to be and the
different skills were involved, but there was no harm to have just kind of a
refresher." (Teacher M-7)

There are four sources to develop self-efficacy: enactive mastery experience (successful task completion), vicarious experience (observation of a task being completed successfully), social persuasion (positive feedback by others), and physiological and affective state (physiological indicants and mood state). As mastery experience is the primary source of self-efficacy (Bandura 1993), teachers' prior experiences in their undergraduate study appeared to have a major influence on this outcome. It was apparent that even before the training and delivering the intervention, teachers in the Modified FLAME group felt competent and confident in teaching motor skills. It is likely the PE specialism of their degree enabled opportunities (both in teaching and observations) that helped them to develop the necessary content and pedagogical knowledge and skills in, and appreciation of high-quality PE (Brennan, Bowles, and Murtagh 2021). A learning focus of MC development in the initial teacher education also enhanced their understanding of the topic (Lander et al. 2017a), so did exposures to Project FLAME through teachers' professional socialisation. These existing mastery and vicarious experiences related to motor skill teaching combined overall contributed to their high self-efficacy, which indicated that there may be less space for improvement for these teachers who have initial high levels of self-efficacy. Regardless, these teachers perceived the current trial as an opportunity for continuing professional development and reflective practice, demonstrated by their increased confidence in using Project FLAME content and resources (e.g., pedagogical cues, games) and tailoring their delivery to various challenges (e.g., a lack of equipment, students with varying needs).

Relatedly, a common pattern in the changes in self-efficacy was that Project FLAME seemed to have narrowed gaps among teachers' self-efficacy levels. Teachers, despite the

group allocation, who had relatively initial low levels of self-efficacy improved after the six-week delivery of Project FLAME. Delivering Project FLAME therefore appeared conducive to developing self-efficacy among teachers. The elements of Project FLAME, including the resource pack with pedagogical cues, performance criteria, and games, were accessed in the teaching preparation to get inspiration and increase confidence in delivering Project FLAME activities. The accumulated experience of preparing and delivering the project, as well as observations of students engaging with the activities, likely influenced teachers' self-efficacy overall.

7.5.1.2 Fidelity and adaptation

Teachers in both the Modified FLAME and Original FLAME groups implemented the intervention with good fidelity, adhering to the core principles of Project FLAME. In the current evaluation, in parallel to the measurement of fidelity, adaptations were also documented to expand on the context of fidelity (Bopp, Saunders, and Lattimore 2013). This model of assessment acknowledges that fidelity to the intervention and adaptation co-occur (Toomey et al. 2019), and in the context of this evaluation, it assisted in recognising which fidelity components are more context-sensitive than others. Combined with the adaptations notes that captured the multi-facetedness of fidelity, the findings generated a series of real-world implementation cases of under what circumstances, adaptations were made and what impacts they had. For instance, utilisation of pedagogical cues and provision of feedback seemed to be implemented across all teachers and schools with no adaptations, despite the individual and contextual variations. This may suggest that these two fidelity components are 'non-negotiable' to the project delivery, it may also indicate that these are essential elements of quality PE delivery recognised by all teachers involved in the intervention. Conversely, fidelity to the digital aspect of the intervention (e.g., using digital demonstration) was largely contingent on the technology and equipment available to the teachers, demonstrated by its poor fidelity

adherence. This revealed that there existed fundamental barriers to adhering to this fidelity component, which posed questions on the necessity of including digital demonstration in the project, and if the fidelity was to be achieved, more supports would be needed (e.g., providing digital equipment in addition to the project resource pack).

A notable finding in the fidelity assessment was the balance between fidelity and adaptation achieved by the teachers. As a result of the implementation strategy that encouraged adaptation, teachers in the Modified FLAME group may have felt more flexible in the delivery and reported more adaptations. Meanwhile, adaptations also occurred in the Original FLAME group without being prompted by the implementation strategy. This phenomenon confirms that adaptations are almost inevitable, especially in a dynamic PE environment, teachers need to make proactive decisions to ensure learning objectives are achieved by the students. One of the common goals for adaptations was to improve the feasibility and fit with the students. Teachers in the Modified FLAME group reported more adaptations to suit student needs and different skill levels. The reported adaptations showcased a diverse range of teaching models and styles, and potentially elucidated some pedagogical mechanisms on how to teach to a diversity of skill levels and interests. For instance, games and practice included in the project resources (that has basic and advanced levels of difficulty) were often set up by the teachers as different stations and let students decide which is the most appropriate for their abilities and motivations. Teachers' observations suggested that students tend to congregate with peers with similar levels of proficiencies, and in the weaker group, they engage in cooperative learning and work towards a common goal for improvement. Under this circumstance, the teacher would provide more feedback and pointers to facilitate the goal achievement (extrinsic motivation). Some teachers would also print out the project resources as skill cards, so that weaker students can practice, and identify errors and improvements among themselves. By contrast, in the stronger group, students tend to engage in competitions, teachers would then give little feedback in this

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instance and encourage students to discover alternatives to improve the performance (e.g., change the task and ask students to find a way to jump higher).

Teachers also made adaptations based on their prior training and experience. While there are no specific teaching models or styles suggested in the Project FLAME resources, these teachers creatively availed of existing resources (cues, games, criteria) and integrated them into different approaches catering to the different ways students learn (Mosston and Ashworth 2008). Teacher M-5 would help students link aspects of existing information to different tasks, for example, using recall and challenging students to apply previously learned skills into a new context (e.g., *can you incorporate the vertical jump into your gymnastic routine now?*). Teacher M-2, based on his understanding of ecological perspectives of skill learning, would make the most use of student-centred approaches and guide students to discover 'when' to apply the skills and 'what' worked best for themselves. Even though some adaptations skipped or substituted the fidelity component (e.g., teacher demonstration), they were appropriate in a particular context and helped achieve the learning outcomes, thus do not count as implementation failures. This reinforces the importance of documenting fidelity and adaptation, which builds the understanding of how, when, and to what extent programme are adapted, what new things are added, or whether parts of a programme are omitted (Durlak and DuPre 2008). This understanding can subsequently be translated into future refinements of project content and resources for better usability.

7.5.1.3 Participant responsiveness

While teachers in the Original FLAME group responded more consistently to the intervention, teachers in the Modified FLAME had mixed responses, likely due to the 'novelty effects' induced by the additional implementation strategies. For example, some teachers found the '*bank of resources*' provided on the website appealing and useful. However, the decline of

teachers' engagement with the website suggested that the perceived newness may have had an initial motivational effect on teachers but did not sustain over time. This could be explained by the fact that not all teachers were used to accessing online resources regularly or had time/equipment to do so. Furthermore, teachers felt it was questionable that students would use the website as intended since it is not a convention to assign PE homework. For this reason, some teachers did not provide the digital resources to students at all, and even other teachers did, they were not hopeful that students were making use of them. Teachers' observations were backed by the web analytics data, in that the website was rarely accessed by the students and their browse duration was probably too short to induce any meaningful engagement. This is perhaps related to the fact that PE in the junior cycle is not formally assessed which could hold students accountable, therefore there is no motivation for students to continue PE learning outside the school hours (MacPhail et al. 2018).

Student responses suggested that Project FLAME appealed equally to students from both groups. However, this needs to be interpreted with caution due to the imbalance of gender distribution between groups (i.e., more male respondents than female). It is likely that girls who responded to the survey had a predilection for PE, sports, or PA more generally. Encouragingly, there are common elements of Project FLAME that were found to have positive effects on teachers' and students' engagement in both groups. Students and teachers responded well to the games in the Project FLAME resources. Notably, Project FLAME activities were perceived as fun and enjoyable, which may have increased students' intrinsic motivation (Deci and Ryan 2012). Students' motivation was not only driven by the 'fun' aspect of the projects, but they also found Project FLAME useful in learning a new skill, improving performance, with recognition of these skills' transferability to other contexts. Specifically, students mentioned behavioural components of skills that helped them learn and improve skills, which showed that the project elements (performance criteria, cues) likely had a direct impact on

students' engagement. Teachers' qualitative data corroborated this observation, and teachers enhanced these project features in their teaching practice to keep students motivated. This is interesting compared with the review findings that students' responsiveness was mainly around enjoyment (see Chapter 4; Ma et al. 2021c). Moreover, both students and teachers enjoyed games and the integration of skills into a sports context that is influenced by their cultural predisposition, such as preference for Gaelic football and hurling.

7.5.2 Impact of implementation strategies

Based on the differences and similarities in implementation outcomes between groups, the impact of the proposed implementation strategies is discussed in this section. Strategy A (i.e., an online knowledge hub) and B (i.e., detailed introduction to the intervention and its delivery process) aimed to enhance teachers' self-efficacy by providing clear and quickly accessible information on project content, evidence-based benefits, delivery, and alignment with the curriculum. However, the difference of self-efficacy between groups was inconclusive, therefore it is not possible to support or negate the effectiveness of the implementation strategies. The reported pre-existing contextual differences between groups may have hindered the confidence to detect the true impact of the implementation strategies (as discussed in Section 7.5.1.1). Nevertheless, the intention of setting the website as an infrastructure ('knowledge hub') resonated among teachers in the Modified FLAME group. The website was described as a '*bank of resources*' where teachers could '*dip in and out of*' when they need ideas for new PE activities. In the broad literature, the benefits of online CPD are evident (Lander et al. 2020b, Lonsdale et al. 2021). Findings from teachers' interviews confirm that the structure of the website is appealing and demonstrates potential usability, however, the content and functionality of the website need to be carefully considered and regularly updated. For example, teachers suggested it is important to include videos examples of effective delivery

of Project FLAME PE lessons for teachers who have no experience and knowledge in motor skills.

Strategy C that explicitly encourages flexibility in the project delivery seemed effective in resulting in more fidelity-consistent adaptations. This finding is anticipated; firstly, the strategy requires minimum implementation (only during the training, and weekly reminders for teachers) and therefore was implemented fully. Indeed, previous research highlighted that implementation strategies need to be implemented with high fidelity to attain changes in outcomes (Wolfenden et al. 2019b). Secondly, adaptation was reported to facilitate teachers' delivery and ownership of an intervention (Lander et al. 2020), so by clearly justifying the need for flexible delivery for the teachers, Project FLAME was adopted naturally as part of the teaching practice.

Strategy D aimed to foster a community of practice in teachers, although the impact was not detectable because this strategy was not successfully adopted by teachers in the trial. This may be due to teachers' fatigue to the virtual environment post COVID-19 lockdown, during which teachers have intensively engaged in online teaching and meetings (Mercier et al. 2021). It also highlights the complexity of integrating technology within PE, whereby the practical nature of PE teachers' work needs to be acknowledged. As aptly put by a teacher's comment, "*when you spend half time out on a field, you can't have your head in an iPad.*" The other cause unpacked in the teachers' interviews, was that all PE teachers belong to a community that they are familiar with (e.g., graduates from the same course), and this existing community of practice was deemed sufficient so they may not need to expand their network further. However, it was also mentioned that such networking could have happened more organically in face-to-face meetings. In hindsight, if the training was held in person, this strategy could have had a wider uptake among teachers. There are ongoing debates on the

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effective CPD for PE teachers (Goodyear et al. 2021, Casey and Goodyear 2015), although it is beyond the scope of the current study. Compared with teachers, students were even less engaged with Strategy D which aimed to facilitate the continuous learning of skills. As teachers suggested, it is not a convention for students to engage in extracurricular PE learning. Given PE in the junior cycle is not formally assessed and a lack of student assessment in the current trial especially, students were not motivated to engage with Project FLAME outside school hour. In the discussion with teachers during the training, the research team suggested including a final assessment to bring all learned skills together at the end of the six-week block, although this faced resistance from teachers due to clashing with mid-term exams. Taken together, despite the effort in the design and planning for the implementation strategies with the stakeholders, strategy D was not universally successful. Apart from the contextual challenges described above, a missing part in the development of the implementation strategies was the student's input. Congruent with a recent investigation on students' perception of a supplemental online PE curriculum, students found it difficult to appreciate the value of the online content without relating to their own lives. Moreover, in the same study, students pointed out the contradiction of engaging in an online course sedentarily to learn how to be more active (Killian and Woods 2021).

7.5.3 Feasibility and sustainability of Project FLAME

Both modes of implementation of Project FLAME were perceived as highly feasible by teachers. Findings on implementation outcomes highlighted that Project FLAME is an adaptable programme that can be taken as a whole or in part. Triangulation of implementation evaluation data allowed for the disaggregation of different components of Project FLAME and identify 'non-negotiable' features that have the potential to be implemented for a longer-term. These features include pedagogical cues and games that can be integrated into short-term lesson planning. Teachers reported that Project FLAME activities were often included as part

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of the warm-up in PE lessons and helped identify skill levels among Year 1 students who just entered post-primary education. Most importantly, Project FLAME provided a bank of resources that inspired teachers to include a variety of activities that enables effective teaching and learning to help students continuingly improve skills.

The findings of the current study also highlighted the complex interconnections of influences on sustainability. While research reported the variations in teachers' perceptions of the sustainability of school-based PA programmes (Nathan et al. 2021). Project FLAME has great potential to be sustained in teachers' practice, and even at the school level, provided careful considerations on the capacity for sustainability can be made. Integrating Project FLAME in medium- and long-term PE planning is influenced by national mandates, guidance, and recommendations from the professional bodies (e.g., Physical Education Association of Ireland). Students (aged 12-16 years) that Project FLAME targets are in the junior cycle education in the Irish curriculum. In this cycle, PE aims to "develop students as knowledgeable, skilful and creative participants who are confident and competent to perform in a range of activities safely" and should provide learning opportunities that contribute to six well-being indicators-Active, Responsible, Connected, Resilient, Respected and Aware (NCCA 2016). It is also worth mentioning that the curriculum models provided in the junior cycle framework are highly flexible, which values students' voices and provides schools and teachers with autonomy to design their programmes to meet the needs of the students (NCCA 2016). In this general context, Project FLAME has the potential to cultivate student awareness of movement opportunities due to its perceived utility in motivating and helping students to develop skills (as reported in Section 7.4.2.5). Teachers reported that in the school planning meetings (e.g., PE Subject Learning and Assessment Review meetings), Project FLAME elements could be considered to direct the goals and strategies for the school curriculum, as well as school-wide activities, hence identifying opportunities to improve student wellbeing as stated in the national

curriculum. This type of meeting is an important step to build capacity to sustain Project FLAME, which needs internal support from the school leadership team. Some school leaders in the current evaluation have a background in PE, which was considered conducive to developing and sustaining effective PE practice in schools. The aforementioned planning meeting was also a platform for teachers to undertake informal evaluations of PE classes and exchange effective practice. This is a promising avenue for Project FLAME activities to be evaluated on an ongoing basis, as there were already initial interest among teachers for the intervention as were shared in the teacher interview. The perceived demand of the intervention is another key determinant of the sustainability of MC interventions (Lander et al. 2020b).

To improve the feasibility and sustainability of Project FLAME, teachers underlined the need for Project FLAME to be further refined, embedded, and scaffolded into the PE teaching strands in the Irish PE curriculum. As specified in the junior cycle framework, PE is structured around four strands, PA for health and wellbeing, Games, Individual and team challenges, and Dance and gymnastics. All four strands need to be taught in equal weight to ensure a developmentally appropriate programme (NCCA 2016). Teachers reflected that Project FLAME resources need to explicitly specify how each skill and resource can be integrated into which strand. For example, in the reported adaptations, teachers included skill performance in gymnastic routines and set up team challenges that motivated students' learning and improvement.

The curriculum for the junior cycle is non-examinable and involves ongoing classroom-based formative assessment (NCCA 2016). Students are placed at the centre of the assessment for they can gather evidence of learning through each strand and submit this evidence along with a short reflection to the final assessment. Project FLAME appears to assist in this process because teachers appreciated the use of Project FLAME to identify areas of improvement. For

example, the performance criteria in the project resources provided teachers an opportunity to observe and identify exemplars of students' MC at different levels. By identifying areas of improvement, teachers can design developmentally appropriate strategies for students to lead on their movement journey. This advantage of Project FLAME is of salience when teachers adopted student-centred pedagogy, where students can explore what are meaningful and motivating experiences for themselves (Cairney et al. 2019, Whitehead 2020).

7.5.4 Summary – What keeps FLAME lit?

This evaluation set out to uncover what influences the implementation, feasibility, and sustainability of two modes of implementation of Project FLAME. The project, despite the implementation modes, was successful in improving teachers' self-efficacy in teaching motor skill focussed PE. A worthwhile finding is that integration of Project FLAME into routine teaching practice requires adaptations to meet contextual and student needs and these adaptations represent key mechanisms and contexts to consider for the refinement of Project FLAME. Irish post-primary school PE continues to shift towards more nuanced and less prescriptive teaching and learning experiences (MacPhail et al. 2018). In this transition, a highly adaptable programme such as Project FLAME has great potential to be sustained in teachers' practice. Project FLAME can potentially be refined and put forward as a guide to support the delivery of post-primary school PE. Recently, a team of Irish PE researchers proposed a new curriculum model (PE4Me) that is undergoing national dissemination (Belton et al. 2022). The original intervention programme (Y-PATH) which PE4Me evolved from share similar principles with Project FLAME regarding supporting PE teachers to help students develop PA and MC. The efforts in this evolvement (i.e., from Y-PATH PE4Me), including multiple iterations of the programme, collaboration with stakeholders, and alignment with the national curriculum, offer much to learn and existing infrastructures to bring evidence-based interventions to PE's redesign (Lawson 2018).

No interventions can be perfectly constructed, or indeed, tested over an infinite period. Successful implementation relies on congruence with the preference and priorities of those who shape, deliver, and participate in the programme (Proctor et al. 2010). Throughout this evaluation, teachers have been active participants in delivering, adapting, and evaluating the intervention. By documenting the implementation process, teachers engaged in reflective practice that helped recognise teaching that promotes learning. The diverse range of fidelity-consistent adaptations reported by the teachers demonstrated the highly-adaptable nature of Project FLAME, which promises its dynamic sustainability (Chambers, Glasgow, and Stange 2013). It also suggests that, by documenting the adaptations of the project delivery, teachers were exploring and understanding their own experience and beliefs as PE teachers, thus developing the skill of reflexivity required for the pedagogical approaches to evolve (evidenced by the increased levels of self-efficacy) (Rief, Oesterhelt, and Amesberger 2022). Therefore, it is through teachers' reflective process that the implementation and sustainability of Project FLAME can be promoted in a naturalistic way. In contrast with the static view of sustainability, the evidence presented in this evaluation has suggested that the ideal scenario of a sustained Project FLAME is the project being continuously refined and improved over the long term. As discussed earlier, records of adaptations generated a series of refinements for Project FLAME; if a feedback loop could be created for teachers and the research team to exchange knowledge and practice, the intervention could be improved over time. The candidate, therefore, contends the true sustained implementation of Project FLAME lies in the ongoing development, evaluation, and adaptations in diverse school contexts.

7.5.5 Strengths and limitations

One strength of this study was the use of mixed methods and measures from multiple sources, to provide a comprehensive understanding of the intervention implementation. The study has demonstrated that rigorously designed and conducted evaluations are needed to capture what

works and how which can be considered for project refinement. Teachers, by collaborating on the design and evaluation of the trial, are active participants in the scientific process. Such a participatory approach was reported to have a positive impact on planning for the sustainability of an intervention (Jull, Giles, and Graham 2017). It is also worth noting that all data collected in this evaluation were analysed and interpreted, meaning that 'research waste' was kept at a minimum. This demonstrates the benefit of considering and planning implementation evaluation early on with clear evaluation aims. Another strength is the assessment on the sustainability capacity when there were limited resources and time available to conduct long-term follow-up. This assessment supports decision-making on key issues such as whether the intervention is suitable for scaling up (Milat et al. 2020).

Potential selection bias is also acknowledged. Schools volunteered to take part in the current trial and therefore participants may already have a greater interest in Project FLAME and consequently report a positive experience. An additional limitation concerning sampling is the imbalance of the sample size of boys and girls between groups. This was by chance and unanticipated. Although teachers' choice to attend one of the two training days and the consequent group allocation were not restricted to any criteria, this was not a strict randomisation procedure given the pragmatic nature of the evaluation. Retrospectively, the imbalance between the two groups could have been minimised by stratification, e.g., by matching the numbers of all boys and all girls schools. However, through the evident variation in implementation outcomes across schools, data provided by teachers and students were a fair representation of their experience. Additionally, the triangulation of data from multiple sources helped to minimise the social desirability bias. Lastly, due to the timing of the evaluation (school returning from the COVID-19 lockdown), emergent challenges in schools may have influenced teachers' and students' engagement with the project. Nevertheless, these challenges were documented in this report and contributed to understanding the wider context. Also due

to the various pandemic-related measures in place, and the lack of access to policy levers, it was not possible to implement and evaluate the classroom component (i.e., motor skill focussed movement break) of the intervention and address the barriers present at the government and institutional level.

Chapter 8. Synthesis of findings

Thesis Map

Chapter	Objective(s)	Key findings and implications
4. A systematic review of process evaluation of MC interventions	Objective 1: To examine the extent that process evaluation has been used in MC interventions and what influences MC intervention process(es).	• Process evaluation is not sufficiently used or adequately reported in MC interventions when used. • Influences on MC intervention processes and outcomes are wide-ranging and include intervention characteristics, and individual, organisational, and system-level factors. • A wide range of typologies of process evaluation outcomes and measures were identified, along with their collection methods. These include measures relating to implementation, mechanism of change, and contextual influences on an intervention. However, it was insufficient to fully understand the implementation of MC interventions given process evaluation is underused. Further experimental studies are warranted.
5. Using an applied systems sciences method (Collective Intelligence) to understand the implementation and sustainability of MC interventions	Objective 2: To explore the barriers to the implementation and sustainability of MC interventions and their interrelationships, as well as identify solutions to address barriers.	• A total of 76 barriers to the implementation and sustainability of MC interventions were identified, these barriers are related to policy, physical education curriculum, and individuals' self-efficacy, knowledge, and appreciation. • The interrelationships of these barriers were described in barrier systems, which provided help to navigate through the complex influences on MC intervention implementation. • The roadmap of actions revealed the ecological context of MC intervention and provides critical components that need to be considered when designing, operationalising, and evaluating MC interventions.
6. Developing implementation strategies and a protocol for implementation evaluation of a MC intervention	Objective 3: To develop strategies intended to improve the implementation of a MC intervention. Objective 4: To plan, design, and conduct an	• Findings from Chapter 4 helped frame implementation outcomes in the evaluation protocol. • Findings from Chapter 5 helped develop strategies to improve the implementation of a specific MC intervention.

	implementation evaluation of a MC intervention using strategies developed.	• Informed by the barrier system generated from CI, fidelity/adaptation, teachers' self-efficacy, and participant responsiveness were identified as driving influences on the implementation of this MC intervention. • The development of implementation strategies and evaluation was in accordance with the PRACTIS guide, which demonstrated a rigorous process to plan and design an implementation evaluation.
7. Outcomes of an implementation evaluation of a MC intervention	Objective 5: To report on the effectiveness of strategies intended to improve the implementation of a MC intervention. Objective 6: To understand the process(es) and factors impacting the implementation and sustainability of a MC intervention.	• The evaluation identified key mechanisms and contexts to consider when planning for the implementation and sustainability of a MC intervention. • Implementation strategies did not seem to be universally effective in improving the implementation of Project FLAME, except for the strategy to encourage the adaptation of the project content and resources. • The adaptations provide a list of future areas of improvement for the MC intervention, highlighting contextual considerations when delivering the intervention (teaching to a diversity of skills, interests, dealing with implementation challenges, etc.)

8.1 Introduction

Framed by the overall PhD aim (see Figure 3.2 and thesis map), this chapter synthesises the findings from previous chapters, provides a discussion of the contribution to knowledge and considers their implications. It then provides a reflection on the research process and methodology applied in this PhD research. Lastly, concluding remarks are provided.

8.2 Summary of findings

Many efficacious interventions (predominantly school/PE-based) exist which improve MC in children and adolescents, with medium to large effect sizes reported in meta-analyses (SMD = 1.42 as reported in Morgan et al. (2013) and Hedge's g = 0.69 as reported in Lorås (2020)). Despite this, less than 50% of children achieve the skill proficiency expected for their age

(Bolger et al. 2020). The impetus for this PhD research arose from practical questions concerning how MC interventions can be effectively implemented to improve MC at a population level. The thesis has considered, in detail, the understanding of the process(es), factors, and strategies relevant to improving the implementation and sustainability of MC interventions.

The work in this thesis represents an original contribution concerning implementation evaluation of MC interventions, which has been previously overlooked in MC literature. For the first time, the use, reporting, and outcome of process evaluation has been investigated in published MC interventions (**Chapter 4**). The following experimental chapter (**Chapter 5**) focussed on the process of identifying implementation barriers, their interrelationship, and corresponding solutions. **Chapters 6 and 7** focussed on a specific MC intervention (Project FLAME). By utilising learnings on the complex interrelated influences on MC interventions, these two chapters reported an evaluation to gain understanding of the specific process(es) and factors impacting the implementation and sustainability of Project FLAME. To sum, this PhD began by examining implementation evaluation in MC interventions broadly and then narrowed the focus to a specific MC intervention to provide a deep analysis of its implementation process. The findings collectively shed light on the complex and interrelated influences on MC intervention processes and outcomes and demonstrated how to address such complexity in a research context.

The systematic review (**Chapter 4**) was the first to examine the use of process evaluations in MC interventions. The findings identified the typology of evaluation outcomes and measures for researchers' considerations to enhance the reporting of implementation evaluation of MC interventions. The systematic review also attempted to establish and quantify the relationship between MC intervention processes and outcomes, which highlighted the wide

range of contextual influences specific to MC interventions. However, due to the inconsistency in reporting MC intervention processes, it was difficult to understand how exactly MC interventions outcomes were affected by the processes and how this may translate to the improved implementation. This warranted the further need for experimental studies.

Chapter 5 subsequently directly probed the questions on the implementation and sustainability of MC interventions. It firstly rationalised the application of a co-production systems science approach—CI and evidenced its usability in understanding MC interventions (**Chapter 5 Part 1**). This part makes a unique contribution to the MC intervention research and implementation research, for it provides a novel tool and working process for unpacking the interrelated influences on the implementation and sustainability. In **Part 2 of Chapter 5**, CI was used with stakeholder groups in three different MC intervention contexts. By synthesising expertise and experience from researchers and practitioners, the study not only helped identify the barriers to the implementation but the interrelationships between them. The visual representation (the barrier system) presented the underlying dynamics of the various factors that impede the intervention implementation and put forward an opportunity for the stakeholder groups to create solutions in a logical manner, which resulted in a roadmap of actions corresponding to the barrier system. The application of CI made a unique contribution to developing a better understanding of how systems approaches can be applied within intervention evaluations.

Findings derived from the preceding chapters were applied in **Chapter 6** to design implementation strategies that addressed barriers specific to a MC intervention (Project FLAME), and an implementation evaluation protocol to examine what impacted the intervention processes and how. This process demonstrated the value of the study conducted in Chapter 5, the barrier system directed attention to the three evaluation priorities specific to

Project FLAME (i.e., teachers' self-efficacy, fidelity and adaptation, and participant engagement). Of note, the evaluation strategies and measurement addressed several issues reviewed in Chapter 4. One issue was the concurrent measurement of fidelity and adaption, which offered a realistic view of the intervention implementation. The other issue was the use of a theoretical implementation framework (i.e., the PRACTIS guide) that was reported to be inadequately used (see Chapter 4), which enhanced the rigour in this developing process.

By examining the 'black box' of MC interventions, it is hoped that this thesis has shown the importance and benefits of conducting implementation evaluation and shed light on some actionable principles of practice for researchers and practitioners to support the implementation of MC interventions and potentially school-based PA programmes more broadly. These implications are discussed in the following sections. If considered or implemented, these implications have the potential to expand the limited understanding of the implementation and sustainability of MC interventions, as well as to leverage effective motor development opportunities as an embedded part of school-based PA and/or PE.

8.3 Implication for research

As reviewed in Chapter 2, implementation evaluation is an important means to facilitate the translation of evidence-based research to practice. The rapidly evolving research in both fields of MC interventions and implementation science present plenty of possibilities for bringing effective research into practical contexts to improve children's and adolescents' MC. However, there seems to be a disconnect between the two fields of exploration, potentially due to a lack of awareness, appreciation, and support for researchers (Koorts et al. 2020). These challenges relating to the knowledge and appreciation are reflected in this thesis, including the under-utilisation of evaluation frameworks in published studies (as reported in Chapter 4) and researchers' lack of experience and knowledge in programme evaluation (as reported in

Chapter 5). Due to these challenges, there is often a lag in research dissemination behind the research publications (Lee et al. 2021). Thus, this PhD research presents a timely effort to show the research community (particularly in motor development) 'what' is out there (via presenting the research findings) and 'how' to address the implementation gap (via documenting the research process). More specifically, this research is intended to lay out options and stimulate the field of MC intervention research toward implementation science. As the field matures, the accumulating evidence on the implementation and sustainability will pave the way for proposing potential solutions to bridge the gap between research and practice. The implications for research are summarised in a concise checklist (Table 8.1), which includes research questions that may be critical to understanding the implementation and sustainability. This list represents a culmination of findings across the PhD and provides researchers a useful summary of considerations when evaluating a MC intervention. The list includes two sets of critical research questions to consider ("essential" or "desirable"), in which essential considerations are achievable in a timeframe of a project/funding cycle whereas desirable questions are suitable for when there are ample research capacity and timescale in a project.

The candidate is aware of the variety of research paradigms different researchers may employ in conducting MC intervention research. By spotlighting the implementation processes and outcomes in MC interventions, this research does not intend to dismiss the importance of the conventional way of measuring intervention effects (e.g., pre-post changes in MC levels under a controlled experimental setting). In fact, the inquiry to establish the efficacy of a new intervention will always be relevant. Therefore, this checklist is by no means to be imposed on researchers, rather it encourages researchers to conceptualise the implementation and sustainability of a MC intervention from the conception, instead of having it as an afterthought. Moreover, this list does not add to the multitude of existing implementation theories and

frameworks, instead, it is purposed to be an applied tool pointing researchers in the direction

that may unpack valuable learnings from an intervention.

TABLE 8. 1 KEY CONSIDERATION FOR RESEARCHERS WHEN EVALUATING MC INTERVENTIONS (AN IMPLEMENTATION EVALUATION FOCUS)

	Essential	Desirable
Define	What are the quantity and quality of what is delivered? (consider intervention reporting standards)	Which mechanism will make the greatest impact? (test mediation and moderation)
	What information should we gather and how, to understand how the intervention works and under what conditions? (consider mixed methods process evaluation and evaluation aims)	What outcomes should be tracked for intervention implementation? (establish progression criteria for implementation)
	What are the key hypothesised mechanism/principles of the intervention? (consider intervention logic models)	
Engage	Who are the key stakeholders we should engage and involve in the evaluation? (consider stakeholder engagement or co-production prior to the intervention)	Who are the key stakeholders we should engage and involve to sustain the intervention?
		What are the communication strategies?
Identify	What are the critical barriers to the intervention implementation? (consider implementation determinant frameworks)	What are the solutions to address the critical barriers to the intervention implementation? (propose implementation strategies)
Evaluate	What are the non-negotiables of the intervention implementation? (consider core principles of an intervention)	Are proposed implementation strategies successful and can they be sustained? (consider long term follow up evaluation)
	How do participants respond to the intervention? (consider participant responsiveness)	
	What are the adaptations made during the intervention, and what are the implications to the intervention mechanism? (consider fidelity/adaptation issue)	What does sustained implementation look like? (considering measuring the capacity for sustainability)
	Will intervention apply to other settings? (consider intervention context)	

Key findings arising from the present PhD research can be used in designing

experiments to answer questions proposed in the checklist. For example, in defining

implementation outcomes, the typology of evaluation outcomes and measurements reported in

the systematic review (Chapter 4) can signpost researchers to select relevant and feasibility process measures specific to MC interventions. When identifying barriers, factors identified in the systematic review (Table 4.7) and barrier categories (Table 5.5) provide a catalogue of common contextual influences on MC interventions. When developing solutions, the road map of actions (Figure 5.4) provides a set of conceptual clusters for researchers to consider what actions may work at what level of influence. Finally, the novel co-production approach reported in Chapter 5 presents a feasible and valid approach for stakeholder engagement in a specific intervention context. Uniquely, these recommendations were developed in this PhD in line with the theories and terminology used in implementation science. If adopted in the reporting of MC intervention evaluations, it can help researchers to report MC interventions more consistently and allows the evaluation outcomes to be more widely disseminated and compared in the broad literature.

As reviewed in Section 2.3, a considerable amount of frameworks and checklists in implementation science exist. Of note, these are generalised theories and need to be adapted to specific implementation contexts for their appropriate use (Damschroder 2020). The development of the checklist in this thesis is grounded in a specific intervention context, that is, school or PE-based MC interventions, therefore it overcomes some limitations of pre-existing frameworks as it explicitly considers implementation determinants and outcomes of MC interventions. Different from evaluation frameworks used in PA interventions such as Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework, this checklist is less structured which can be used more flexibly in evaluating diverse interventions. More importantly, the checklist prompts the consideration on *improving* instead of just *evaluating* the implementation.

8.4 Implication for policy and practice

8.4.1 Identify and utilise emergent evaluation findings

As the Greek philosopher Heraclitus proposed, "the only constant in life is change". Throughout this PhD research, a common theme found is that intervention implementation is complex and will always need adapting. Evidence and research process presented in this thesis have demonstrated that conducting implementation evaluation can capture these changes in the intervention process and provide meaningful learnings to optimise the intervention and maximise the potential for the intervention to be sustained.

Teachers, the primary changing agents in the MC interventions focussed on in this thesis, have constantly changing ideas, beliefs, professional theories, and values about teaching (Tsangaridou 2006). Under these circumstances, implementation efforts need to be assessed on an ongoing basis and the outcome could help to establish implementation progression criteria and subsequently, an accountability system, to build awareness around what elements of interventions are being assessed and taking effect (Klepac Pogrmilovic et al. 2020).

Ongoing evaluation requires a partnership between research and practice. Such a partnership is considered as 'soft' infrastructure that offers opportunities to design and implement strategies in response to the changing contexts of an intervention (Kavanagh et al. 2022). The research process documented in this thesis has shown that a co-production process with researchers and practitioners can identify the driving influences on implementation efforts, help build a common understanding of the intervention aim, and identify adaptations to refine the intervention further (see Chapter 5-6). The findings suggested that the implementation and sustainability of a MC intervention is a continuum (see Chapter 7). Top-down approaches to an intervention that prescribe discrete practice recommendations are too regimented to fit to and have less powerful leverage in changing the practice on the ground.

This is because the practice is enacted by individuals who are constantly learning and adapting. Therefore, policies at the government and institutional levels, as the driving influences on MC interventions as identified in this thesis, should include flexible strategies that allow for practice to evolve and adapt. As reflected in Chapter 7, the flexible curriculum models offered by the national PE framework may have created a conducive environment for teaching adaptations. Moreover, the partnership should also include professional organisations (e.g., Physical Education Association of Ireland, Association for Physical Education) since they have a firm understanding of practitioners, having the recommendations endorsed by these organisations can enhance the buy-in of the strategies the intervention advocates for. In this way, it is more likely to identify effective practice-relevant evidence and disseminate them for wider uptake.

8.4.2 The power of reflective practice

This thesis showed that the implementation and sustainability of MC interventions come in different forms and configurations. In the implementation trial (Chapter 7), implementation efforts varied by individuals. Teachers' interpretations of the intervention and curriculum differed, which resulted in variation in localised implementation. Although the intervention aim was clarified before the trial, the implementation was still driven by individual experience and belief (as was reported in Section 7.4.2.4). Teachers' delivery was an open, emergent, and reflexive process where teachers were finding the balance between fidelity and adaptation (as was reported in Section 7.4.2.2). Nevertheless, teachers reported context-specific adaptions that are highly relevant to increasing the ecological validity of the intervention. Documenting students' learning, teachers' use and adaptation of the intervention and the wider context, naturally, facilitated the understanding of PE teaching and self-efficacy improvement. These learnings would not have been possible without their conscientious efforts in documenting the implementation process. As reported in Chapter 7, the teacher's log was considered as a means of reflective practice, whereby teachers critically reflected on how implementing Project

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FLAME differs from their routine practice, what worked and did not work for them, as well as student learning. Meanwhile, whether supported by the implementation strategies or facilitated by the organic conversation through meetings with peers, PE teachers voiced the need for a community in which to reflect. This view is corroborated by a prior review of PE teachers' reflective practice (Standal and Moe, 2013).

Reflective practice is an important educational discourse (Tsangaridou and O'Sullivan, 1994), the evidence presented in this thesis have demonstrated the importance to support PE teachers' reflective practice and showed a way of how to. The implementation evaluation encouraged teachers to reflect on students' learning and enjoyment of Project FLAME PE lessons. These reflections then guided teachers to make adjustments in the teaching practice. This reflective practice may be an important means and infrastructure to identify and utilise emergent evaluation findings as aforementioned. In the implementation trial (Chapter 7), some enthusiastic individuals proactively sought continuing professional development opportunities and engaged in reflective practice, recognising, and mobilising the autonomy at individual levels may help identify key processes and practice needed to practically deliver interventions over the longer term. In the context of Project FLAME, these individuals were recommended to champion the implementation at schools and act as a liaison to promote knowledge exchange between schools and the research team.

8.4.3 A systems perspective and co-production

As demonstrated in this thesis, a systems perspective certainly facilitated the understanding of the 'unknown' and 'messy' influences on the implementation of MC interventions (Chapter 5). Combining researchers' expertise and knowledge with practitioners' real-world understanding of practical constraints can help decision-making in improving and evaluating the implementation (Chapter 6 and 7). As we shift to a system-wide focus in public health research

(Koorts and Rutter 2021, Rutter et al. 2017, Reis et al. 2016), findings in this thesis highlighted a wider influence in the system that promotes or demotes motor development opportunities for young people.

As reported in Chapter 4, the majority of MC interventions are school or PE-based, this PhD research inevitably has a focus on the role of PE and teachers in implementing MC interventions and promoting students' MC development. However, it must be noted that PE does not equate to MC development, or indeed PA promotion (Bailey et al. 2022). Teachers and PE alone do not seem to be sufficient in advancing MC of all students, and over the longer term. As reported in Chapter 7, despite students' engagement and enjoyment in Project FLAME activities, only approximately half would consider the skill practice outside school hours. This called for consideration of the multiple aims and aspirations of PE and what contributes to fulfilling these aims. Research suggests PE should focus on the holistic aspect of a child's development, which encompasses the affective, cognitive, physical, and behavioural aspects (Bailey et al. 2009). This notion is theorised to equip students with the 'motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engaging physical activity for life, also known as physical literacy (International Physical Literacy Association 2017). Many national recommendations have endorsed this holistic concept of physical literacy as an underlying aim and rationale of PE (UK Department for Education 2019, National Assembly for Wales 2019, NCCA 2021). Linking back to the development models presented in Chapter 2, each child is on their own journey of motor development, PE plays a role in ensuring every child makes progress on this journey (Whitehead 2020). This implies that irrespective of interventions or PE, these initiatives are only part of a broader strategy in public health, education, or both (Dudley et al. 2020). Thus, promoting and sustaining positive improvements in health outcomes among children and adolescents require coordinated efforts.

As depicted in all barrier systems presented in Chapter 5, the driving influences on the implementation and sustainability of MC intervention operate across multiple levels and stakeholders, which agrees with Bronfenbrenner's biological systems theory of development (Bronfenbrenner 1986; Figure 2.4). In light of this, this thesis has revealed some system-level influences and proposed potential ways to create systems changes to implement and sustain MC interventions (as shown in Figure 5.10). For example, in Chapter 5, stakeholders identified that a learning collaborative for teachers and parents to share knowledge regarding the healthy development of children can help create opportunities for students' continuous learning and movement experience. Consistent with a previous review finding, MC interventions with at-home practice components and parental involvement appeared more efficacious than school PE alone (Tompsett et al. 2017). Undoubtedly, parental beliefs and values have an impact on children's MC through encouragement and provision of practice opportunities (Jarvis et al. 2020). By the same token, findings from Chapter 5 suggested that without allocating resources and dedicating time to implement interventions or having consensus on an ethos that underpins the intervention aim, teachers' practice and perceptions adopted from the intervention are less likely to persist. As per an example discussed in Chapter 7, Project FLAME, as a highly adaptable MC intervention, was perceived feasible and sustainable partially due to the varied and flexible nature of the Irish PE curriculum.

These wider influences were identified in Chapter 5 but it was not possible to address them all in the scope of this PhD. As a limitation highlighted in Chapter 7, this PhD does not have access to policy levers, and the restrictions brought by the pandemic eliminated the possibility to collaborate with external organisations at the time (e.g., sports clubs, Gaelic Games Association). Nevertheless, the application of stakeholder co-production has successfully generated an understanding of the barriers impeding the implementation and sustainability of MC interventions and options to overcome the barriers. The CI process

demonstrated that a problem may be complex, but a relevant solution can be proposed when a group of stakeholders were facilitated to navigate through the interrelationship between barriers (see Chapter 5, Part 1). There is growing recognition of co-production in exercise and health sciences (Smith et al. 2022). Framed by the typology of co-production proposed in Smith et al., CI utilised in this PhD research is instrumental in harnessing expertise, knowledge, and experience from academics and practitioners, thus producing means of integrating knowledge translation. The Project FLAME trial regarded teachers as active participants in the evaluation and emphasised teachers' practical experience and knowledge as one of the main outcomes of interest, which contributes to shaping and optimising the project with teachers' experiential knowledge (Smith et al. 2022). Yet, as a result of a series of co-production, the implementation strategies proposed in the trial were not universally successful (see Section 7.5.2). This stresses the need to include wider stakeholders in the ecological context of interventions when using co-production approaches, which ensures social and physical environments are maintained to provide opportunities for MC development. First, exploring students' experiences and voices and aligning those opportunities provided is critical (Coulter et al. 2020, Ní Chróinín et al. 2021). Findings concerning student responsiveness in the evaluation (see section 7.5.1.3) provide directions on what intervention features may be needed and enhanced in the future iteration of Project FLAME. Secondly, stakeholders that play decisive roles (e.g., school leadership, policymakers) need to be included to identify strategy and capacity for uptake and sustainability that are aligned with the institutional aim or political agenda. Recent evidence from implementation research suggests incorporating environmental and political context into the implementation planning from the outset (Lee et al. 2020, Koorts et al. 2022). Overall, combining a whole-of-school approach with systems perspectives may assist in identifying critical players and components needed in achieving implementation success.

8.5 Reflection on this thesis and future research

Reflections on the strengths and limitations of each study have been provided in the preceding chapters. This section reflects on the strengths and limitations of this PhD research in its entirety, and subsequently provides directions for future research. Through the research process of unpacking the 'black box' of MC interventions, this PhD research represents a dynamic problem-solving process to address the complexity of this topic, specifically through the systems-based stakeholder-driven co-production. This was a key strength that resulted in findings and implications of practical relevance that represented views from stakeholders. The inter-disciplinary applications of implementation theories and frameworks in motor development research was another strength, which promoted methodological development concerning evaluating MC intervention effectiveness. The dissemination of research outputs arising from this thesis has made an initial impact in motor development research, evidenced by citations in an expert statement on MC among children in the UK and Ireland (Duncan et al. 2022), a movement and physical activity-related policy analysis in five Nordic countries (Sollerhed et al. 2021), and some intervention studies (Philpott et al. 2021a, Gavigan et al. 2021). It was the candidate's pleasure to see the research being acknowledged and applied in a research context, which in turn inspired the candidate on the potential implications and contribution this PhD research can make. The candidate also proactively sought public engagement opportunities to disseminate via other non-academic media with an aim to reach the community of practitioners. These activities include an invited UK Coaching podcast to discuss how to embed strategies to PE and coaching practice in engaging children's learning and the creation and dissemination of infographics to increase the reach of research implications (see Appendix 22 for infographics).

Some limitations are worth noting. As discussed in the previous section, the broader community and stakeholder engagement would have been beneficial in creating system-level changes. Although the CI study and implementation trial involved public health practitioners and teachers who don't have a research background and accounted for their experiential knowledge, a more diverse sample would have generated more practice-based evidence for the research. For example, school leadership was acknowledged as an important lever in creating and sustaining organisational changes, but no school leaders were included in the study sample. This is partially due to the pandemic-related travel and social restrictions that impeded the candidate's ability to build stakeholder relationships with schools and teachers in person.

This PhD research presented a linked narrative, in which each study addressed research objectives that feed into the overall research aim. Consequently, the PhD had limited use of deductive approaches which means some emergent research findings were not explored further. Evaluation research often engages with an iterative process of refining and optimising intervention and its implementation (Peason et al. 2020). For example, the barrier systems generated in the CI study could be exchanged between the consultation groups for comments regarding similar and different challenges faced in distinctive intervention contexts. The solutions generated could also be presented across groups and explored their applicability. Additionally, findings from the implementation trial could be utilised to refine the implementation strategies and their effectiveness can be further tested.

Given the limited evidence concerning the implementation evaluation of MC interventions, to help continue contributing to our understanding of the uptake of effective MC interventions into routine practice, future research should seek to:

- use stakeholder-driven methods for selecting implementation strategies, as well as meaningfully specifying and prioritising strategies according to contexts (Ashley et al. 2022).

- explore the role of community of practice (Hennein et al. 2022) in improving teachers' self-efficacy and reflective practice in the context of interventions and PE.

- explore using a whole-of-school systems approach to promote young people's MC development.

- engage multi-level stakeholders, including teachers (and other deliverers), families, students, school leadership, external sports clubs, professional bodies, and potentially policymakers to explore strategies that support programme availability and accessibility.

- as in this research, conceptualise and measure implementation outcomes from the outset, as well as document implementation processes to capture the information needed to improve the implementation and sustainability.

- report the non-academic impact of the intervention and expand the availability of evidence-based strategies and findings (especially relating to the real-world effectiveness) via appropriate dissemination. For example, to increase the adoption of the new practice from schools and teachers, testimonies of students and teachers who have experienced effective interventions can be collated and disseminated using social media and other online tools to increase inclusivity and impact.

- combine theories and methods from health psychology (e.g., Behaviour Change Wheel) and implementation science to identify mechanisms of implementation (Presseau et al. 2021).

8.6 Concluding remarks

This PhD was born of practical questions concerning MC interventions and how they can be effectively implemented in the long term to benefit more children and adolescents. This research is the first, to the candidate's knowledge, to systematically examine the implementation evaluation of MC interventions. This body of work includes: 1) the first systematic review to examine MC intervention processes and how they influence outcomes, 2) a novel contribution of applying an interdisciplinary method (CI) for the first time in motor development and physical activity research, and 3) an examination of interrelationship of barriers to the implementation and sustainability from stakeholder perspectives, which contributed to the design of implementation strategies and implementation evaluation of a MC intervention.

Intervention implementation must have real-world effectiveness in mind. This is a critical research need. Conducting implementation evaluation gives opportunities to examine the impact of interventions beyond physical outcomes and explore value-added components of interventions that may contribute to young people's healthy development. Without this, potential facilitating mechanisms and evidence to support research-to-practice translation is unlikely to be generated.

This PhD research contributed to improving the understanding of the process(es), factors, and strategies relevant to the implementation of MC interventions into routine practice and provided suggestions regarding implementation evaluation. It is hoped that this thesis stimulates further debates and research on how best to conduct evaluations in a way to produce evidence for greater adoption, dissemination, and institutionalisation of MC interventions for improved health outcomes.

References

Abraham, C. and Michie, S. (2008) "A Taxonomy of Behavior Change Techniques Used in Interventions". *Health Psychology* 27 (3), 379–387

Adeyemi-Walker, L.J., Duncan, M., Tallis, J., and Eyre, E. (2018) "Fundamental Motor Skills of Children in Deprived Areas of England: A Focus on Age, Gender and Ethnicity." *Children (Basel, Switzerland)* 5 (8)

Adolph, K.E. and Franchak, J.M. (2017) "The Development of Motor Behavior". in *Wiley Interdisciplinary Reviews: Cognitive Science*. vol. 8 (1–2). Wiley-Blackwell

Akbari, H., Abdoli, B., Shafizadeh, M., Khalaji, H., Hajihosseini, S., and Ziaee, V. (2009) "The Effect of Traditional Games in Fundamental Motor Skill Development in 7-9 Year-Old Boys". *Iranian Journal of Pediatrics* [online] 19 (2 PG-123–129), 123–129. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-67549147251&partnerID=40&md5=0f6c03091b141f8c62ee0f4dfe42a5ad NS ->

Hajihosseini, S. (2016) "A School-Based Physical Activity Intervention to Promote Motor Proficiency among Adolescent Girls: A Randomized Controlled Trial". *Biolmedonline.Com* [online] 8, 1. available from <https://biolmedonline.com/content/BM-165-16_A-school-based-physical-activity-intervention-to-promote-Motor-Proficiency.pdf> [14 April 2022]

Andruschko, J., Okely, A.D., and Pearson, P. (2018) "A School-Based Physical Activity and Motor Development Program for Low-Fit Adolescent Females: The Sport4Fun Pilot Randomized Controlled Trial". *Journal of Motor Learning and Development* [online] 6 (2), 345–356. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85060222503&doi=10.1123%2Fjmld.2017-0013&partnerID=40&md5=2af11134afd1bd6b7e96c7bdf6533287 NS ->

An, R., Liu, J., and Liu, R. (2021) "State Laws Governing School Physical Education in Relation to Attendance and Physical Activity among Students in the USA: A Systematic Review and Meta-Analysis". *Journal of Sport and Health Science* 10 (3), 277–287

Aubert, S., Barnes, J.D., Abdeta, C., Nader, P.A., Adeniyi, A.F., Aguilar-Farias, N., Tenesaca, D.S.A., Bhawra, J., Brazo-Sayavera, J., Cardon, G., Chang, C.K., Delisle Nyström, C., Demetriou, Y., Draper, C.E., Edwards, L., Emeljanovas, A., Gába, A., Galaviz, K.I., González, S.A., Herrera-Cuenca, M., Huang, W.Y., Ibrahim, I.A.E., Jürimäe, J., Kämppi, K., Katapally, T.R., Katewongsa, P., Katzmarzyk, P.T., Khan, A., Korcz, A., Kim, Y.S., Lambert, E., Lee, E.Y., Löf, M., Loney, T., López-Taylor, J., Liu, Y., Makaza, D., Manyanga, T., Mileva, B., Morrison, S.A., Mota, J., Nyawornota, V.K., Ocansey, R., Reilly, J.J., Roman-Viñas, B., Silva, D.A.S., Saonuam, P., Scriven, J., Seghers, J., Schranz, N., Skovgaard, T., Smith, M., Standage, M., Starc, G., Stratton, G., Subedi, N., Takken, T., Tammelin, T., Tanaka, C., Thivel, D., Tladi, D., Tyler, R., Uddin, R., Williams, A., Wong, S.H.S., Wu, C.L., Zembura, P., and Tremblay, M.S. (2018) "Global Matrix 3.0 Physical Activity Report Card Grades for Children and

Youth: Results and Analysis from 49 Countries". *Journal of Physical Activity and Health* 15 (s2), S251–S273

Azeem, Z., Tanveer, B. (2015) "Effects of Short Term Agility Training on the Gross Motor Development and Agility Competence in Pre-pubertal Children" *International Journal of Sports Sciences and Fitness* 5(2).

Bagnall, A.M., Radley, D., Jones, R., Gately, P., Nobles, J., Van Dijk, M., Blackshaw, J., Montel, S., and Sahota, P. (2019) "Whole Systems Approaches to Obesity and Other Complex Public Health Challenges: A Systematic Review". *BMC Public Health* 19 (1), 8

Bailey, R., Armour, K., Kirk, D., Jess, M., Pickup, I., and Sandford, R. (2009) "The Educational Benefits Claimed for Physical Education and School Sport: An Academic Review". *Research Papers in Education* 24 (1), 1–27

Bailey, R., Vašíčková, J., Vlček, P., Raya Demidoff, A., Pühse, U., Heck, S., and Scheuer, C. (2022) *An International Review of the Contributions of School-Based Physical Activity, Physical Education, and School Sport to the Promotion of Health-Enhancing Physical Activity*. [online] available from <https://zenodo.org/record/5899571> [13 April 2022]

Bandura, A. (1993) "Perceived Self-Efficacy in Cognitive Development and Functioning". *Educational Psychologist* 28 (2), 117–148

Bardid, F., Lenoir, M., Huyben, F., de Martelaer, K., Seghers, J., Goodway, J.D., and Deconinck, F.J.A. (2017) "The Effectiveness of a Community-Based Fundamental Motor Skill Intervention in Children Aged 3-8 Years: Results of the 'Multimove for Kids' Project". *Journal of Science and Medicine in Sport* [online] 20 (2 PG-184–189), 184–189. available from <https://www.jsams.org/article/S1440-2440(16)30139-6/fulltext NS ->

Bardid, F., Rudd, J.R., Lenoir, M., Polman, R., and Barnett, L.M. (2015) "Cross-Cultural Comparison of Motor Competence in Children from Australia and Belgium". *Frontiers in Psychology* 6 (July), 1–8

Barnes, C., Mccrabb, S., Stacey, F., Nathan, N., Yoong, S.L., Grady, A., Sutherland, R., Hodder, R., Innes-Hughes, C., Davies, M., and Wolfenden, L. (2021) "Improving Implementation of School-Based Healthy Eating and Physical Activity Policies, Practices, and Programs: A Systematic Review". *Translational Behavioral Medicine* 11 (7), 1365–1410

Barnett, L.M., van Beurden, E., Morgan, P.J., Brooks, L.O., Zask, A., and Beard, J.R. (2009) "Six Year Follow-up of Students Who Participated in a School-Based Physical Activity Intervention: A Longitudinal Cohort Study". *International Journal of Behavioral Nutrition and Physical Activity 2009 6:1* [online] 6 (1), 1–8. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-6-48> [5 October 2021]

Barnett, L.M., Lai, S.K., Veldman, S.L.C., Hardy, L.L., Cliff, D.P., Morgan, P.J., Zask, A., Lubans, D.R., Shultz, S.P., Ridgers, N.D., Rush, E., Brown, H.L., and Okely, A.D. (2016) "Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis". *Sports Medicine* [online] 46 (11), 1663–1688. available from <http://www.ncbi.nlm.nih.gov/pubmed/26894274> [26 August 2019]

Barnett, L.M., Morgan, P.J., van Beurden, E., and Beard, J.R. (2008) "Perceived Sports Competence Mediates the Relationship between Childhood Motor Skill Proficiency and Adolescent Physical Activity and Fitness: A Longitudinal Assessment". *International Journal of Behavioral Nutrition and Physical Activity* 5

Barnett, L.M., Ridgers, N.D., Reynolds, J., Hanna, L., and Salmon, J. (2015) "Playing Active Video Games May Not Develop Movement Skills: An Intervention Trial". *Preventive Medicine Reports* [online] 2 (PG-673-678), 673–678. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84940101435&doi=10.1016%2Fj.pmedr.2015.08.007&partnerID=40&md5=3d32316f41ffe370ab28a01d1b06d283 NS ->

Barnett, L.M., Telford, R.M., Strugnell, C., Rudd, J., Olive, L.S., and Telford, R.D. (2019) "Impact of Cultural Background on Fundamental Movement Skill and Its Correlates". *Journal of Sports Sciences* [online] 37 (5), 492–499. available from <https://www.tandfonline.com/doi/full/10.1080/02640414.2018.1508399> [30 June 2020]

Barnett, L.M., Webster, E.K., Hulteen, R.M., de Meester, A., Valentini, N.C., Lenoir, M., Pesce, C., Getchell, N., Lopes, V.P., Robinson, L.E., Brian, A., and Rodrigues, L.P. (2022) "Through the Looking Glass: A Systematic Review of Longitudinal Evidence, Providing New Insight for Motor Competence and Health". *Sports Medicine (Auckland, N.Z.)* [online] 52 (4). available from <https://pubmed.ncbi.nlm.nih.gov/34463945/> [29 March 2022]

Bauman, A.E., Reis, R.S., Sallis, J.F., Wells, J.C., Loos, R.J.F., Martin, B.W., Alkandari, J.R., Andersen, L.B., Blair, S.N., Brownson, R.C., Bull, F.C., Craig, C.L., Ekelund, U., Goenka, S., Guthold, R., Hallal, P.C., Haskell, W.L., Heath, G.W., Inoue, S., Kahlmeier, S., Katzmarzyk, P.T., Kohl, H.W., Lambert, E.V., Lee, I.M., Leetongin, G., Lobelo, F., Marcus, B., Owen, N., Parra, D.C., Pratt, M., Puska, P., Ogilvie, D., and Sarmiento, O.L. (2012) "Correlates of Physical Activity: Why Are Some People Physically Active and Others Not?" *The Lancet* 380 (9838), 258–271

Bauman, A.E., Sallis, J.F., Dzewaltowski, D.A., and Owen, N. (2002) "Toward a Better Understanding of the Influences on Physical Activity". *American Journal of Preventive Medicine* [online] 23 (2), 5–14. available from <http://linkinghub.elsevier.com/retrieve/pii/S0749379702004695> [21 December 2017]

Belton, S., O'Brien, W., Murtagh, E., Costa, J., Issartel, J., McGann, J., and Manninen, M. (2022) "A New Curriculum Model for Second-Level Physical Education: Y-PATH PE4Me". *Curriculum Studies in Health and Physical Education* [online] available from

<https://www.tandfonline.com/action/journalInformation?journalCode=rasp21> [5 April 2022]

Berman, J. and Smyth, R. (2015) "Conceptual Frameworks in the Doctoral Research Process: A Pedagogical Model". *Http://Dx.Doi.Org/10.1080/14703297.2013.809011* [online] 52 (2), 125–136. available from <https://www.tandfonline.com/doi/abs/10.1080/14703297.2013.809011> [8 April 2022]

Bolger, L.E., Bolger, L.A., O'Neill, C., Coughlan, E., O'Brien, W., Lacey, S. and Burns, C., (2018) "Age and sex differences in fundamental movement skills among a cohort of Irish school children". *Journal of motor learning and development*, 6(1), 81-100.

Bolger, L.A., Bolger, L.E., O'Neill, C., Coughlan, E., Lacey, S., O'Brien, W., and Burns, C. (2019) "Fundamental Movement Skill Proficiency and Health Among a Cohort of Irish Primary School Children". *Research Quarterly for Exercise and Sport* [online] 90 (1), 24–35. available from <https://pubmed.ncbi.nlm.nih.gov/30707088/> [19 April 2022]

Bolger, L.E., Bolger, L.A., O'Neill, C., Coughlan, E., O'Brien, W., Lacey, S., Burns, C., and Bardid, F. (2020) "Global Levels of Fundamental Motor Skills in Children: A Systematic Review". *Journal of Sports Sciences* [online] available from <https://www.tandfonline.com/action/journalInformation?journalCode=rjsp20> [13 January 2021]

Bopp, M., Saunders, R.P., and Lattimore, D. (2013) "The Tug-of-War: Fidelity versus Adaptation throughout the Health Promotion Program Life Cycle". *Journal of Primary Prevention* 34 (3), 193–207

Borrelli, B., Sepinwall, D., Bellg, A.J., Breger, R., DeFrancesco, C., Sharp, D.L., Ernst, D., Czajkowski, S., Levesque, C., Ogedegbe, G., Resnick, B., and Orwig, D. (2005) "A New Tool to Assess Treatment Fidelity and Evaluation of Treatment Fidelity across 10 Years of Health Behavior Research". *Journal of Consulting and Clinical Psychology*

Boyle-Holmes, T., Grost, L., Russell, L., Laris, B.A., Robin, L., Haller, E., Potter, S., and Lee, S. (2010) "Promoting Elementary Physical Education: Results of a School-Based Evaluation Study". *Health Education and Behavior* [online] 37 (3), 377–389. available from <NS ->

Brailey, G., Metcalf, B., Lear, R., Price, L., Cumming, S., and Stiles, V. (2022) "A Comparison of the Associations between Bone Health and Three Different Intensities of Accelerometer-Derived Habitual Physical Activity in Children and Adolescents: A Systematic Review". *Osteoporosis International*

Bremer, E. and Cairney, J. (2016) "Fundamental Movement Skills and Health-Related Outcomes: A Narrative Review of Longitudinal and Intervention Studies Targeting Typically Developing Children": *Https://Doi.Org/10.1177/1559827616640196* 12 (2), 148–159

Brennan, C., Bowles, R., and Murtagh, E. (2021) "The Best of Both Worlds? The Impact of the Initial Teacher Education Physical Education Specialism Programme on Generalist Teachers' Self-Efficacy, Beliefs, and Practices". *Https://Doi.Org/10.1080/03004279.2021.2001557* [online] available from <https://www.tandfonline.com/doi/abs/10.1080/03004279.2021.2001557> [11 January 2022]

Brian, A., Getchell, N., True, L., de Meester, A., and Stodden, D.F. (2020) "Reconceptualizing and Operationalizing Seefeldt's Proficiency Barrier: Applications and Future Directions". *Sports Medicine* [online] 50 (11), 1889–1900. available from <https://link.springer.com/article/10.1007/s40279-020-01332-6> [1 April 2022]

Brian, A., Goodway, J.D., Logan, J.A., and Sutherland, S. (2017) "SKIPing with Teachers: An Early Years Motor Skill Intervention". *Physical Education and Sport Pedagogy* 22 (3), 270–282

Bronfenbrenner, U. (1992) *Ecological Systems Theory.* [online] available from <https://psycnet.apa.org/record/1992-98662-005> [8 April 2022]

Broome, B.J. (1995) "Collective Design of the Future: Structural Analysis of Tribal Vision Statements". *American Indian Quarterly* 19 (2), 205

Brown, D.M.Y. and Cairney, J. (2020) "The Synergistic Effect of Poor Motor Coordination, Gender and Age on Self-Concept in Children: A Longitudinal Analysis". *Research in Developmental Disabilities* [online] 98. available from <https://pubmed.ncbi.nlm.nih.gov/31991260/> [1 April 2022]

Brown, H., Hume, C., Pearson, N., and Salmon, J. (2013) "A Systematic Review of Intervention Effects on Potential Mediators of Children's Physical Activity". *BMC Public Health* [online] 13 (1), 1. available from <BMC Public Health>

Bryant, E.S., Duncan, M.J., Birch, S.L., and James, R.S. (2016) "Can Fundamental Movement Skill Mastery Be Increased via a Six Week Physical Activity Intervention to Have Positive Effects on Physical Activity and Physical Self-Perception?" *Sports (Basel, Switzerland)* [online] 4 (1). available from <https://pubmed.ncbi.nlm.nih.gov/29910259/> [8 April 2022]

Bull, F.C., Al-Ansari, S.S., Biddle, S., Borodulin, K., Buman, M.P., Cardon, G., Carty, C., Chaput, J.P., Chastin, S., Chou, R., Dempsey, P.C., Dipietro, L., Ekelund, U., Firth, J., Friedenreich, C.M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P.T., Lambert, E., Leitzmann, M., Milton, K., Ortega, F.B., Ranasinghe, C., Stamatakis, E., Tiedemann, A., Troiano, R.P., Van Der Ploeg, H.P., Wari, V., and Willumsen, J.F. (2020) "World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behaviour". *British Journal of Sports Medicine* 54 (24), 1451–1462

Cairney, J., Dudley, D., Kwan, M., Bulten, R., and Kriellaars, D. (2019) "Physical Literacy, Physical Activity and Health: Toward an Evidence-Informed Conceptual Model". *Sports Medicine* 49 (3), 371–383

Capio, C.M., Sit, C.H.P., Eguia, K.F., Abernethy, B., and Masters, R.S.W. (2015) "Fundamental Movement Skills Training to Promote Physical Activity in Children with and without Disability: A Pilot Study". *Journal of Sport and Health Science* 4 (3), 235–243

Carlin, A., Perchoux, C., Puggina, A., Aleksovska, K., Buck, C., Burns, C., Cardon, G., Chantal, S., Ciarapica, D., Condello, G., Coppinger, T., Cortis, C., D'Haese, S., de Craemer, M., di Blasio, A., Hansen, S., Iacoviello, L., Issartel, J., Izzicupo, P., Jaeschke, L., Kanning, M., Kennedy, A., Lakerveld, J., Ling, F.C.M., Luzak, A., Napolitano, G., Nazare, J.A., Pischon, T., Polito, A., Sannella, A., Schulz, H., Sohun, R., Steinbrecher, A., Schlicht, W., Ricciardi, W., Macdonncha, C., Capranica, L., and Boccia, S. (2017) "A Life Course Examination of the Physical Environmental Determinants of Physical Activity Behaviour: A 'Determinants of Diet and Physical Activity' (DEDIPAC) Umbrella Systematic Literature Review". *PLOS ONE* [online] 12 (8), e0182083. available from
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0182083> [24 March 2022]

Carroll, C., Patterson, M., Wood, S., Booth, A., Rick, J., and Balain, S. (2007) "A Conceptual Framework for Implementation Fidelity". *Implementation Science* [online] 2 (1), 40. available from
<http://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-2-40> [25 June 2019]

Dyson, B. and Casey, A. eds., (2012) *Cooperative learning in physical education* (p. 17). New York, NY: Taylor & Francis.

Casey, A. and Goodyear, V.A. (2015) "Can Cooperative Learning Achieve the Four Learning Outcomes of Physical Education? A Review of Literature". *Http://Dx.Doi.Org/10.1080/00336297.2014.984733* 67 (1), 56–72

Casey, Ashley. and Kirk, D. (2020) *Models-Based Practice in Physical Education* [online] available from <https://www.routledge.com/Models-based-Practice-in-Physical-Education/Casey-Kirk/p/book/9780367333324> [28 March 2022]

Caspersen, C.J., Powell, K.E., and Christenson, G.M. (1985) "Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research." *Public Health Reports (Washington, D.C. : 1974)* 100 (2), 126–31

Cassar, S., Salmon, J., Timperio, A., Koch, S., and Koorts, H. (2020) "A Qualitative Study of School Leader Experiences Adopting and Implementing a Whole of School Physical Activity and Sedentary Behaviour Programme: Transform-Us!" *Health Education* ahead-of-p (ahead-of-print)

Cassar, S., Salmon, J., Timperio, A., Naylor, P.-J.J., Nassau, F. van, Ayala, A.M.C., Koorts, H., van Nassau, F., Contardo Ayala, A.M., and Koorts, H. (2019a) "Adoption, Implementation and Sustainability of School-Based Physical Activity and Sedentary Behaviour Interventions in Real-World Settings: A Systematic Review". *International*

Journal of Behavioral Nutrition and Physical Activity [online] 16 (1), 120. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0876-4> [5 December 2019]

Cassar, S., Salmon, J., Timperio, A., Naylor, P.-J., Nassau, F. van, Ayala, A.M.C., and Koorts, H. (2019b) "Adoption, Implementation and Sustainability of School-Based Physical Activity and Sedentary Behaviour Interventions in Real-World Settings: A Systematic Review". *International Journal of Behavioral Nutrition and Physical Activity 2019 16:1* [online] 16 (1), 1–13. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0876-4> [27 July 2021]

Chagas, D. v, Paixão Macedo, L., and Batista, L.A. (2018) "The Effect of One Year of Unstructured Table Tennis Participation on Motor Coordination Level among Young Recreational Players". *Archivos de Medicina Del Deporte* [online] 35 (4 PG-223–227), 223–227. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85057416835&partnerID=40&md5=8e9fccc4c402578dafc51f5b412bc7f4 NS ->

Chalkley, A. (2020) *Implementation Evaluation of a Primary School-Based Running Programme*. Loughborough University

Chambers, D.A., Glasgow, R.E., and Stange, K.C. (2013) "The Dynamic Sustainability Framework: Addressing the Paradox of Sustainment amid Ongoing Change". *Implementation Science*

Chan, C., Ha, A., and Ng, J.Y.Y. (2016) "Improving Fundamental Movement Skills in Hong Kong Students through an Assessment for Learning Intervention That Emphasizes Fun, Mastery, and Support: The A + FMS Randomized Controlled Trial Study Protocol". *SpringerPlus* [online] 5 (1). available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84976315238&doi=10.1186%2Fs40064-016-2517-6&partnerID=40&md5=35ee41d7598fe75a59bb45309ac9ca6c NS -> [21 February 2019]

Chang, N. (2010) *Using Structural Equation Modeling to Test the Validity of Interactive Management*. (2010)

Chaput, J.P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., Jago, R., Ortega, F.B., and Katzmarzyk, P.T. (2020) "2020 WHO Guidelines on Physical Activity and Sedentary Behaviour for Children and Adolescents Aged 5–17 Years: Summary of the Evidence". *International Journal of Behavioral Nutrition and Physical Activity* 17 (1), 1–9

Chow, J.Y. and Atencio, M., (2014) "Complex and nonlinear pedagogy and the implications for physical education". *Sport, Education and Society*, 19(8), 1034-1054.

Clark, J.E. (2005) "From the Beginning: A Developmental Perspective on Movement and Mobility". *Quest*

Clark, J.E. and Metcalfe, J.S. (2002) "The Mountain of Motor Development". *Motor Development: Research and Reviews* 2, 163–190

Clark, J.E. and Whitall, J. (1989) "What Is Motor Development? The Lessons of History". *Quest* [online] 41 (3), 183–202. available from <https://www.tandfonline.com/doi/abs/10.1080/00336297.1989.10483969> [1 July 2020]

Cliff, D.P., Okely, A.D., Morgan, P.J., Jones, R.A., Steele, J.R., and Baur, L.A. (2012) "Proficiency Deficiency: Mastery of Fundamental Movement Skills and Skill Components in Overweight and Obese Children". *Obesity* 20 (5), 1024–1033

Cliff, D.P., Okely, A.D., Morgan, P.J., Steele, J.R., Jones, R.A., Colyvas, K., and Baur, L.A. (2011) "Movement Skills and Physical Activity in Obese Children: Randomized Controlled Trial". *Medicine and Science in Sports and Exercise* [online] 43 (PG-90-100), 90–100. available from <NS ->

Cohen, K.E., Morgan, P.J., Plotnikoff, R.C., Barnett, L.M., and Lubans, D.R. (2015a) "Improvements in Fundamental Movement Skill Competency Mediate the Effect of the SCORES Intervention on Physical Activity and Cardiorespiratory Fitness in Children". *Journal of Sports Sciences* 33 (18), 1908–1918

Cohen, K.E., Morgan, P.J., Plotnikoff, R.C., Callister, R., and Lubans, D.R. (2015b) "Physical Activity and Skills Intervention: SCORES Cluster Randomized Controlled Trial". *Medicine and Science in Sports and Exercise* 47 (4), 765–774

Colella, D. and Bonasia, M. (2019) "Teaching Styles, Physical Literacy and Perceived Physical Self-Efficacy. Results of A Learning Unit in Primary School". *Turkish Journal of Sports Medicine* [online] 54 (Supp1), 1–7. available from <http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=sph&AN=137930657&site=ehost-live&authtype=sso&custid=s9872838 NS - NS ->

Condello, G., Puggina, A., Aleksovska, K., Buck, C., Burns, C., Cardon, G., Carlin, A., Simon, C., Ciarapica, D., Coppinger, T., Cortis, C., D'Haese, S., De Craemer, M., Di Blasio, A., Hansen, S., Iacoviello, L., Issartel, J., Izzicupo, P., Jaeschke, L., Kanning, M., Kennedy, A., Ling, F.C.M., Luzak, A., Napolitano, G., Nazare, J.A., Perchoux, C., Pesce, C., Pischon, T., Polito, A., Sannella, A., Schulz, H., Sohun, R., Steinbrecher, A., Schlicht, W., Ricciardi, W., MacDonncha, C., Capranica, L., and Boccia, S. (2017) "Behavioral Determinants of Physical Activity across the Life Course: A 'DEterminants of DIet and Physical ACtivity' (DEDIPAC) Umbrella Systematic Literature Review". *International Journal of Behavioral Nutrition and Physical Activity* 14 (1), 58

Cook, C.R., Lyon, A.R., Locke, J., Waltz, T., and Powell, B.J. (2019) "Adapting a Compilation of Implementation Strategies to Advance School-Based Implementation Research and Practice". *Prevention Science* 20 (6), 914–935

Cooper, A.R., Goodman, A., Page, A.S., Sherar, L.B., Esliger, D.W., van Sluijs, E.M.F., Andersen, L.B., Anderssen, S., Cardon, G., Davey, R., Froberg, K., Hallal, P., Janz, K.F., Kordas, K., Kreimler, S., Pate, R.R., Puder, J.J., Reilly, J.J., Salmon, J., Sardinha,

L.B., Timperio, A., and Ekelund, U. (2015) "Objectively Measured Physical Activity and Sedentary Time in Youth: The International Children's Accelerometry Database (ICAD)". *International Journal of Behavioral Nutrition and Physical Activity* 12 (1), 1–10

Cooper, J., Murphy, J., Woods, C., van Nassau, F., McGrath, A., Callaghan, D., Carroll, P., Kelly, P., Murphy, N., and Murphy, M. (2021) "Barriers and Facilitators to Implementing Community-Based Physical Activity Interventions". *International Journal of Behavioral Nutrition and Physical Activity* [online] 18 (1), 118. available from <https://pure.ulster.ac.uk/en/publications/barriers-and-facilitators-to-implementing-community-based-physica> [8 April 2022]

Coppens, E., de Meester, A., Deconinck, F.J.A., de Martelaer, K., Haerens, L., Bardid, F., Lenoir, M., and D'hondt, E. (2021) "Differences in Weight Status and Autonomous Motivation towards Sports among Children with Various Profiles of Motor Competence and Organized Sports Participation". *Children 2021, Vol. 8, Page 156* [online] 8 (2), 156. available from <https://www.mdpi.com/2227-9067/8/2/156/htm> [1 April 2022]

Corr, M., McSharry, J., and Murtagh, E.M. (2019) "Adolescent Girls' Perceptions of Physical Activity: A Systematic Review of Qualitative Studies". *American Journal of Health Promotion* [online] 33 (5), 806–819. available from <https://journals.sagepub.com/doi/10.1177/0890117118818747?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed> [1 April 2022]

Cortis, C., Puggina, A., Pesce, C., Aleksovska, K., Buck, C., Burns, C., Cardon, G., Carlin, A., Simon, C., Ciarapica, D., Condello, G., Coppinger, T., D'Haese, S., de Craemer, M., Di Blasio, A., Hansen, S., Iacoviello, L., Issartel, J., Izzicupo, P., Jaeschke, L., Kanning, M., Kennedy, A., Ling, F.C.M., Luzak, A., Napolitano, G., Nazare, J.A., O'Donoghue, G., Perchoux, C., Pischon, T., Polito, A., Sannella, A., Schulz, H., Sohun, R., Steinbrecher, A., Schlicht, W., Ricciardi, W., Castellani, L., Macdonncha, C., Capranica, L., and Boccia, S. (2017) "Psychological Determinants of Physical Activity across the Life Course: A 'DEterminants of DIet and Physical ACtivity' (DEDIPAC) Umbrella Systematic Literature Review". *PloS One* 12 (8)

Coulter, M., Scanlon, D., MacPhail, A., O'Brien, W., Belton, S., and Woods, C. (2020) "The (Mis)Alignment between Young People's Collective Physical Activity Experience and Physical Education Curriculum Development in Ireland". *Https://Doi.Org/10.1080/25742981.2020.1808493* [online] 11 (3), 204–221. available from <https://www.tandfonline.com/doi/abs/10.1080/25742981.2020.1808493> [1 April 2022]

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., and Petticrew, M. (2008) "Developing and Evaluating Complex Interventions: The New Medical Research Council Guidance Revisiting the 2000 MRC Framework". *British Medical Journal* [online] 337 (a1655), 979-983. available from <http://www.bmj.com/content/bmj/337/bmj.a1655.full.pdf>

Creswell, J.W. (2013) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage publications

Creswell, J.W. and Clark, V.L.P. (2017) *Designing and Conducting Mixed Methods Research*. Sage publications

Daly-Smith, A., Quarmby, T., Archbold, V.S.J., Corrigan, N., Wilson, D., Resaland, G.K., Bartholomew, J.B., Singh, A., Tjomsland, H.E., Sherar, L.B., Chalkley, A., Routen, A.C., Shickle, D., Bingham, D.D., Barber, S.E., Van Sluijs, E., Fairclough, S.J., and McKenna, J. (2020a) "Using a Multi-Stakeholder Experience-Based Design Process to Co-Develop the Creating Active Schools Framework". *International Journal of Behavioral Nutrition and Physical Activity* 17 (1), 13

Daly-Smith, A., Quarmby, T., Archbold, V.S.J., Routen, A.C., Morris, J.L., Gammon, C., Bartholomew, J.B., Resaland, G.K., Llewellyn, B., Allman, R., and Dorling, H. (2020b) "Implementing Physically Active Learning: Future Directions for Research, Policy, and Practice". *Journal of Sport and Health Science* 9 (1), 41–49

Dalziell, A., Booth, J.N., Boyle, J., and Mutrie, N. (2019) "Better Movers and Thinkers: An Evaluation of How a Novel Approach to Teaching Physical Education Can Impact Children's Physical Activity, Coordination and Cognition". *British Educational Research Journal* 45 (3), 576–591

Damschroder, L.J. (2020) "Clarity out of Chaos: Use of Theory in Implementation Research". *Psychiatry Research* 283, 112461

Damschroder, L.J., Aron, D.C., Keith, R.E., Kirsh, S.R., Alexander, J.A., and Lowery, J.C. (2009) "Fostering Implementation of Health Services Research Findings into Practice: A Consolidated Framework for Advancing Implementation Science". *Implementation Science* [online] 4 (1), 50. available from <http://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-4-50> [30 October 2020]

Deci, E.L. and Ryan, R.M. (2012) "Self-Determination Theory". in *Handbook of Theories of Social Psychology: Volume 1*. SAGE Publications Inc., 416–437

Department for Education (2013) *National Curriculum in England: Physical Education Programmes of Study*.

DiPietro, L., Al-Ansari, S.S., Biddle, S.J.H., Borodulin, K., Bull, F.C., Buman, M.P., Cardon, G., Carty, C., Chaput, J.P., Chastin, S., Chou, R., Dempsey, P.C., Ekelund, U., Firth, J., Friedenreich, C.M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P.T., Lambert, E., Leitzmann, M., Milton, K., Ortega, F.B., Ranasinghe, C., Stamatakis, E., Tiedemann, A., Troiano, R.P., van der Ploeg, H.P., and Willumsen, J.F. (2020) "Advancing the Global Physical Activity Agenda: Recommendations for Future Research by the 2020 WHO Physical Activity and Sedentary Behavior Guidelines Development Group". *International Journal of Behavioral Nutrition and Physical Activity* 17 (1), 1–11

Dudley, D., Okely, A., Pearson, P., and Cotton, W. (2011) "A Systematic Review of the Effectiveness of Physical Education and School   Sport Interventions Targeting Physical Activity, Movement Skills and Enjoyment of Physical   Activity": *Http://Dx.Doi.Org/10.1177/1356336X11416734* [online] 17 (3), 353–378. available from <https://journals.sagepub.com/doi/10.1177/1356336X11416734> [12 April 2022]

Duncan, M.J., Eyre, E.L.J., and Oxford, S.W. (2017) "The Effects of 10 Weeks Integrated Neuromuscular Training on Fundamental Movement Skills and Physical Self-Efficacy in 6-7 Year Old Children": *Journal of Strength and Conditioning Research* [online] 1. available from <http://insights.ovid.com/crossref?an=00124278-900000000-96057> [18 December 2017]

Duncan, M.J., Foweather, L., Bardid, F., Barnett, A.L., Rudd, J., O'Brien, W., Foulkes, J.D., Roscoe, C., Issartel, J., Stratton, G., and Clark, C.C.T. (2022) "Motor Competence Among Children in the United Kingdom and Ireland: An Expert Statement on Behalf of the International Motor Development Research Consortium". *Journal of Motor Learning and Development* [online] 10 (1), 7–26. available from <https://journals.humankinetics.com/view/journals/jmld/10/1/article-p7.xml> [31 March 2022]

Duncan, M.J., Roscoe, C.M.P., Noon, M., Clark, C.C.T., O'Brien, W., and Eyre, E.L.J. (2020) "Run, Jump, Throw and Catch: How Proficient Are Children Attending English Schools at the Fundamental Motor Skills Identified as Key within the School Curriculum?" *European Physical Education Review* [online] 26 (4), 814–826. available from <http://journals.sagepub.com/doi/10.1177/1356336X19888953> [13 October 2020]

Durlak, J.A. (2009) "How to Select, Calculate, and Interpret Effect Sizes". *Journal of Pediatric Psychology* [online] 34 (9), 917–928. available from <https://pubmed.ncbi.nlm.nih.gov/19223279/> [7 July 2020]

Durlak, J.A. and DuPre, E.P. (2008) "Implementation Matters: A Review of Research on the Influence of Implementation on Program Outcomes and the Factors Affecting Implementation". *American Journal of Community Psychology* 41 (3–4), 327–350

Eccles, M.P. and Mittman, B.S. (2006) "Welcome to Implementation Science". *Implementation Science* [online] 1 (1), 1–3. available from <https://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-1-1> [24 March 2022]

Eather, N., Bull, A., Young, M.D., Barnes, A.T., Pollock, E.R. and Morgan, P.J., (2018) "Fundamental movement skills: Where do girls fall short? A novel investigation of object-control skill execution in primary-school aged girls". *Preventive medicine reports*, 11, 191-195.

Eddy, L., Hill, L.J.B., Mon-Williams, M., Preston, N., Daly-Smith, A., Medd, G., and Bingham, D.D. (2021) "Fundamental Movement Skills and Their Assessment in

Primary Schools from the Perspective of Teachers". *Measurement in Physical Education and Exercise Science* 1–14

Eddy, L.H., Wood, M.L., Shire, K.A., Bingham, D.D., Bonnick, E., Creaser, A., Mon-Williams, M., and Hill, L.J.B. (2019a) "A Systematic Review of Randomised and Case-controlled Trials Investigating the Effectiveness of School-based Motor-skill Interventions in 3-12-year-old Children". *Child: Care, Health and Development* [online] (August), cch.12712. available from <https://onlinelibrary.wiley.com/doi/abs/10.1111/cch.12712>

Eddy, L.H., Wood, M.L., Shire, K.A., Bingham, D.D., Bonnick, E., Creaser, A., Mon-Williams, M., and Hill, L.J.B. (2019b) "A Systematic Review of Randomized and Case-Controlled Trials Investigating the Effectiveness of School-Based Motor Skill Interventions in 3- to 12-Year-Old Children". *Child: Care, Health and Development* 45 (6), 773–790

Engel, A.C., Broderick, C.R., van Doorn, N., Hardy, L.L., and Parmenter, B.J. (2018) "Exploring the Relationship Between Fundamental Motor Skill Interventions and Physical Activity Levels in Children: A Systematic Review and Meta-Analysis". *Sports Medicine* [online] 48 (8), 1845–1857. available from <https://doi.org/10.1007/s40279-018-0923-3>

Ericsson, I. (2008) "Motor Skills, Attention and Academic Achievements. An Intervention Study in School Years 1-3". *British Educational Research Journal* [online] 34 (3 PG-301–313), 301–313. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-45849086905&doi=10.1080%2F01411920701609299&partnerID=40&md5=eac41e557e97bbf8fc2e22160d024cfe NS - Ericsson 2008>

Estabrooks, P.A. and Glasgow, R.E. (2006) "Translating Effective Clinic-Based Physical Activity Interventions into Practice". *American Journal of Preventive Medicine* 31 (4), 45–56

Estevan, I., Bardid, F., Utesch, T., Menescardi, C., Barnett, L.M., and Castillo, I. (2020) "Examining Early Adolescents' Motivation for Physical Education: Associations with Actual and Perceived Motor Competence". *Https://Doi.Org/10.1080/17408989.2020.1806995* [online] 26 (4), 359–374. available from <https://www.tandfonline.com/doi/abs/10.1080/17408989.2020.1806995> [1 April 2022]

Eyre, E.L.J., Walker, L.J., and Duncan, M.J. (2018) "Fundamental Movement Skills of Children Living in England: The Role of Ethnicity and Native English Language". *Perceptual and Motor Skills* 125 (1), 5–20

Fahimi, M., Aslankhani, M.A., Shojaee, M., Beni, M.A., and Gholhaki, M.R. (2013) "The Effect of Four Motor Programs on Motor Proficiency in 7-9 Years Old Boys". *Middle-East Journal of Scientific Research* [online] 13 (11), 1526–1532. available from <NS ->

Fairclough, S.J., Weaver, R.G., Johnson, S., and Rawlinson, J. (2018) "Validation of an Observation Tool to Assess Physical Activity-Promoting Physical Education Lessons in High Schools: SOFIT". *Journal of Science and Medicine in Sport* 21 (5), 495–500

Famelia, R., Goodway, J., and Chen, Y.-J. (2019) "The Feasibility of Indonesian Early Childhood Teachers in Delivering the INDO-SKIP Intervention to Muslim Preschoolers". in *Journal of Sport and Exercise Psychology.*

Farooq, A., Martin, A., Janssen, X., Wilson, M.G., Gibson, A.M., Hughes, A., and Reilly, J.J. (2020) "Longitudinal Changes in Moderate-to-Vigorous-Intensity Physical Activity in Children and Adolescents: A Systematic Review and Meta-Analysis". *Obesity Reviews* 21 (1), e12953

Fauville, G., Mchugh, P., Domegan, C., Mäkitalo, Å., Møller, F., Papathanassiou, M., Chicote, C.A., Lincoln, S., Batista, V., Copejans, E., Crouch, F., and Gotensparre, S. (2018) *Using Collective Intelligence to Identify Barriers to Teaching 12-19 Year Olds about the Ocean in Europe.* [online] available from <https://doi.org/10.1016/j.marpol.2018.01.034> [12 April 2022]

van der Fels, I.M.J., Hartman, E., Bosker, R.J., de Greeff, J.W., de Bruijn, A.G.M., Meijer, A., Oosterlaan, J., Smith, J., and Visscher, C. (2020) "Effects of Aerobic Exercise and Cognitively Engaging Exercise on Cardiorespiratory Fitness and Motor Skills in Primary School Children: A Cluster Randomized Controlled Trial". *Journal of Sports Sciences* [online] (PG-1-9), 1–9. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85087884011&doi=10.1080%2F02640414.2020.1765464&partnerID=40&md5=511f240b76ac21d85fb024f560707c4c NS - NS ->

Fernandez-Rio, J. and Iglesias, D. (2022) "What Do We Know about Pedagogical Models in Physical Education so far? An Umbrella Review". *Physical Education and Sport Pedagogy,* 1-16. [online] available from <https://www.tandfonline.com/action/journalInformation?journalCode=cpes20> [28 March 2022]

Foweather, L., McWhannell, N., Henaghan, J., Lees, A., Stratton, G., and Batterham, A.M. (2008) "Effect of a 9-Wk. After-School Multiskills Club on Fundamental Movement Skill Proficiency in 8- to 9-Yr.-Old Children: An Exploratory Trial". *Perceptual and Motor Skills* [online] 106 (3), 745–754. available from <https://journals.sagepub.com/doi/10.2466/pms.106.3.745-754> [19 April 2022]

Foweather, L. and Rudd, J.R. (2020) "Fundamental Movement Skill Interventions". *The Routledge Handbook of Youth Physical Activity* [online] 715–737. available from <https://www.taylorfrancis.com/chapters/edit/10.4324/9781003026426-45/fundamental-movement-skill-interventions-lawrence-foweather-james-rudd> [23 August 2021]

Fynn, J.F., Hardeman, W., Milton, K., Murphy, J., and Jones, A. (2020) "A Systematic Review of the Use and Reporting of Evaluation Frameworks within Evaluations of Physical Activity Interventions". *International Journal of Behavioral Nutrition and*

Physical Activity [online] 17 (1), 107. available from
<https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-020-01013-7> [27 August
2020]

Gabbard, C.P. (2021) *Lifelong Motor Development* [online] Lippincott Williams &
Wilkins. available from <www.pearsoned.co.uk> [21 March 2022]

Gallahue, D.L., Ozmun, J.C., and Goodway, Jackie. (2012) *Understanding Motor
Development : Infants, Children, Adolescents, Adults*. McGraw-Hill

Gallotta, M.C., Emerenziani, G. pietro, Iazzoni, S., Iasevoli, L., Guidetti, L., and
Baldari, C. (2017) "Effects of Different Physical Education Programmes on Children's
Skill- and Health-Related Outcomes: A Pilot Randomised Controlled Trial". *Journal of
Sports Sciences* 35 (15 PG-1547–1555), 1547–1555

Gandotra, A., Csaba, S., Sattar, Y., Cserényi, V., Bizonics, R., Cserjesi, R., and Kotyuk,
E. (2021) "A Meta-Analysis of the Relationship between Motor Skills and Executive
Functions in Typically-Developing Children".
Https://Doi.Org/10.1080/15248372.2021.1979554 [online] 23 (1), 83–110. available
from <https://www.tandfonline.com/doi/abs/10.1080/15248372.2021.1979554> [1 April
2022]

García-Hermoso, A., Alonso-Martínez, A.M., Ramírez-Vélez, R., Pérez-Sousa, M.Á.,
Ramírez-Campillo, R., and Izquierdo, M. (2020) "Association of Physical Education
with Improvement of Health-Related Physical Fitness Outcomes and Fundamental
Motor Skills among Youths: A Systematic Review and Meta-Analysis". in *JAMA
Pediatrics* [online] vol. 174 (6). American Medical Association, e200223–e200223.
available from <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2763829>
[21 August 2020]

Gavigan, N., Belton, S., Meegan, S., and Issartel, J. (2021) "Moving Well-Being Well:
A Process Evaluation of a Physical Literacy-Based Intervention in Irish Primary
Schools". *Https://Doi.Org/10.1080/17408989.2021.1967305* [online] available from
<https://www.tandfonline.com/doi/abs/10.1080/17408989.2021.1967305> [31 March
2022]

Geldsetzer, P. and Fawzi, W. (2017) "Quasi-Experimental Study Designs Series—Paper
2: Complementary Approaches to Advancing Global Health Knowledge". *Journal of
Clinical Epidemiology* 89, 12–16

Getchell, N., Schott, N., and Brian, A. (2020) "Motor Development Research: Designs,
Analyses, and Future Directions". *Journal of Motor Learning and Development* 8 (2),
410–437

Glasgow, R.E. (2008) "What Types of Evidence Are Most Needed to Advance
Behavioral Medicine?" in *Annals of Behavioral Medicine*.

Glasgow, R.E. and Chambers, D. (2012) "Developing Robust, Sustainable, Implementation Systems Using Rigorous, Rapid and Relevant Science". *Clinical and Translational Science* 5 (1), 48–55

Glasgow, R.E., Lichtenstein, E., and Marcus, A.C. (2003) "Why Don't We See More Translation of Health Promotion Research to Practice? Rethinking the Efficacy-to-Effectiveness Transition." *American Journal of Public Health* 93 (8), 1261–7

Goodyear, V.A., Skinner, B., McKeever, J., and Grifftiths, M. (2021) "The Influence of Online Physical Activity Interventions on Children and Young People's Engagement with Physical Activity: A Systematic Review". *Physical Education and Sport Pedagogy*

Graf, C., Koch, B., Falkowski, G., Jouck, S., Christ, H., Staudenmaier, K., Tokarski, W., Gerber, A., Predel, H.-G., and Dordel, S. (2008) "School-Based Prevention: Effects on Obesity and Physical Performance after 4 Years". *Journal of Sports Sciences* [online] 26 (10), 987–994. available from <http://www.ncbi.nlm.nih.gov/pubmed/18608843> [26 June 2019]

Graf, C., Koch, B., Falkowski, G., Jouck, S., Christ, H., Stauenmaier, K., Bjarnason-Wehrens, B., Tokarski, W., Dordel, S., and Predel, H.G. (2005) "Effects of a School-Based Intervention on BMI and Motor Abilities in Childhood". *Journal of Sports Science and Medicine* 4 (3), 291–299

Graham, M., Azevedo, L., Wright, M., and Innerd, A.L. (2021) "The Effectiveness of Fundamental Movement Skill Interventions on Moderate to Vigorous Physical Activity Levels in 5- to 11-Year-Old Children: A Systematic Review and Meta-Analysis". *Sports Medicine* [online] 1–24. available from <https://link.springer.com/article/10.1007/s40279-021-01599-3> [31 March 2022]

Grillich, L., Kien, C., Takuya, Y., Weber, M., and Gartlehner, G. (2016) "Effectiveness Evaluation of a Health Promotion Programme in Primary Schools: A Cluster Randomised Controlled Trial." *BMC Public Health* [online] 16, 679. available from <http://www.ncbi.nlm.nih.gov/pubmed/27475339> [26 June 2019]

Griffin, L.L. and Butler, J., (2005) *Teaching games for understanding: Theory, research, and practice*. Human Kinetics.

Groarke, J.M. and Hogan, M.J. (2016) "Enhancing Wellbeing: An Emerging Model of the Adaptive Functions of Music Listening". *Psychology of Music* 44 (4), 769–791

Grunseit, A.C., O'Hara, B.J., Drayton, B., Learnihan, V., Hardy, L.L., Clark, E., Klarenaar, P., and Engelen, L. (2020) "Ecological Study of Playground Space and Physical Activity among Primary School Children". *BMJ Open* 10 (6), e034586

Guerrero, M.D. and Chandler, K. (2018) "Using Imagery to Improve Sub-Domains of Physical Literacy". *Journal of Imagery Research in Sport and Physical Activity* [online] 13 (1 PG-). available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85056607729&doi=10.1515%2Fjirspa-2018-0008&partnerID=40&md5=3d3cc682ec023a1160a5af66f59b0675 NS ->

Guthold, R., Stevens, G.A., Riley, L.M., and Bull, F.C. (2020) "Global Trends in Insufficient Physical Activity among Adolescents: A Pooled Analysis of 298 Population-Based Surveys with 1·6 Million Participants". *The Lancet Child & Adolescent Health* 4 (1), 23–35

Gu, X., Chen, Y., … A.J.-P.E. and, and 2018, undefined (2017) "Impact of a Pedometer-Based Goal-Setting Intervention on Children's Motivation, Motor Competence, and Physical Activity in Physical Education". *Taylor & Francis* [online] 23 (1), 54–65. available from
<https://www.tandfonline.com/doi/abs/10.1080/17408989.2017.1341475> [19 April 2022]

Haerens, L., Kirk, D., Cardon, G. and De Bourdeaudhuij, I., (2011). "Toward the development of a pedagogical model for health-based physical education". *Quest*, 63(3), 321-338.

Haga, M., Tortella, P., Asonitou, K., Charitou, S., Koutsouki, D., Fumagalli, G., and Sigmundsson, H. (2018) "Cross-Cultural Aspects: Exploring Motor Competence Among 7- to 8-Year-Old Children From Greece, Italy, and Norway". *SAGE Open* 8 (2)

Hale, G.E., Colquhoun, L., Lancastle, D., Lewis, N., and Tyson, P.J. (2021) "Review: Physical Activity Interventions for the Mental Health and Well-Being of Adolescents - a Systematic Review". *Child and Adolescent Mental Health* 26 (4), 357–368

Hamilton, A.B. and Finley, E.P. (2019) "Qualitative Methods in Implementation Research: An Introduction". *Psychiatry Research* 280, 112516

Hardy, L.L., Barnett, L., Espinel, P., and Okely, A.D. (2013) "Thirteen-Year Trends in Child and Adolescent Fundamental Movement Skills: 1997-2010". *Medicine and Science in Sports and Exercise* 45 (10), 1965–1970

Harter, S. (1982) "The Perceived Competence Scale for Children". *Child Development* 53 (1), 87

Hastie, P.A. and Casey, A., (2014) "Fidelity in models-based practice research in sport pedagogy: A guide for future investigations". *Journal of Teaching in Physical Education*, 33(3), 422-431.

Hawe, P. (2015) "Lessons from Complex Interventions to Improve Health". *Annual Review of Public Health* 36 (1), 307–323

Hawe, P., Shiell, A., and Riley, T. (2004) "Complex Interventions: How 'out of Control' Can a Randomised Controlled Trial Be?" *Bmj* [online] 328 (7455), 1561. available from <http://www.bmj.com/cgi/doi/10.1136/bmj.328.7455.1561> [22 January 2018]

Haynes, A., Brennan, S., Redman, S., Williamson, A., Gallego, G., and Butow, P. (2016) "Figuring out Fidelity: A Worked Example of the Methods Used to Identify, Critique and Revise the Essential Elements of a Contextualised Intervention in Health Policy Agencies". *Implementation Science* [online] 11 (1), 23. available from <http://www.implementationscience.com/content/11/1/23> [4 September 2020]

Hayward, J., Morton, S., Johnstone, M., Creighton, D., and Allender, S. (2020) "Tools and Analytic Techniques to Synthesise Community Knowledge in CBPR Using Computer-Mediated Participatory System Modelling". *Npj Digital Medicine* [online] 3 (1), 1–6. available from <http://dx.doi.org/10.1038/s41746-020-0230-x>

Haywood, K.M. and Getchell, N. (2009) "Life Span Motor Development 5th Ed". *Champaign, Illinois: Human Kinetics* 4

Hennein, R., Ggita, J.M., Turimumahoro, P., Ochom, E., Gupta, A.J., Katamba, A., Armstrong-Hough, M., and Davis, J.L. (2022) "Core Components of a Community of Practice to Improve Community Health Worker Performance: A Qualitative Study". *Implementation Science Communications 2022 3:1* [online] 3 (1), 1–14. available from <https://implementationsciencecomms.biomedcentral.com/articles/10.1186/s43058-022-00279-1> [11 April 2022]

Hesketh, K.R., Lakshman, R., and van Sluijs, E.M.F. (2017) "Barriers and Facilitators to Young Children's Physical Activity and Sedentary Behaviour: A Systematic Review and Synthesis of Qualitative Literature". *Obesity Reviews* 18 (9), 987–1017

Higgins, J.P. and Green, S. (2008) *Cochrane Handbook for Systematic Reviews of Interventions: Cochrane Book Series*.

Hogan, M. and Broome, B. (2019) "Facilitation and the Focus on Process". *Systems Research and Behavioral Science* (October), 1–4

Hogan, M., Hall, T., and Harney, O. (2017) "Collective Intelligence Design and a New Politics of System". *Civitas Educationis* 6 (1), 51–78

Hogan, M., Harney, O., and Broome, B. (2014) "Integrating Argument Mapping with Systems Thinking Tools: Advancing Applied Systems Science". in *Advanced Information and Knowledge Processing*. Springer London, 401–421

Hogan, M., Harney, O., and Razzante, R. (2020) "Responding to the Need for Online Collective Intelligence Facilitation: A Framework for Systems Thinking Facilitators". *Systems Research and Behavioral Science*

Hogan, M.J., Dwyer, C.P., Harney, O.M., Noone, C., and Conway, R.J. (2015a) "Metacognitive Skill Development and Applied Systems Science: A Framework of Metacognitive Skills, Self-Regulatory Functions and Real-World Applications". *Intelligent Systems Reference Library* 76, 75–106

Hogan, M.J., Johnston, H., Broome, B., McMoreland, C., Walsh, J., Smale, B., Duggan, J., Andriessen, J., Leyden, K.M., Domegan, C., McHugh, P., Hogan, V., Harney, O., Groarke, J., Noone, C., and Groarke, A.M. (2015b) "Consulting with Citizens in the Design of Wellbeing Measures and Policies: Lessons from a Systems Science Application". *Social Indicators Research*

Hogan, M., Johnston, H., Broome, B., and Noone, C. (2015) "On the Design of National Wellbeing Measures and Policies". in *Crisis and Renewal of Civilizations: The 21st Century Crisis of Ideas and Character*. 277–294

Hogan, M., Ojo, A., Harney, O., Ruijer, E., Meijer, A., Andriessen, J., Pardijs, M., Boscolo, P., Palmisano, E., Satta, M., Groff, J., Baker, M., Détienne, F., Porwol, L., Scarano, V., and Malandrino, D. (2017) "Governance, Transparency and the Collaborative Design of Open Data Collaboration Platforms: Understanding Barriers, Options, and Needs". in *Public Administration and Information Technology*. vol. 32. Springer, 299–332

Holmes, B.J., Best, A., Hunter, D., Kelly, M.P., Marshall, M., and Rycroft-Malone, J. (2017) "Mobilising Knowledge in Complex Health Systems: A Call to Action". *Evidence & Policy* • 13, 3–539

Hulteen, R.M., Morgan, P.J., Barnett, L.M., Stodden, D.F., Lubans, D.R., David, •, Stodden, F., and Lubans, R. (2018) "Development of Foundational Movement Skills: A Conceptual Model for Physical Activity Across the Lifespan". *Sports Med* [online] 48 (7), 1533–1540. available from <https://doi.org/10.1007/s40279-018-0892-6> [15 May 2019]

Invernizzi, P.L., Crotti, M., Bosio, A., Cavaggioni, L., Alberti, G., and Scurati, R. (2019) "Multi-Teaching Styles Approach and Active Reflection: Effectiveness in Improving Fitness Level, Motor Competence, Enjoyment, Amount of Physical Activity, and Effects on the Perception of Physical Education Lessons in Primary School Children". *Sustainability (Switzerland)* [online] 11 (2 PG-). available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85059975619&doi=10.3390%2Fsu11020405&partnerID=40&md5=eda75bec9d84d870bd2bdbc5212ac4b3 NS ->

Jarani, J., Grøntved, A., Muca, F., Spahi, A., Qefalia, D., Ushtelenca, K., Kasa, A., Caporossi, D., and Gallotta, M.C. (2016) "Effects of Two Physical Education Programmes on Health- and Skill-Related Physical Fitness of Albanian Children". *Journal of Sports Sciences* 34 (1), 35–46

Jarvis, S., Williams, M., Rainer, P., Saunders, J., and Mullen, R. (2020) "The Relationship of Family Characteristics, Parental Beliefs and Parenting Behaviours with the Fundamental Movement Proficiency of Primary School Children in South East Wales". *European Physical Education Review* 26 (4), 970–986

Jiménez-Díaz, J., Chaves-Castro, K., and Salazar, W. (2019) "Effects of Different Movement Programs on Motor Competence: A Systematic Review With Meta-Analysis". *Journal of Physical Activity and Health* [online] 16 (8), 657–666. available from <https://journals.humankinetics.com/view/journals/jpah/16/8/article-p657.xml> [27 July 2021]

Johnson, A.M., Moore, J.E., Chambers, D.A., Rup, J., Dinyarian, C., and Straus, S.E. (2019) "How Do Researchers Conceptualize and Plan for the Sustainability of Their NIH R01 Implementation Projects?" *Implementation Science* 14 (1), 50

Johnson, T.M., Ridgers, N.D., Hulteen, R.M., Mellecker, R.R., and Barnett, L.M. (2016) "Does Playing a Sports Active Video Game Improve Young Children's Ball Skill

Competence?" *Journal of Science and Medicine in Sport* [online] 19 (5), 432–436. available from <https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01380124/full NS ->

Johnstone, A., Hughes, A.R., Bonnar, L., Booth, J.N., and Reilly, J.J. (2019) "An Active Play Intervention to Improve Physical Activity and Fundamental Movement Skills in Children of Low Socioeconomic Status: Feasibility Cluster Randomised Controlled Trial". *Pilot and Feasibility Studies* [online] 5 (1), 1–13. available from <https://pilotfeasibilitystudies.biomedcentral.com/articles/10.1186/s40814-019-0427-4> [19 April 2022]

Johnstone, A., Hughes, A.R., Janssen, X., and Reilly, J.J. (2017) "Pragmatic Evaluation of the Go2Play Active Play Intervention on Physical Activity and Fundamental Movement Skills in Children". *Preventive Medicine Reports* [online] 7, 58–63. available from <https://pubmed.ncbi.nlm.nih.gov/28593124/> [12 April 2022]

Jones, D., Innerd, A., Giles, E.L., and Azevedo, L.B. (2021) "The Association between Physical Activity, Motor Skills and School Readiness in 4–5-Year-Old Children in the Northeast of England". *International Journal of Environmental Research and Public Health* 18 (22)

Jones, L. and Green, K. (2017) "Who Teaches Primary Physical Education? Change and Transformation through the Eyes of Subject Leaders". *Sport, Education and Society* 22 (6), 759–771

Jull, J., Giles, A., and Graham, I.D. (2017) "Community-Based Participatory Research and Integrated Knowledge Translation: Advancing the Co-Creation of Knowledge". *Implementation Science* [online] 12 (1). available from </pmc/articles/PMC5735911/?report=abstract> [25 June 2020]

Kalaja, S.P., Jaakkola, T.T., Liukkonen, J.O., and Digelidis, N. (2012) "Development of Junior High School Students' Fundamental Movement Skills and Physical Activity in a Naturalistic Physical Education Setting". *Physical Education and Sport Pedagogy* [online] 17 (4), 411–428. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84865500796&doi=10.1080%2F17408989.2011.603124&partnerID=40&md5=4d8131025c55aa9eacd10dfd9988129d NS ->

Karabourniotis, D., Evaggelinou, C., Tzetzis, G., and Kourtessis, T. (2002) "Curriculum Enrichment with Self-test Activities in Development of Fundamental Movement Skills of First-Grade Children in Greece". *Perceptual & Motor Skills* 94 (3 PG-1259–1259), 1259

Kavanagh, S.A., Hawe, P., Shiell, A., Mallman, M., and Garvey, K. (2022) "Soft Infrastructure: The Critical Community-Level Resources Reportedly Needed for Program Success". *BMC Public Health 2022 22:1* 22 (1), 1–9

Killian, C.M. and Woods, A.M. (2021) "Physical Education Students' Usage and Perceptions of a Supplemental Online Health-Related Fitness Knowledge Curriculum (IPE):" *Https://Doi.Org/10.1177/1356336X211065953*

Klepac Pogrmilovic, B., Ramirez Varela, A., Pratt, M., Milton, K., Bauman, A., Biddle, S.J.H., and Pedisic, Z. (2020) "National Physical Activity and Sedentary Behaviour Policies in 76 Countries: Availability, Comprehensiveness, Implementation, and Effectiveness". *International Journal of Behavioral Nutrition and Physical Activity* [online] 17 (1). available from <https://pubmed.ncbi.nlm.nih.gov/32948193/> [20 April 2021]

Knowles, Z.R. ebecca, Parnell, D., Stratton, G., and Ridgers, N.D. iane (2013) "Learning from the Experts: Exploring Playground Experience and Activities Using a Write and Draw Technique". *Journal of Physical Activity & Health* 10 (3), 406–415

Koorts, H., Eakin, E., Estabrooks, P., Timperio, A., Salmon, J., and Bauman, A. (2018b) "Implementation and Scale up of Population Physical Activity Interventions for Clinical and Community Settings: The PRACTIS Guide". *International Journal of Behavioral Nutrition and Physical Activity 2018 15:1* [online] 15 (1), 1–11. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-018-0678-0> [27 July 2021]

Koorts, H., Maple, J.-L., Eakin, E., Lawrence, M., and Salmon, J. (2022) "Complexities and Context of Scaling Up: A Qualitative Study of Stakeholder Perspectives of Scaling Physical Activity and Nutrition Interventions in Australia". *Frontiers in Public Health* 0, 662

Koorts, H., Naylor, P.-J.J., Laws, R., Love, P., Maple, J.-L.L., Nassau, F. van, and van Nassau, F. (2020) "What Hinders and Helps Academics to Conduct Dissemination and Implementation (D&I) Research in the Field of Nutrition and Physical Activity? An International Perspective". *International Journal of Behavioral Nutrition and Physical Activity* [online] 17 (1), 7. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-020-0909-z> [20 January 2020]

Koorts, H. and Rutter, H. (2021) "A Systems Approach to Scale-up for Population Health Improvement". in *Health Research Policy and Systems* [online] vol. 19 (1). BioMed Central Ltd, 27. available from <http://creativecommons.org/licenses/by/4.0/.TheCreativeCommonsPublicDomainDedicationwaiver> [4 May 2021]

Kumar, R. (n.d.) *Research Methodology : A Step-by-Step Guide for Beginners*. 503

Kwon, S., Janz, K.F., Letuchy, E.M., Burns, T.L., and Levy, S.M. (2015) "Developmental Trajectories of Physical Activity, Sports, and Television Viewing During Childhood to Young Adulthood: Iowa Bone Development Study". *JAMA Pediatrics* 169 (7), 666–672

Lai, S.K., Costigan, S.A., Morgan, P.J., Lubans, D.R., Stodden, D.F., Salmon, J., and Barnett, L.M. (2014) "Do School-Based Interventions Focusing on Physical Activity,

Fitness, or Fundamental Movement Skill Competency Produce a Sustained Impact in These Outcomes in Children and Adolescents? A Systematic Review of Follow-up Studies". *Sports Medicine* [online] 44 (1), 67–79. available from <http://link.springer.com/10.1007/s40279-013-0099-9> [18 December 2017]

Lander, N., Eather, N., Morgan, P.J., Salmon, J., and Barnett, L.M. (2017a) "Characteristics of Teacher Training in School-Based Physical Education Interventions to Improve Fundamental Movement Skills and/or Physical Activity: A Systematic Review". *Sports Medicine* [online] 47 (1), 135–161. available from <http://link.springer.com/10.1007/s40279-016-0561-6> [1 February 2019]

Lander, N., Koorts, H., Mazzoli, E., Moncrieff, K., and Salmon, J. (2019) "The Feasibility and Impact of Embedding Pedagogical Strategies Targeting Physical Activity within Undergraduate Teacher Education: Transform-Ed!" *Pilot and Feasibility Studies* 5 (1), 125

Lander, N., Lewis, S., Nahavandi, D., Amsbury, K., and Barnett, L.M. (2020a) "Teacher Perspectives of Online Continuing Professional Development in Physical Education". *Sport, Education and Society*

Lander, N., Mergen, J., Morgan, P.J., Salmon, J., and Barnett, L.M. (2018) "Can a Teacher-Led RCT Improve Adolescent Girls' Physical Self-Perception and Perceived Motor Competence?" *Journal of Sports Sciences* [online] 00 (00), 1–7. available from <https://doi.org/10.1080/02640414.2018.1504397>

Lander, N., Morgan, P.J., Salmon, J., and Barnett, L.M. (2017b) "Improving Early Adolescent Girls' Motor Skill: A Cluster Randomized Controlled Trial". *Medicine and Science in Sports and Exercise* [online] 49 (12), 2498–2505. available from <https://journals.lww.com/acsm-msse/Fulltext/2017/12000/Improving_Early_Adolescent_Girls__Motor_Skill__A.15.aspx> [27 July 2021]

Lander, N., Morgan, P.J., Salmon, J., and Barnett, L.M. (2016) "Teachers Perceptions of a Fundamental Movement Skill (FMS) Assessment Battery in a School Setting". *Measurement in Physical Education and Exercise Science* 20 (1), 50–62

Lander, N., Salmon, J., Morgan, P.J., Symington, N., and Barnett, L.M. (2020b) "Three-Year Maintenance of a Teacher-Led Programme Targeting Motor Competence in Early Adolescent Girls". *Journal of Sports Sciences*

Landsverk, J., Hendricks Brown, C., Chamberlain, P., Palinkas, L., Ogihara, M., Czaja, S., Goldhaber-Fiebert, J.D., Rolls Reutz, J.A., and Horwitz, S.M.C. (2012) "Design and Analysis in Dissemination and Implementation Research". *Dissemination and Implementation Research in Health: Translating Science to Practice* [online] available from <https://www.scholars.northwestern.edu/en/publications/design-and-analysis-in-dissemination-and-implementation-research-2> [8 April 2022]

Laukkanen, A., Pesola, A.J., Heikkinen, R., Sääkslahti, A.K., and Finni, T. (2015) "Family-Based Cluster Randomized Controlled Trial Enhancing Physical Activity and Motor Competence in 4–7-Year-Old Children". *PLoS ONE* 10 (10 PG-1–17), 1–17

Lawson, H.A. (2018) "From Whole Group Pedagogy to Tailor-Made Interventions". *Redesigning Physical Education* [online] 86–103. available from <https://www.taylorfrancis.com/chapters/edit/10.4324/9780429466991-5/whole-group-pedagogy-tailor-made-interventions-hal-lawson> [4 April 2022]

Lee, K., Ding, D., Grunseit, A., Wolfenden, L., Milat, A., and Bauman, A. (2021) "Many Papers but Limited Policy Impact? A Bibliometric Review of Physical Activity Research". *Translational Journal of the American College of Sports Medicine* 6 (4)

Lee, K., van Nassau, F., Grunseit, A., Conte, K., Milat, A., Wolfenden, L., and Bauman, A. (2020) "Scaling up Population Health Interventions from Decision to Sustainability – a Window of Opportunity? A Qualitative View from Policy-Makers". *Health Research Policy and Systems* [online] 18 (1). available from </pmc/articles/PMC7547476/> [11 April 2022]

Leeman, J., Birken, S.A., Powell, B.J., Rohweder, C., and Shea, C.M. (2017) "Beyond 'Implementation Strategies': Classifying the Full Range of Strategies Used in Implementation Science and Practice". *Implementation Science* [online] 12 (1), 125. available from <http://implementationscience.biomedcentral.com/articles/10.1186/s13012-017-0657-x> [6 February 2019]

Lima, R.A., Drenowatz, C. and Pfeiffer, K.A., (2022) "Expansion of Stodden et al.'s Model". *Sports Medicine*, 52(4), 679-683.

Van Lente, E. and Hogan, M.J. (2020) "Understanding the Nature of Oneness Experience in Meditators Using Collective Intelligence Methods". *Frontiers in Psychology* 11, 2092

Lester, D. (2020) *The Design, Development, Implementation and Evaluation of Project FLAME: A Multi-Component, School-Based, Motor Competence Intervention for Adolescent Youth in Ireland.* Unversity College Cork

Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P.A., Clarke, M., Devereaux, P.J., Kleijnen, J., and Moher, D. (2009) "The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration". in *PLoS Medicine*. vol. 6 (7)

Lipsey, M.W. and Wilson, D.B. (2001) "Practical Meta-Analysis". *Applied Social Research Methods Series*

Littlecott, H.J., Moore, G.F., Gallagher, H.C., Murphy, S., Littlecott, H.J., Moore, G.F., Gallagher, H.C., and Murphy, S. (2019) "From Complex Interventions to Complex Systems: Using Social Network Analysis to Understand School Engagement with

Health and Wellbeing". *International Journal of Environmental Research and Public Health* 16 (10), 1694

Lizarondo L, Stern C, Carrier J, Godfrey C, Rieger K, Salmond S, Apostolo J, Kirkpatrick P, L.H. (2020) *Chapter 8: Mixed Methods Systematic Reviews.In: Aromataris E, Munn Z (Editors).* [online] available from <https://synthesismanual.jbi.global>

Logan, S.W., Kipling Webster, E., Getchell, N., Pfeiffer, K.A., and Robinson, L.E. (2015) "Relationship Between Fundamental Motor Skill Competence and Physical Activity During Childhood and Adolescence: A Systematic Review". *Kinesiology Review* 4 (4), 416–426

Logan, S.W., Ross, S.M., Chee, K., Stodden, D.F., and Robinson, L.E. (2018) "Fundamental Motor Skills: A Systematic Review of Terminology". in *Journal of Sports Sciences* [online] vol. 36 (7). Routledge, 781–796. available from <https://www.tandfonline.com/doi/full/10.1080/02640414.2017.1340660> [23 January 2019]

Lonsdale, C., Sanders, T., Cohen, K.E., Parker, P., Noetel, M., Hartwig, T., Vasoncellos, D., Kirwan, M., Morgan, P., Salmon, J., Moodie, M., McKay, H., Bennie, A., Plotnikoff, R., Cinelli, R.L., Greene, D., Peralta, L.R., Cliff, D.P., Kolt, G.S., Gore, J.M., Gao, L., and Lubans, D.R. (2016) "Scaling-up an Efficacious School-Based Physical Activity Intervention: Study Protocol for the 'Internet-Based Professional Learning to Help Teachers Support Activity in Youth' (IPLAY) Cluster Randomized Controlled Trial and Scale-up Implementation Evaluat". *BMC Public Health* [online] 16 (1). available from <http://dx.doi.org/10.1186/s12889-016-3243-2>

Lonsdale, C., Sanders, T., Parker, P., Noetel, M., Hartwig, T., Vasconcellos, D., Lee, J., Antczak, D., Kirwan, M., Morgan, P., Salmon, J., Moodie, M., McKay, H., Bennie, A., Plotnikoff, R.C., Cinelli, R., Greene, D., Peralta, L., Cliff, D., Kolt, G., Gore, J., Gao, L., Boyer, J., Morrison, R., Hillman, C., Shigeta, T.T., Tan, E., and Lubans, D.R. (2021) "Effect of a Scalable School-Based Intervention on Cardiorespiratory Fitness in Children: A Cluster Randomized Clinical Trial". *JAMA Pediatrics* [online] available from <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2779446> [7 May 2021]

Lopes, L., Santos, R., Coelho-e-Silva, M., Draper, C., Mota, J., Jidovtseff, B., Clark, C., Schmidt, M., Morgan, P., Duncan, M., O'Brien, W., Bentsen, P., D'Hondt, E., Houwen, S., Stratton, G., de Martelaer, K., Scheuer, C., Herrmann, C., García-Hermoso, A., Ramírez-Vélez, R., Palmeira, A., Gerlach, E., Rosário, R., Issartel, J., Esteban-Cornejo, I., Ruiz, J., Veldman, S., Zhang, Z., Colella, D., Póvoas, S., Haibach-Beach, P., Pereira, J., McGrane, B., Saraiva, J., Temple, V., Silva, P., Sigmund, E., Sousa-Sá, E., Adamakis, M., Moreira, C., Utesch, T., True, L., Cheung, P., Carcamo-Oyarzun, J., Charitou, S., Chillón, P., Robazza, C., Silva, A., Silva, D., Lima, R., Mourão-Carvalhal, I., Khodaverdi, Z., Zequinão, M., Pereira, B., Prista, A., and Agostinis-Sobrinho, C. (2020) "A Narrative Review of Motor Competence in Children and Adolescents: What

We Know and What We Need to Find Out". *International Journal of Environmental Research and Public Health* [online] 18 (1), 18. available from <https://www.mdpi.com/1660-4601/18/1/18> [13 January 2021]

Lorås, H. (2020) "The Effects of Physical Education on Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis". *Sports* 8 (6)

Lounassalo, I., Hirvensalo, M., Palomäki, S., Salin, K., Tolvanen, A., Pahkala, K., Rovio, S., Fogelholm, M., Yang, X., Hutri-Kähönen, N., Raitakari, O.T., and Tammelin, T.H. (2021) "Life-Course Leisure-Time Physical Activity Trajectories in Relation to Health-Related Behaviors in Adulthood: The Cardiovascular Risk in Young Finns Study". *BMC Public Health* 21 (1), 1–13

Love, R., Adams, J., and van Sluijs, E.M.F. (2018) "Are School-Based Physical Activity Interventions Effective and Equitable? A Systematic Review and Meta-Analysis of Cluster Randomised Controlled Trials". *The Lancet* 392 (August 2018), S53

Lubans, D.R., Morgan, P.J., Cliff, D.P., Barnett, L.M., and Okely, A.D. (2010) "Fundamental Movement Skills in Children and Adolescents: Review of Associated Health Benefits". in *Sports Medicine*. vol. 40 (12). 1019–1035

Lüdecke, D. (2019) *Effect Size Computation for Meta Analysis (Version 0.5.1)*. available from <https://cran.r-project.org/package=esc>

Luke, D.A., Calhoun, A., Robichaux, C.B., Moreland-Russell, S., and Elliott, M.B. (2014) "Peer Reviewed: The Program Sustainability Assessment Tool: A New Instrument for Public Health Programs". *Preventing Chronic Disease* [online] 11 (2014). available from </pmc/articles/PMC3900326/> [15 April 2022]

Luz, C., Cordovil, R., Rodrigues, L.P., Gao, Z., Goodway, J.D., Sacko, R.S., Nesbitt, D.R., Ferkel, R.C., True, L.K., and Stodden, D.F. (2019) "Motor Competence and Health-Related Fitness in Children: A Cross-Cultural Comparison between Portugal and the United States". *Journal of Sport and Health Science* 8 (2), 130–136

Lyon, A.R., Cook, C.R., Brown, E.C., Locke, J., Davis, C., Ehrhart, M., and Aarons, G.A. (2018) "Assessing Organizational Implementation Context in the Education Sector: Confirmatory Factor Analysis of Measures of Implementation Leadership, Climate, and Citizenship". *Implementation Science* 13 (1)

MacPhail, A., O'Sullivan, M., Tannehill, D., and Parker, M. (2018) "Redesigning Physical Education in Ireland : Significant Redesign over Modest Reforms?" *Redesigning Physical Education* [online] 171–181. available from <https://www.taylorfrancis.com/chapters/edit/10.4324/9780429466991-11/redesigning-physical-education-ireland-ann-macphail-mary-sullivan-deborah-tannehill-melissa-parker> [4 April 2022]

Ma, J., Duncan, M.J., Chen, S.T., Eyre, E.L.J., and Cai, Y. (2021a) "Cross-Cultural Comparison of Fundamental Movement Skills in 9- to 10-Year-Old Children from England and China": *Https://Doi.Org/10.1177/1356336X211055585* [online] available

from <https://journals.sagepub.com/doi/10.1177/1356336X211055585> [8 February 2022]

Ma, J., Hogan, M.J., Eyre, E.L.J.J., Lander, N., Barnett, L.M., and Duncan, M.J. (2021b) "Using Collective Intelligence to Identify Barriers to Implementing and Sustaining Effective Fundamental Movement Skill Interventions: A Rationale and Application Example". *Journal of Sports Sciences* 39 (6), 1–8

Ma, J., Lander, N., Eyre, E.L.J., Barnett, L.M., Essiet, I.A., and Duncan, M.J. (2021c) "It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence". *Sports Medicine 2021* 1–23

Macdonald, K., Milne, N., Orr, R. and Pope, R., (2018) "Relationships between motor proficiency and academic performance in mathematics and reading in school-aged children and adolescents: a systematic review". *International journal of environmental research and public health*, 15(8), 1603.

Malina, R.M. (2014) "Top 10 Research Questions Related to Growth and Maturation of Relevance to Physical Activity, Performance, and Fitness". *Http://Dx.Doi.Org/10.1080/02701367.2014.897592* [online] 85 (2), 157–173. available from <https://www.tandfonline.com/doi/abs/10.1080/02701367.2014.897592> [31 March 2022]

Martin, E.H., Rudisill, M.E., and Hastie, P.A. (2009) "Motivational Climate and Fundamental Motor Skill Performance in a Naturalistic Physical Education Setting". *Physical Education & Sport Pedagogy* 14 (3), 227–240

Martins, C.M. de L., Bandeira, P.F.R., Lemos, N.B.A.G., Bezerra, T.A., Clark, C.C.T., Mota, J., and Duncan, M.J. (2020) "A Network Perspective on the Relationship between Screen Time, Executive Function, and Fundamental Motor Skills among Preschoolers". *International Journal of Environmental Research and Public Health* [online] 17 (23), 1–12. available from <https://pubmed.ncbi.nlm.nih.gov/33260528/> [1 April 2022]

Mateo-Orcajada, A., Abenza-Cano, L., and Vaquero-Cristóbal, R. (2022) "Analyzing the Changes in the Psychological Profile of Professional League of Legends Players during Competition". *Computers in Human Behavior* 126, 107030

Matvienko, O. and Ahrabi-Fard, I. (2010) "The Effects of a 4-Week After-School Program on Motor Skills and Fitness of Kindergarten and First-Grade Students". *American Journal of Health Promotion* 24 (5 PG-299–303), 299–303

McCrorie, P., Martin, A., and Janssen, X. (2020) "Physical Activity Guidelines and Recommendations". *The Routledge Handbook of Youth Physical Activity* 69–100

McGann, J., Issartel, J., Hederman, L., and Conlan, O. (2020) "Hop.Skip.Jump.Games: The Effect of 'Principled' Exergameplay on Children's Locomotor Skill Acquisition". *British Journal of Educational Technology* [online] 51 (3), 798–816. available from

<http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=a9h&AN=142971766&site=ehost-live&authtype=sso&custid=s9872838 NS - NS ->

McGee, D., Lorencatto, F., Matvienko-Sikar, K., and Toomey, E. (2018) "Surveying Knowledge, Practice and Attitudes towards Intervention Fidelity within Trials of Complex Healthcare Interventions". *Trials*

McGoey, T., Root, Z., Bruner, M.W., and Law, B. (2016) "Evaluation of Physical Activity Interventions in Children via the Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) Framework: A Systematic Review of Randomized and Non-Randomized Trials". *Preventive Medicine* [online] 82, 8–19. available from <http://dx.doi.org/10.1016/j.ypmed.2015.04.006>

McGrane, B., Belton, S., Fairclough, S.J., Powell, D., and Issartel, J. (2018) "Outcomes of the Y-PATH Randomized Controlled Trial: Can a School-Based Intervention Improve Fundamental Movement Skill Proficiency in Adolescent Youth?" *Journal of Physical Activity and Health* [online] 15 (2 PG-89–98), 89–98. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054848769&doi=10.1123%2Fjpah.2016-0474&partnerID=40&md5=ed2290eb380d80156e21ea0b1ee2733b NS ->

McKay, H., Naylor, P.-J., Lau, E., Gray, S.M., Wolfenden, L., Milat, A., Bauman, A., Race, D., Nettlefold, L., and Sims-Gould, J. (2019) "Implementation and Scale-up of Physical Activity and Behavioural Nutrition Interventions: An Evaluation Roadmap". *International Journal of Behavioral Nutrition and Physical Activity 2019 16:1* [online] 16 (1), 1–12. available from <https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0868-4> [27 July 2021]

McKenzie, T.L., Alcaraz, J.E., Sallis, J.F., and Faucette, F.N. (1998) "Effects of a Physical Education Program on Children's Manipulative Skills". *Journal of Teaching in Physical Education* [online] 17 (3), 327–341. available from <NS ->

de Meester, A., van Duyse, F., Aelterman, N., de Muynck, G.J., and Haerens, L. (2020) "An Experimental, Video-Based Investigation into the Motivating Impact of Choice and Positive Feedback among Students with Different Motor Competence Levels". *Https://Doi.Org/10.1080/17408989.2020.1725456* [online] 25 (4), 361–378. available from <https://www.tandfonline.com/doi/abs/10.1080/17408989.2020.1725456> [5 April 2022]

de Meester, A. de, Galle, J., Soenens, B., and Haerens, L. (2022) "Perseverance in Motor Tasks: The Impact of Different Types of Positive Feedback". *Https://Doi.Org/10.1080/17408989.2022.2054969* [online] 1–14. available from <https://www.tandfonline.com/doi/abs/10.1080/17408989.2022.2054969> [29 March 2022]

de Meester, A., Stodden, D., Goodway, J., True, L., Brian, A., Ferkel, R., and Haerens, L. (2018) "Identifying a Motor Proficiency Barrier for Meeting Physical Activity Guidelines in Children". *Journal of Science and Medicine in Sport* 21 (1), 58–62

Menescardi, C., de Meester, A., Morbée, S., Haerens, L., and Estevan, I. (2022) "The Role of Motivation into the Conceptual Model of Motor Development in Childhood". *Psychology of Sport and Exercise* [online] 102188. available from <https://linkinghub.elsevier.com/retrieve/pii/S1469029222000565> [1 April 2022]

Michie, S., Fixsen, D., Grimshaw, J.M., and Eccles, M.P. (2009) "Specifying and Reporting Complex Behaviour Change Interventions: The Need for a Scientific Method". *Implementation Science*

Milat, A.J., Bauman, A.E., Redman, S., and Curac, N. (2011) "Public Health Research Outputs from Efficacy to Dissemination: A Bibliometric Analysis". *BMC Public Health* 11 (1), 1–9

Milat, A.J., Bauman, A., and Redman, S. (2015) [online] BioMed Central Ltd. available from <http://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0301-6> [6 February 2019]

Milat, A., Lee, K., Conte, K., Grunseit, A., Wolfenden, L., Van Nassau, F., Orr, N., Sreeram, P., and Bauman, A. (2020) "Intervention Scalability Assessment Tool: A Decision Support Tool for Health Policy Makers and Implementers". *Health Research Policy and Systems* 18 (1), 1

Miller, A., Christensen, E., Eather, N., Gray, S., Sproule, J., Keay, J., and Lubans, D. (2016) "Can Physical Education and Physical Activity Outcomes Be Developed Simultaneously Using a Game-Centered Approach?" *European Physical Education Review* [online] 22 (1), 113–133. available from <http://journals.sagepub.com/doi/10.1177/1356336X15594548> [26 June 2019]

Miller, A., Christensen, E.M., Eather, N., Sproule, J., Annis-Brown, L., and Lubans, D.R. (2015) "The PLUNGE Randomized Controlled Trial: Evaluation of a Games-Based Physical Activity Professional Learning Program in Primary School Physical Education". *Preventive Medicine* [online] 74 (PG-1-8), 1–8. available from <https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01052717/full NS ->

Mills, J. and Birks, M. (2017) "Qualitative Methodology: A Practical Guide". *Qualitative Methodology: A Practical Guide*

Moher, D., Hopewell, S., Schulz, K.F., Montori, V., Gøtzsche, P.C., Devereaux, P.J., Elbourne, D., Egger, M., and Altman, D.G. (2010) "CONSORT 2010 Explanation and Elaboration: Updated Guidelines for Reporting Parallel Group Randomised Trials". *Journal of Clinical Epidemiology*

Montgomery, P., Underhill, K., Gardner, F., Operario, D., and Mayo-Wilson, E. (2013) "The {Oxford} {Implementation} {Index}: A New Tool for Incorporating Implementation Data into Systematic Reviews and Meta-Analyses". *Journal of Clinical Epidemiology* [online] 66 (8), 874–882. available from <http://linkinghub.elsevier.com/retrieve/pii/S0895435613001078> [23 January 2018]

Moore, G.F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., Moore, L., O'Cathain, A., Tinati, T., Wight, D., and Baird, J. (2015) "Process Evaluation of Complex Interventions: Medical Research Council Guidance". *BMJ (Online)* 350

Moore, G.F., Evans, R.E., Hawkins, J., Littlecott, H., Melendez-Torres, G.J., Bonell, C., and Murphy, S. (2019) "From Complex Social Interventions to Interventions in Complex Social Systems: Future Directions and Unresolved Questions for Intervention Development and Evaluation". *Evaluation* 25 (1), 23–45

Morgan, P.J., Barnett, L.M., Cliff, D.P., Okely, A.D., Scott, H.A., Cohen, K.E., and Lubans, D.R. (2013) "Fundamental Movement Skill Interventions in Youth: A Systematic Review and Meta-Analysis". *Pediatrics* [online] 132 (5), e1361–e1383. available from <http://www.ncbi.nlm.nih.gov/pubmed/24167179> [18 December 2017]

Morgan, P.J. and Hansen, V. (2008) "Physical Education in Primary Schools: Classroom Teachers' Perceptions of Benefits and Outcomes". *Health Education Journal* 67 (3), 196–207

Mosston, M. and Ashworth, S. (2008) *First Online Edition of Teaching Physical Education*.

Moullin, J.C., Dickson, K.S., Stadnick, N.A., Albers, B., Nilsen, P., Broder-Fingert, S., Mukasa, B., and Aarons, G.A. (2020) "Ten Recommendations for Using Implementation Frameworks in Research and Practice". *Implementation Science Communications* 1 (1), 1–12

Nathan, N., Hall, A., McCarthy, N., Sutherland, R., Wiggers, J., Bauman, A.E., Rissel, C., Naylor, P.-J., Cradock, A., Lane, C., Hope, K., Elton, B., Shoesmith, A., Oldmeadow, C., Reeves, P., Gillham, K., Duggan, B., Boyer, J., Lecathelinais, C., and Wolfenden, L. (2021) "Multi-Strategy Intervention Increases School Implementation and Maintenance of a Mandatory Physical Activity Policy: Outcomes of a Cluster Randomised Controlled Trial". *British Journal of Sports Medicine* 0, 1–10

Nathan, N., Sutherland, R., Beauchamp, M.R., Cohen, K., Hulteen, R.M., Babic, M., Wolfenden, L., and Lubans, D.R. (2017) "Feasibility and Efficacy of the Great Leaders Active StudentS (GLASS) Program on Children's Physical Activity and Object Control Skill Competency: A Non-Randomised Trial". *Journal of Science and Medicine in Sport* [online] 20 (12), 1081–1086. available from <https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01458677/full NS ->

National Council for Curriculum and Assessment (NCCA) (2021) *Junior Cycle Wellbeing Guidelines 2021*. Dublin, Ireland

National Council for Curriculum and Assessment (NCCA) (2017) *Guidelines for Wellbeing in Junior Cycle 2017*. Dublin, Ireland

National Council for Curriculum and Assessment (NCCA) (2016) *Short Course Physical Education: Specification for Junior Cycle.* Dublin, Ireland

Naylor, P.-J., Nettlefold, L., Race, D., Hoy, C., Ashe, M.C., Wharf Higgins, J., and McKay, H.A. (2015) "Implementation of School Based Physical Activity Interventions: A Systematic Review". *Preventive Medicine* [online] 72, 95–115. available from <http://www.ncbi.nlm.nih.gov/pubmed/25575800> [1 February 2019]

Neil-Sztramko, S.E., Caldwell, H., and Dobbins, M. (2021) "School-Based Physical Activity Programs for Promoting Physical Activity and Fitness in Children and Adolescents Aged 6 to 18". *Cochrane Database of Systematic Reviews* 2021 (9)

Newell, K.M. (1986) "Constraints on the Development of Coordination". *Motor Development in Children: Aspects of Coordination and Control* 341–360

Ní Chróinín, D., Fletcher, T., Beni, S., Griffin, C., and Coulter, M. (2021) "Children's Experiences of Pedagogies That Prioritise Meaningfulness in Primary Physical Education in Ireland". *Education 3-13* 1–14

Nilsen, P. (2015) "Making Sense of Implementation Theories, Models and Frameworks". *Implementation Science* [online] 10 (1), 53. available from <http://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0242-0> [6 February 2019]

Nobre, G.C., Valentini, N.C., and Nobre, F.S.S. (2018) "Fundamental Motor Skills, Nutritional Status, Perceived Competence, and School Performance of Brazilian Children in Social Vulnerability: Gender Comparison". *Child Abuse & Neglect* 80, 335–345

Nobre GG, de Almeida MB, Nobre IG, Dos Santos FK, Brinco RA, Arruda-Lima TR, Borba Neto, M.E., Damasceno Rodrigues, E.M., Santos Silva, S.M., Leandro, C.G., and Moura Dos Santos, M.A. (2017). "Twelve weeks of plyometric training improves motor performance of 7-to 9-year-old boys who were overweight/obese: a randomized controlled intervention.". *Journal of Strength & Conditioning Research (Lippincott Williams & Wilkins)* 31 (8 PG-2091–2099), 2091–2099

Nowicki, H. and Merenstein, C. (2016) *Radar Chart* [online] available from <https://www.cs.middlebury.edu/~candrews/showcase/infovis_techniques_s16/radar_chart/>

Nutbeam, D. and Bauman, A. (2006) "Rocket Model - Stages of Research and Evaluation". in *Evaluation in a Nutshell: A Practical Guide to the Evaluation of Health Promotion Programs*.

Oakley, A., Strange, V., Bonell, C., Allen, E., and Stephenson, J. (2006) "Process Evaluation in Randomised Controlled Trials of Complex Interventions". *BMJ (Clinical Research Ed.)* [online] 332 (7538), 413–416. available from <https://pubmed.ncbi.nlm.nih.gov/16484270/> [8 April 2022]

O' Brien, W., Belton, S., and Issartel, J. (2015) "Fundamental Movement Skill Proficiency amongst Adolescent Youth". *Http://Dx.Doi.Org/10.1080/17408989.2015.1017451* [online] 21 (6), 557–571. available

from <https://www.tandfonline.com/doi/abs/10.1080/17408989.2015.1017451> [8 April 2022]

O'Cathain, A., Thomas, K.J., Drabble, S.J., Rudolph, A., and Hewison, J. (2013) "What Can Qualitative Research Do for Randomised Controlled Trials? A Systematic Mapping Review". *BMJ Open* [online] 3 (6), e002889. available from <http://www.ncbi.nlm.nih.gov/pubmed/23794542> [16 April 2019]

Okely, A.D., Booth, M.L., and Patterson, J.W. (2001) "Relationship of Physical Activity to Fundamental Movement Skills among Adolescents." *Medicine and Science in Sports and Exercise* 33 (11), 1899–904

Okely, A.D., Hardy, L.L., Batterham, M., Pearson, P., McKeen, K., and Puglisi, L. (2017) "Promoting Motor Skills in Low-Income, Ethnic Children: The Physical Activity in Linguistically Diverse Communities (PALDC) Nonrandomized Trial". *Journal of Science and Medicine in Sport* [online] 20 (11 PG-1008–1014), 1008–1014. available from <https://www.jsams.org/article/S1440-2440(17)30398-5/fulltext NS -> [23 January 2019]

Oppici, L., Rudd, J., Buszard, T., Exercise, S.S.-P. of S. and, and 2020, undefined (n.d.) "Efficacy of a 7-Week Dance (RCT) PE Curriculum with Different Teaching Pedagogies and Levels of Cognitive Challenge to Improve Working Memory Capacity". *Elsevier* [online] available from <https://www.sciencedirect.com/science/article/pii/S1469029219305291> [19 April 2022]

Ouzzani, M., Hammady, H., Fedorowicz, Z., and Elmagarmid, A. (2016) "Rayyan-a Web and Mobile App for Systematic Reviews". *Systematic Reviews*

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N., and Hoagwood, K. (2015) "Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research". *Administration and Policy in Mental Health and Mental Health Services Research* 42 (5), 533–544

Pascoe, M., Bailey, A.P., Craike, M., Carter, T., Patten, R., Stepto, N., and Parker, A. (2020) "Physical Activity and Exercise in Youth Mental Health Promotion: A Scoping Review". *BMJ Open Sport & Exercise Medicine* 6 (1), e000677

Pearson, A., White, H., Bath-Hextall, F., Salmond, S., Apostolo, J., and Kirkpatrick, P. (2015) "A Mixed-Methods Approach to Systematic Reviews". *International Journal of Evidence-Based Healthcare*

Pearson, N., Naylor, P.-J., Ashe, M.C., Fernandez, M., Yoong, S.L., and Wolfenden, L. (2020) "Guidance for Conducting Feasibility and Pilot Studies for Implementation Trials". *Pilot and Feasibility Studies 2020 6:1* 6 (1), 1–12

Pesce, C., Masci, I., Marchetti, R., Vazou, S., Sääkslahti, A., and Tomporowski, P.D. (2016) "Deliberate Play and Preparation Jointly Benefit Motor and Cognitive Development: Mediated and Moderated Effects". *Frontiers in Psychology* [online] 7

(MAR). available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84963642380&doi=10.3389%2Ffpsyg.2016.00349&partnerID=40&md5=e6ec54f9e9d478ae50659384172fbfee NS ->

Phillippi, J. and Lauderdale, J. (2018) "A Guide to Field Notes for Qualitative Research: Context and Conversation". *Qualitative Health Research* 28 (3), 381–388

Philpott, C., Utesch, T., Belton, S., Donovan, B., Chambers, F., Lester, D., and O'Brien, W. (2021a) "Effects of an 8-Week Intervention Targeting the Veridicality of Actual and Perceived Motor Competence Among Irish Adolescents in Project FLAME". *Perceptual and Motor Skills* [online] 128 (5), 2186–2210. available from <https://journals.sagepub.com/doi/10.1177/00315125211035090> [31 March 2022]

Philpott, C., Utesch, T., Belton, S., Donovan, B., Chambers, F., Lester, D., and O'Brien, W. (2021b) "Effects of an 8-Week Intervention Targeting the Veridicality of Actual and Perceived Motor Competence Among Irish Adolescents in Project FLAME": *Https://Doi.Org/10.1177/00315125211035090* 003151252110350

Physical Activity Guidelines Advisory Committee (2018) *Physical Activity Guidelines Advisory Committee.2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: U.S. Department of Health and Human Services, 2018.*

Platvoet, S.W.J., Elferink-Gemser, M.T., Kannekens, R., de Niet, M., and Visscher, C. (2016) "Four Weeks of Goal-Directed Learning in Primary Physical Education Classes". *Perceptual and Motor Skills* 122 (3), 871–885

Posner, P.L. (2009) "The Pracademic: An Agenda for Re-Engaging Practitioners and Academics". *Public Budgeting and Finance* 29 (1), 12–26

Powell, B.J., Fernandez, M.E., Williams, N.J., Aarons, G.A., Beidas, R.S., Lewis, C.C., McHugh, S.M., and Weiner, B.J. (2019) "Enhancing the Impact of Implementation Strategies in Healthcare: A Research Agenda". *Frontiers in Public Health* 7 (JAN), 3

Powell, B.J., Waltz, T.J., Chinman, M.J., Damschroder, L.J., Smith, J.L., Matthieu, M.M., Proctor, E.K., and Kirchner, J.E. (2015) "A Refined Compilation of Implementation Strategies: Results from the Expert Recommendations for Implementing Change (ERIC) Project". *Implementation Science 2015 10:1* [online] 10 (1), 1–14. available from <https://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0209-1> [27 July 2021]

Presseau, J., Byrne-Davis, L.M.T., Hotham, S., Lorencatto, F., Potthoff, S., Atkinson, L., Bull, E.R., Dima, A.L., van Dongen, A., French, D., Hankonen, N., Hart, J., ten Hoor, G.A., Hudson, K., Kwasnicka, D., van Lieshout, S., McSharry, J., Olander, E.K., Powell, R., Toomey, E., and Byrne, M. (2021) "Enhancing the Translation of Health Behaviour Change Research into Practice: A Selective Conceptual Review of the Synergy between Implementation Science and Health Psychology". *Https://Doi.Org/10.1080/17437199.2020.1866638* [online] 16 (1), 22–49. available

from <https://www.tandfonline.com/doi/abs/10.1080/17437199.2020.1866638> [31 March 2022]

Proctor, E., Luke, D., Calhoun, A., McMillen, C., Brownson, R., McCrary, S., and Padek, M. (2015) "Sustainability of Evidence-Based Healthcare: Research Agenda, Methodological Advances, and Infrastructure Support". *Implementation Science* 10 (1), 1–13

Rabin, B.A., Brownson, R.C., Kerner, J.F., and Glasgow, R.E. (2006) "Methodologic Challenges in Disseminating Evidence-Based Interventions to Promote Physical Activity". *American Journal of Preventive Medicine* 31 (4 SUPPL.), 24–34

Rapport, F. and Braithwaite, J. (2018) "Are We on the Cusp of a Fourth Research Paradigm? Predicting the Future for a New Approach to Methods-Use in Medical and Health Services Research". *BMC Medical Research Methodology 2018 18:1* [online] 18 (1), 1–7. available from <https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/s12874-018-0597-4> [23 August 2021]

Reis, R.S., Salvo, D., Ogilvie, D., Lambert, E. V., Goenka, S., and Brownson, R.C. (2016) "Scaling up Physical Activity Interventions Worldwide: Stepping up to Larger and Smarter Approaches to Get People Moving". *Lancet (London, England)* 388 (10051), 1337–1348

RezaeiZadeh, M., Hogan, M., O'Reilly, J., Cunningham, J., and Murphy, E. (2017) "Core Entrepreneurial Competencies and Their Interdependencies: Insights from a Study of Irish and Iranian Entrepreneurs, University Students and Academics". *International Entrepreneurship and Management Journal* 13 (1), 35–73

Rhodes, R.E., McEwan, D., and Rebar, A.L. (2019) "Theories of Physical Activity Behaviour Change: A History and Synthesis of Approaches". *Psychology of Sport and Exercise* 42, 100–109

Ridgers, N.D., Knowles, Z.R., and Sayers, J. (2012) "Encouraging Play in the Natural Environment: A Child-Focused Case Study of Forest School". *Https://Doi.Org/10.1080/14733285.2011.638176* [online] 10 (1), 49–65. available from <https://www.tandfonline.com/doi/abs/10.1080/14733285.2011.638176> [8 April 2022]

Rief, M., Oesterhelt, V., and Amesberger, G. (2022) "Education and Professionalization of Physical Education Teachers: Research Trends and Developments in German-Language Literature in Relation to Anglophone Perspectives". *Physical Education and Sport Pedagogy,* 1-17.

Ritchie, J., Lewis, J., Elam, G., Tennant, R., and Rahim, N. (2014) *Qualitative Research Approach : A Guide for Social Science Students and Researchers*. xxiv, 430 pages : illustrations ; 24 cm

Robinson, L.E., Stodden, D.F., Barnett, L.M., Lopes, V.P., Logan, S.W., Rodrigues, L.P., and D'Hondt, E. (2015) "Motor Competence and Its Effect on Positive

Developmental Trajectories of Health". *Sports Medicine 2015 45:9* [online] 45 (9), 1273–1284. available from <https://link.springer.com/article/10.1007/s40279-015-0351-6> [27 July 2021]

Rodriguez, M.C., Wade, T.J., Veldhuizen, S., Missiuna, C., Timmons, B., and Cairney, J. (2019) "Emotional and Behavioral Problems in 4- and 5-Year Old Children With and Without Motor Delays". *Frontiers in Pediatrics* [online] 7. available from <https://pubmed.ncbi.nlm.nih.gov/31803697/> [1 April 2022]

Rudd, J., Butson, M.L., Barnett, L., Farrow, D., Berry, J., Borkoles, E., and Polman, R. (2016) "A Holistic Measurement Model of Movement Competency in Children". *Journal of Sports Sciences* [online] 34 (5), 477–485. available from <https://pubmed.ncbi.nlm.nih.gov/26119031/> [28 June 2020]

Rudd, J R, Barnett, L.M., Farrow, D., Berry, J., Borkoles, E., and Polman, R. (2017) "The Impact of Gymnastics on Children's Physical Self-Concept and Movement Skill Development in Primary Schools". *Measurement in Physical Education and Exercise Science* [online] 21 (2 PG-92–100), 92–100. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85011875926&doi=10.1080%2F1091367X.2016.1273225&partnerID=40&md5=ff0c0773ecec902f93100f6e7f88894b NS ->

Rudd, James R, Barnett, L.M., Farrow, D., Berry, J., Borkoles, E., and Polman, R. (2017) "Effectiveness of a 16 Week Gymnastics Curriculum at Developing Movement Competence in Children". *Journal of Science and Medicine in Sport* [online] 20 (2 PG-164–169), 164–169. available from <https://www.jsams.org/article/S1440-2440(16)30118-9/fulltext NS ->

Rudd, J.R., Crotti, M., Fitton-Davies, K., O'Callaghan, L., Bardid, F., Utesch, T., Roberts, S., Boddy, L.M., Cronin, C.J., Knowles, Z., Foulkes, J., Watson, P.M., Pesce, C., Button, C., Lubans, D.R., Buszard, T., Walsh, B., and Foweather, L. (2020) "Skill Acquisition Methods Fostering Physical Literacy in Early-Physical Education (SAMPLE-PE): Rationale and Study Protocol for a Cluster Randomized Controlled Trial in 5–6-Year-Old Children From Deprived Areas of North West England". *Frontiers in Psychology* 11, 1228

Rudd, J.R., O'Callaghan, L., and Williams, J. (2019) "Physical Education Pedagogies Built upon Theories of Movement Learning: How Can Environmental Constraints Be Manipulated to Improve Children's Executive Function and Self-Regulation Skills?" *International Journal of Environmental Research and Public Health* 16 (9)

Rudd, J.R., Woods, C., Correia, V., Seifert, L. and Davids, K., (2021) "An ecological dynamics conceptualisation of physical 'education': Where we have been and where we could go next". *Physical Education and Sport Pedagogy*, 26(3), 293-306.

Rutter, H., Cavill, N., Bauman, A., and Bull, F. (2019) "Systems Approaches to Global and National Physical Activity Plans". in *Bulletin of the World Health Organization*. vol. 97 (2). World Health Organization, 162–165

Rutter, H., Savona, N., Glonti, K., Bibby, J., Cummins, S., Finegood, D.T., Greaves, F., Harper, L., Hawe, P., Moore, L., Petticrew, M., Rehfuess, E., Shiell, A., Thomas, J., and White, M. (2017) "The Need for a Complex Systems Model of Evidence for Public Health". in *The Lancet*. vol. 390 (10112). Lancet Publishing Group, 2602–2604

Salmon, J., Ball, K., Hume, C., Booth, M., and Crawford, D. (2008) "Outcomes of a Group-Randomized Trial to Prevent Excess Weight Gain, Reduce Screen Behaviours and Promote Physical Activity in 10-Year-Old Children: Switch-Play". *International Journal of Obesity* [online] 32 (4), 601–612. available from <http://www.nature.com/articles/0803805> [26 June 2019]

Saunders, R.P., Evans, M.H., and Joshi, P. (2005) "Developing a Process-Evaluation Plan for Assessing Health Promotion Program Implementation: A How-to Guide." *Health Promotion Practice* [online] 6 (2), 134–47. available from <https://journals.sagepub.com/doi/pdf/10.1177/1524839904273387> [16 May 2019]

Scheirer, M.A. and Dearing, J.W. (2011) "An Agenda for Research on the Sustainability of Public Health Programs". *American Journal of Public Health*

Schmidt, M., Valkanover, S., Roebers, C., and Conzelmann, A. (2013) "Promoting a Functional Physical Self-Concept in Physical Education: Evaluation of a 10-Week Intervention": *Http://Dx.Doi.Org/10.1177/1356336X13486057* 19 (2), 232–255

Schmidt, R.A., Lee, T.D., Winstein, C., Wulf, G. and Zelaznik, H.N., (2018). *Motor control and learning: A behavioral emphasis*. Human kinetics.

Schoenwald, S.K., Garland, A.F., Chapman, J.E., Frazier, S.L., Sheidow, A.J., and Southam-Gerow, M.A. (2011) "Toward the Effective and Efficient Measurement of Implementation Fidelity". *Administration and Policy in Mental Health* [online] 38 (1), 32–43. available from <https://pubmed.ncbi.nlm.nih.gov/20957425/> [15 April 2022]

Shea, C.M., Jacobs, S.R., Esserman, D.A., Bruce, K., and Weiner, B.J. (2014) "Organizational Readiness for Implementing Change: A Psychometric Assessment of a New Measure". *Implementation Science* 9 (1), 1–15

Silva Silveira, D., Barbosa Ferreira Lemos, L.F.G., Miranda Tassitano, R., Teresa Cattuzzo, M., Pereira Feitoza, A.H., Moreira Carneiro Aires, L.M.S., Silva Mota, J.A.P., de Lucena Martins, C.M., Silveira, D.S., Lemos, L.F.G.B.F., Tassitano, R.M., Cattuzzo, M.T., Feitoza, A.H.P., Aires, L.M.S.M.C., Silva Mota, J.A.P., and Martins, C.M. de L. (2018) "Effect of a Pilot Multi-Component Intervention on Motor Performance and Metabolic Risks in Overweight/Obese Youth". *Journal of Sports Sciences* 36 (20 PG-2317–2326), 2317–2326

Singal, A.G., Higgins, P.D.R., and Waljee, A.K. (2014) "A Primer on Effectiveness and Efficacy Trials". *Clinical and Translational Gastroenterology* [online] 5 (1). available from <https://pubmed.ncbi.nlm.nih.gov/24384867/> [8 April 2022]

Singh, A.S., Saliasi, E., van den Berg, V., Uijtdewilligen, L., de Groot, R.H.M., Jolles, J., Andersen, L.B., Bailey, R., Chang, Y.K., Diamond, A., Ericsson, I., Etnier, J.L.,

Fedewa, A.L., Hillman, C.H., McMorris, T., Pesce, C., Pühse, U., Tomporowski, P.D., and Chinapaw, M.J.M. (2019) "Effects of Physical Activity Interventions on Cognitive and Academic Performance in Children and Adolescents: A Novel Combination of a Systematic Review and Recommendations from an Expert Panel". in *British Journal of Sports Medicine*.

Siedentop, D., 1994. *Sport education: Quality PE through positive sport experiences*. Human Kinetics Publishers.

Skowroński, W., Skowrońska, M., Rutkowska, I., Bednarczuk, G., Kaźmierska-Kowalewska, K.M., and Marszałek, J. (2019) "The Effects of Extracurricular Physical Education Classes on Gross Motor Development in Primary School Children - Pilot Study". *Biomedical Human Kinetics* [online] 11 (1), 136–143. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85073875656&doi=10.2478%2Fbhk-2019-0019&partnerID=40&md5=c1652344c3e6af661f01eebc14e22788 NS - NS ->

Van Sluijs, E.M.F., McMinn, A.M., and Griffin, S.J. (2007) "Effectiveness of Interventions to Promote Physical Activity in Children and Adolescents: Systematic Review of Controlled Trials". *BMJ (Clinical Research Ed.)* 335 (7622), 653–657

Smith, B., Williams, O., Bone, L., and Collective, the M.S.W.C. (2022) "Co-Production: A Resource to Guide Co-Producing Research in the Sport, Exercise, and Health Sciences". *Https://Doi.Org/10.1080/2159676X.2022.2052946* [online] 1–29. available from <https://www.tandfonline.com/doi/abs/10.1080/2159676X.2022.2052946> [31 March 2022]

Smith, J.D., Li, D.H., and Rafferty, M.R. (2020) "The Implementation Research Logic Model: A Method for Planning, Executing, Reporting, and Synthesizing Implementation Projects". *Implementation Science* 15 (1), 1–12

Smith, J.J., Dudley, D., Lenoir, M., Brown, H., Iivonen, S., Laukkanen, A., Miller, A.D., Lubans, D.R., Cohen, K.E., Lander, N.J., Morgan, P.J., Barnett, L.M., Stodden, D., Cohen, K.E., Smith, J.J., Lubans, D.R., Lenoir, M., Iivonen, S., Miller, A.D., Laukkanen, A., Dudley, D., Lander, N.J., Brown, H., Morgan, P.J., Lenoir, M., Brown, H., Iivonen, S., Laukkanen, A., Miller, A.D., Lubans, D.R., Cohen, K.E., Lander, N.J., Morgan, P.J., Barnett, L.M., Stodden, D., Cohen, K.E., Smith, J.J., Lubans, D.R., Lenoir, M., Iivonen, S., Miller, A.D., Laukkanen, A., Dudley, D., Lander, N.J., Brown, H., and Morgan, P.J. (2016) "Fundamental Movement Skills: An Important Focus". *Journal of Teaching in Physical Education* 35 (3), 219–225

Sollerhed, A.C. and Ejlertsson, G. (2008) "Physical Benefits of Expanded Physical Education in Primary School: Findings from a 3-Year Intervention Study in Sweden". *Scandinavian Journal of Medicine and Science in Sports* [online] 18 (1), 102–107. available from <NS ->

Sollerhed, A.C., Olesen, L.G., Froberg, K., Soini, A., Sääkslahti, A., Kristjánsdóttir, G., Vilhjálmsson, R., Fjørtoft, I., Larsen, R., and Ekberg, J.E. (2021) "Movement and

Physical Activity in Early Childhood Education and Care Policies of Five Nordic Countries". *International Journal of Environmental Research and Public Health 2021, Vol. 18, Page 13226* [online] 18 (24), 13226. available from <https://www.mdpi.com/1660-4601/18/24/13226/htm> [31 March 2022]

Steckler, A. and Linnan, L. (2002) *Process Evaluation for Public Health Interventions and Research*. 1st ed. ed. by Steckler, A.B. and Linnan, L. San Francisco, Calif: Jossey-Bass

Stirman, S.W., Baumann, A.A., and Miller, C.J. (2019) "The FRAME: An Expanded Framework for Reporting Adaptations and Modifications to Evidence-Based Interventions". *Implementation Science* [online] 14 (1), 1–10. available from <https://implementationscience.biomedcentral.com/articles/10.1186/s13012-019-0898-y> [15 April 2022]

Stodden, D.F., Goodway, J.D., Langendorfer, S.J., Roberton, M.A., Rudisill, M.E., Garcia, C., and Garcia, L.E. (2008) *A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship* [online] vol. 60. Taylor & Francis Group . available from <https://www.tandfonline.com/doi/abs/10.1080/00336297.2008.10483582> [13 May 2019]

Strifler, L., Cardoso, R., McGowan, J., Cogo, E., Nincic, V., Khan, P.A., Scott, A., Ghassemi, M., MacDonald, H., Lai, Y., Treister, V., Tricco, A.C., and Straus, S.E. (2018) "Scoping Review Identifies Significant Number of Knowledge Translation Theories, Models, and Frameworks with Limited Use". *Journal of Clinical Epidemiology* [online] 100, 92–102. available from <https://pubmed.ncbi.nlm.nih.gov/29660481/> [8 April 2022]

Stylianou, M., Woodforde, J., Duncombe, S., Kolbe-Alexander, T., and Gomersall, S. (2022) "School Physical Activity Policies and Associations with Physical Activity Practices and Behaviours: A Systematic Review of the Literature". *Health & Place* 73, 102705

Sullivan, G.M. and Feinn, R. (2012) "Using Effect Size—or Why the P Value Is Not Enough". *Journal of Graduate Medical Education* 4 (3), 279

Sutherland, R., Campbell, E., McLaughlin, M., Nathan, N., Wolfenden, L., Lubans, D.R., Morgan, P.J., Gillham, K., Oldmeadow, C., Searles, A., Reeves, P., Williams, M., Kajons, N., Bailey, A., Boyer, J., Lecathelinais, C., Davies, L., McKenzie, T., Hollis, J., and Wiggers, J. (2020) "Scale-up of the Physical Activity 4 Everyone (PA4E1) Intervention in Secondary Schools: 12-Month Implementation Outcomes from a Cluster Randomized Controlled Trial". *International Journal of Behavioral Nutrition and Physical Activity* 17 (1), 1–14

Tabak, R.G., Khoong, E.C., Chambers, D.A., and Brownson, R.C. (2012) "Bridging Research and Practice: Models for Dissemination and Implementation Research".

American Journal of Preventive Medicine [online] 43 (3), 337–350. available from <https://pubmed.ncbi.nlm.nih.gov/22898128/> [24 March 2022]

Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T., Viikari, J.S.A., and Raitakari, O.T. (2014) "Tracking of Physical Activity from Early Childhood through Youth into Adulthood". *Medicine and Science in Sports and Exercise* 46 (5), 955–962

Telford, R.M., Olive, L.S., Keegan, R.J., Keegan, S., and Telford, R.D. (2021) "Teacher and School Outcomes of the Physical Education and Physical Literacy (PEPL) Approach: A Pragmatic Cluster Randomised Controlled Trial of a Multicomponent Intervention to Improve Physical Literacy in Primary Schools". *Physical Education and Sport Pedagogy* [online] 26 (1), 79–96. available from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85088962519&doi=10.1080%2F17408989.2020.1799967&partnerID=40&md5=0ebaaf6445de5cc715aa97b613975f91 NS - NS ->

Teychenne, M., Apostolopoulos, M., Ball, K., Olander, E.K., Opie, R.S., Rosenbaum, S., and Laws, R. (2021) "Key Stakeholder Perspectives on the Development and Real-World Implementation of a Home-Based Physical Activity Program for Mothers at Risk of Postnatal Depression: A Qualitative Study". *BMC Public Health* 21 (1)

Thiese, M.S. (2014) "Observational and Interventional Study Design Types; an Overview". *Biochemia Medica* 24 (2), 199

Tietjens, M., Barnett, L.M., Dreiskämper, D., Holfelder, B., Utesch, T.O., Lander, N., Hinkley, T., and Schott, N. (2020) "Conceptualising and Testing the Relationship between Actual and Perceived Motor Performance: A Cross-Cultural Comparison in Children from Australia and Germany". *Journal of Sports Sciences* 38 (17), 1984–1996

Tomporowski, P.D. and Pesce, C. (2019) "Exercise, Sports, and Performance Arts Benefit Cognition via a Common Process". *Psychological Bulletin* 145 (9), 929–951

Tompsett, C., Sanders, R., Taylor, C., and Cobley, S. (2017) "Pedagogical Approaches to and Effects of Fundamental Movement Skill Interventions on Health Outcomes: A Systematic Review". *Sports Medicine* [online] 47 (9), 1795–1819. available from <https://link.springer.com/content/pdf/10.1007%2Fs40279-017-0697-z.pdf> [15 May 2019]

Toomey, E., Matvienko-Sikar, K., Heary, C., Delaney, L., Queally, M., Hayes, C.B., Kearney, P.M., and Byrne, M. (2019) "Intervention Fidelity Within Trials of Infant Feeding Behavioral Interventions to Prevent Childhood Obesity: A Systematic Review". *Annals of Behavioral Medicine* 53 (1), 75–97

Top, E., Kıbrıs, A., and Kargı, M. (2020) "Effects of Turkey's Folk Dance on the Manual and Body Coordination among Children of 6–7 Years of Age". *Research in Dance Education* 21 (1), 34–42

Trecroci, A., Invernizzi, P.L., Monacis, D. and Colella, D., (2021) "Actual and perceived motor competence in relation to body mass index in primary school-aged children: A systematic review". *Sustainability*, 13(17), 9994.

Tsangaridou, N. (2006) "Teachers' Beliefs". *Handbook of Physical Education* 486–501

UNESCO (2021) *How To Influence the Development of Quality Physical Education Policy : A Policy Advocacy Toolkit For Youth*.

United Nations Educational, S. and C.O. (UNESCO) (2015) *Quality Physical Education (QPE): Guidelines for Policy Makers*.

Utesch, T. and Bardid, F. (2019) "Motor Competence in Dictionary of Sport Psychology". *Dictionary of Sport Psychology, Editors, Amesterdam, Elsevier,* [online] 186. available from <https://pureportal.strath.ac.uk/en/publications/motor-competence> [24 March 2022]

Utesch, T., Bardid, F., Büsch, D., and Strauss, B. (2019) "The Relationship Between Motor Competence and Physical Fitness from Early Childhood to Early Adulthood: A Meta-Analysis". *Sports Medicine* 49 (4), 541–551

Veritas Health Innovation (2019) *Covidence Systematic Review Sofware*.

Vernadakis, N., Papastergiou, M., Education, E.Z.-C.&, and 2015, undefined (n.d.) "The Impact of an Exergame-Based Intervention on Children's Fundamental Motor Skills". *Elsevier* [online] available from <https://www.sciencedirect.com/science/article/pii/S0360131515000172> [19 April 2022]

Venetsanou, F. and Kambas, A., (2010) "Environmental factors affecting preschoolers' motor development". *Early childhood education journal*, 37(4), 319-327.

Visier-Alfonso, M.E., Sánchez-López, M., Álvarez-Bueno, C., Ruiz-Hermosa, A., Nieto-López, M., and Martínez-Vizcaíno, V. (2022) "Mediators between Physical Activity and Academic Achievement: A Systematic Review". *Scandinavian Journal of Medicine & Science in Sports* 32 (3), 452–464

Waltz, T.J., Powell, B.J., Matthieu, M.M., Damschroder, L.J., Chinman, M.J., Smith, J.L., Proctor, E.K., and Kirchner, J.A.E. (2015) "Use of Concept Mapping to Characterize Relationships among Implementation Strategies and Assess Their Feasibility and Importance: Results from the Expert Recommendations for Implementing Change (ERIC) Study". *Implementation Science* 10 (1), 109

Ward, G. and Griggs, G. (2018) "Primary Physical Education: A Memetic Perspective". *European Physical Education Review* 24 (4), 400–417

Warfield, J.N. (2006) *An Introduction to Systems Science*. WORLD SCIENTIFIC

Warfield, J.N. and Cardenas, A.R. (2002) *A Handbook of Interactive Management* [online] available from <http://dl.acm.org/citation.cfm?id=560690> [9 June 2021]

Weiner, B.J. (2009) "A Theory of Organizational Readiness for Change". *Implementation Science* 4 (1), 1–9

Weiner, B.J., Lewis, C.C., Stanick, C., Powell, B.J., Dorsey, C.N., Clary, A.S., Boynton, M.H., and Halko, H. (2017) "Psychometric Assessment of Three Newly Developed Implementation Outcome Measures". *Implementation Science*

Weissgerber, T.L., Milic, N.M., Winham, S.J., and Garovic, V.D. (2015) "Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm". *PLOS Biology* 13 (4), e1002128

Whitehead, M. (2020) "The Nature of Physical Education". *A Practical Guide to Teaching Physical Education in the Secondary School* [online] 7–16. available from <https://www.taylorfrancis.com/chapters/edit/10.4324/9780429061318-2/nature-physical-education-margaret-whitehead> [29 March 2022]

WHO (2019) *Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 Years of Age*. World Health Organization

WHO (2010) *Global Recommendations on Physical Activity for Health* [online] available from <http://medcontent.metapress.com/index/A65RM03P4874243N.pdf%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Global+Recomendations+on+physical+activity+for+health#0> [15 May 2019]

Wolfenden, L., Chai, L.K., Jones, J., McFadyen, T., Hodder, R., Kingsland, M., Milat, A.J., Nathan, N., Wiggers, J., and Yoong, S.L. (2019a) "What Happens Once a Program Has Been Implemented? A Call for Research Investigating Strategies to Enhance Public Health Program Sustainability". *Australian and New Zealand Journal of Public Health* 43 (1), 3–4

Wolfenden, L., Reilly, K., Kingsland, M., Grady, A., Williams, C.M., Nathan, N., Sutherland, R., Wiggers, J., Jones, J., Hodder, R., Finch, M., McFadyen, T., Bauman, A., Rissel, C., Milat, A., Swindle, T., and Yoong, S.L. (2019b) "Identifying Opportunities to Develop the Science of Implementation for Community-Based Non-Communicable Disease Prevention: A Review of Implementation Trials". in *Preventive Medicine*. vol. 118. Academic Press Inc., 279–285

Wrotniak, B.H., Epstein, L.H., Dorn, J.M., Jones, K.E., and Kondilis, V.A. (2006) *The Relationship between Motor Proficiency and Physical Activity in Children*. vol. 118. American Academy of Pediatrics

Wu, C., Xu, Y., Chen, Z., Cao, Y., Yu, K., and Huang, C. (2021) "The Effect of Intensity, Frequency, Duration and Volume of Physical Activity in Children and Adolescents on Skeletal Muscle Fitness: A Systematic Review and Meta-Analysis of Randomized Controlled Trials". *International Journal of Environmental Research and Public Health 2021, Vol. 18, Page 9640* 18 (18), 9640

Ye, S., Lee, J.E., Stodden, D.F., and Gao, Z. (2018) "Impact of Exergaming on Children's Motor Skill Competence and Health-Related Fitness: A Quasi-Experimental Study". *Journal of Clinical Medicine* 7 (9 PG-261–261), 261

Young, M.D., Plotnikoff, R.C., Collins, C.E., Callister, R., and Morgan, P.J. (2014) "Social Cognitive Theory and Physical Activity: A Systematic Review and Meta-Analysis". *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity* 15 (12), 983–995

Zask, A., Barnett, L.M., Rose, L., Brooks, L.O., Molyneux, M., Hughes, D., Adams, J., and Salmon, J. (2012) "Three Year Follow-up of an Early Childhood Intervention: Is Movement Skill Sustained?" *International Journal of Behavioral Nutrition and Physical Activity 2012 9:1* 9 (1), 1–9

Zhang, L. and Cheung, P. (2019) "Making a Difference in PE Lessons: Using a Low Organized Games Approach to Teach Fundamental Motor Skills in China". *International Journal of Environmental Research and Public Health* [online] 16 (23), 4618. available from <https://www.mdpi.com/1660-4601/16/23/4618> [12 October 2020]

Zhou, Y., de Shao, W., and Wang, L. (2021) "Effects of Feedback on Students' Motor Skill Learning in Physical Education: A Systematic Review". *International Journal of Environmental Research and Public Health 2021, Vol. 18, Page 6281* [online] 18 (12), 6281. available from <https://www.mdpi.com/1660-4601/18/12/6281/htm> [1 April 2022]

Appendices

APPENDIX 1 PRISMA CHECKLIST

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5-6
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7-8
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Table 1
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplementary table S1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Fig. 1

Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	9-10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-10
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	12
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11-12
Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	12
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	12
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Fig. 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	13-14
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Supplementary Table S2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Supplementary Table S3, Table 8
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	19
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	19
DISCUSSION			

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	20-21
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	28-29
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	29-30
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Funding claims have been made under declaration section.

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Search	Query
#1	(child* or student* or children or childhood or kids or adolescen* or "young person*" or "young people" or teen* or youth* or boy* or girl* or juvenile*).ti,ab.
#2	exp child/
#3	exp adolescent/
#4	(#2 or #3).ti,ab.
#5	#1 or #4
#6	("Fundamental Movement Skill*" or "FMS" or "fundamental motor skill*" or "motor skill*" or "motor ability" or "motor learning*" or "motor competence" or "motor proficiency" or "motor development" or coordination or co-ordination or "gross motor skill*" or "motor pattern*").ti,ab.
#7	(Intervention* or "intervention stud*" or evaluat* or effect*).ti,ab.
#8	(random* or trial* or controlled or randomised or randomized or randomization or randomisation or RCT or non-RCT or non-randomised or non-randomized or control* or experimental or quasi-experimental).ti,ab.
#9	exp randomized controlled trial/
#10	exp clinical trial/
#11	exp randomized controlled trials as topic/
#12	exp clinical trial as topic/

#13   exp non-randomized controlled trial as topic/

#14   (#9 or #10 or #11 or #12 or #13).ti,ab.

#15   #8 or #14

#16   ("systematic review*" or "literature review*" or "case study" or "case report" or "abstract report" or letter).ti,ab.

#17   exp letter/

#18   exp historical article/

#19   exp case reports/

#20   exp systematic review/

#21   (#17 or #18 or #19 or #20).ti,ab.

#22   #16 or #21

#23   #15 not #22

#24   #5 and #6 and #7 and #23

#25   Limit #24 to English language

Study, Country	Design, Setting and Participant	Programme Length	Intervention Content and Deliverer	Instrument and Outcome
		Duration of one session (focus on FMS)		
Akbari et al. [80], Iran	Quasi-experimental, school N=40 boys, aged 7-9 y	8 wk/1440 min 60 min	Traditional game-based PE curriculum	TGMD-2 INT>CON for total FMS (p<0.001), locomotor (p<0.001), and object control skills (p<0.001)
Andruschko et al. [52]*, Australia	RCT, school N=20 girls, mean age=13.2±0.9	17 wk/3435 min 90 min	SCT; Multicomponent Component 1: weekly school sport sessions, incorporating fun and enjoyable activities designed to develop FMS Component 2: behaviour modification lessons. Teaching behavioural skills required for PA participation. Component 3: weekly non-compulsory sports session	Get Skilled Get Active INT>CON for total FMS (p=0.26, Cohen's d=0.48)
Azeem et al [73], India	Quasi-experimental, school N=100, mean age=10.02	2 wk/350 min 30 min	Short term agility training: Lateral shuffle, z drill, cone drill, ladder drill.	TGMD-2 (locomotor skills only) INT>CON for gallop (p<0.001), leap (p=0.021), horizontal jump (p<0.001), sliding (p<0.001).

Bakhtiari et al [84], Iran	RCT, school N=40, mean age=8.9 ±0.5	8 wk/1080 min 45 min	Specific PE curriculum with selected exercise	TGMD-2 INT>CON for total FMS, locomotor skills, and object control skills (p=0.001)
Bardid et al. [60], Belgium	Retrospective cohort study, community N=992, mean age=5.6±1.4	30 wk/1800 min 60 min	MultiMove for Kids: Provided by a trained local instructor (e.g. sport and recreation leaders, school teachers or caregivers). Activity sessions using 12 basic motor skills themes: running, climbing, swinging, gliding, rotating, jumping, catching and throwing, pushing and pulling, lifting and carrying, hitting, kicking, dribbling.	TGMD-2 INT>CON for both locomotor (p<0.001, ES=0.57) and object control skills (p<0.001,ES=0.69). Girls demonstrated a lower gain in object control skills (SE=0.49, p<0.001) and higher gain in locomotor skills (p=0.022)than boys.
Barnett et al. [94]*, Australia	Quasi-experimental, school N=1045, aged 7-10	1 y	Move It Groove It: CMT and PA tracking. Whole School Approach 1)supporting teachers; 2)creating supportive environments and healthy school policies. Five strategies: school project teams, a buddy programme, professional development for teachers, project website, funding for purchase of equipment.	Get Skilled Get Active INT significant 16.8% improvement for all skills combined (p<0.0001). At 6-year follow up, INT had improved their catch ability relative to controls and were five times more likely to be able to catch but had lost their advantage in the throw and kick. INT

				maintained their advantages on jump and gallop.
Barnett et al. [72]*, Australia	RCT, after school N=95, mean age=6.2±0.95	6 wk/360 min 60 min	Active Video Game (AVG)	TGMD-2 (object control) Actual and perceived object control skills improved in both INT and CON, no significant difference between groups.
Boyle-Holmes et al. [82]*, United States	Quasi-experimental, school N=1464, mean age=9.8	2 y/44 sessions/ 3520 mins 40 min	Michigan's Exemplary PE Curriculum: focuses on developing knowledge, attitudes, skills, and behaviours that are associated with lifelong physical activity through teaching and motor skills learning progressions. Using Learning progression to improve student confidence from novice through mastery stages of movement skills. Lessons focussed on the following three standards: motor skill and movement, values of PA for health and enjoyment, and regular PA.	Observation rubric (developed for the study). Measures performance on forehand strike, lift and carry, and leap based on van Beurden (2003) INT>CON forehand strike, lift and carry (p<0.05). INT>CON 5th grade leap (p<0.05).
Capio et al. [71], Hong Kong	Quasi-experimental, school N=26, mean age=7.17±2.17	8 wk/360 min 45 min	Session consisted of skill-specific training of two locomotor (run,jump) and three object control skills (kick, throw and catch) with progression in task difficulty. No instructions directed to aim for performance outcome. Practice were verified before proceeding to the next level of difficulty.	TGMD-2 INT>CON for all five skills, p<0.05.

Chagas et al. [51], Brazil	Quasi-experimental, school	3-5pw for one year, average 3102mins	Unstructured sport activity (table tennis)	KTK INT and CON both increased motor coordination level (p=0.01). No significant time X group effect for INT.
	N=36, mean age=13.0±0.5	30-40 min		
Chan et al. [98]*, Hong Kong	CRCT, school N=276, mean age=8.4±0.56, 10 schools	Once or twice pw for 6 month/550 min 45-70 min	CMT Assessment-based intervention that emphasises on: 1) student-centred formative assessments to improve instruction and learning (based on TGMD-3); 2) use of technology (e.g. QR codes) to make the teaching–learning process more meaningful and fun (self and peer assessment); 3) quality instruction and practice coupled with constructive feedback to improve mastery of movement and; 4) provision of resources to support teachers	TGMD-3 Significant intervention effects were found for total FMS (d=0.93), locomotor (d=0.76).
Cliff et al. [83]*, Australia	RCT, community N=166, aged 5.5-9 y	10 sessions over 6 month/900 min 90 min	CMT INT 1: weekly group sessions and home challenge activities. Facilitated by two qualified teachers with expertise in PE, focussed on developing 12 FMS and letting students experience success and improving PMC with a supportive environment. Parents were involved in the 1st session and encouraged to complete skill development activities at home. Facilitators focused on correcting errors	TGMD-2 INT1 and IN3 > INT2 for locomotor and object control (p<0.01) and total FMS (p<0.001). No difference at FU.

			and providing feedback for each skill component. 3-month minimal maintenance phase with monthly phone calls and 1 skill booster session. INT2: Parent-only focused on diet behaviours and quality INT3: Combination of INT1 and INT2	
Cohen et al. [97]*, Australia	CRCT, school N=460, mean age=8.5±0.6, 25 classes in eight schools	120 min compulsory PE and sport pw for 12 month 120 min	Socioecological model, SDT, CMT Three phases: P1 teacher training, student leadership workshops, PA promotion tasks to achieve awards, provision of PA equipment, school committee. P2: schools encouraged to implement 6 PA policies. Policy 1: functioning school PA committee, policy 2 Student participation in at least 120min of PE and school sport per week, policy 3 50% of PE and school sport time allocated to MVPA, policy 4 annual reporting of students FMS and fitness levels, policy 5 promotion of active playgrounds, policy 6 involve family members/carers in school-based PA. Targeting home environment. P3 improve school-community links.	TGMD-2 INT>CON for total FMS (p=0.008)
Duncan et al. [50]*, England	RCT, school N=94, mean age=6.34±0.5	10 wk/350 min 30-40 min	Integrated neuromuscular training (INT). Designed to be time efficient, inexpensive and developmentally appropriate and have little disturbance on curriculum. Mobility focused warm up exercises, followed by a series of FMS exercises, participants received skill-specific feedback on the quality of each movement and were	TGMD-2 INT>CON in process FMS scores (p=0.001). For product measures of FMS, INT>CON in 10m sprint time, counter movement jump, seated

			taught the value of initiating exercises from an athletic stance.	medicine ball throw and standing long jump (p=0.001).
Ericsson et al. [93], Sweden	Quasi-experimental, school N=263, aged 6 y	Unclear	SCT 3 PE lessons and 2 PA session pw. 1 extra motor training pw if needed. Training based on MUGI model aiming to let students feel motivated and enjoy taking part in PA.	MUGI observation checklist INT>CON for motor skills after one year of intervention (p<0.05, Cramér's index = 0.24). In year 3, the differences increased and greatest in the variable balance/bilateral coordination (Cramér's index = 0.37). School year 9 differences were even larger(Cramér's index = 0.62).
Fahimi et al. [86], Iran	Quasi-experimental, school N=120, aged 7-9 y	4 wk/1080 min 90 min	Four motor programmes: gymnastics, soccer, school games, and usual control	BOT2 INT>CON for total FMS (p<0.05). Mean difference of each group compared to CON are 4.50 (school games), 3.46 (soccer) and 3.53 (gymnastics)
Foweather et al. [90], UK(England)	CRCT, after school	Semi-weekly for 9 wk/1080 min 60 min	Multiskill club. Focusing on FMS. Consisted of a variety of games, drills and self-learning activities.	Modified checklist developed using Get Skilled Get Active

				INT>CON for static balance (p=0.005)
Gallotta et al. [59], Italy	RCT, school N=230, aged 8-9 y	2 sessions pw for 5 month 60 min	INT1: Focusing on fitness. Aiming to improve aerobic endurance by varying exercise intensity and gaits (e.g., fast walking, running, skipping) without any specific coordinative request. INT 2: Focusing on coordination and dexterity. Aiming to develop psychomotor competence and movement-based problem solving. Lesson consisted of a combination of different exercises that require various skills and abilities.	KTK No effects on KTK performance. All groups showed a general improvement in KTK performance from pre- to post-intervention.
Graf et al. [88], Germany	CRCT, school N=615, mean age=6.85±0.47	1y8m	TPB and precaution adoption process model. One health education lesson pw (20-30mins) comprising topics of biological background, nutrition, and self-management. PA breaks (5min) once a morning. PA opportunities in breaks and PE which were optimised by trained teachers. One induction training workshop and yearly follow up.	KTK INT>CON for lateral jumps (p<0.001) and 6-min run (p=0.002). 4y FU: An increase in improvement in INT.
Gu et al. [49]*, United States	Quasi-experimental, school N=273, mean age=10.9±0.8	3 sessions pw for 8 wk	Pedometer-based, goal setting. INT1: personalised pedometer weekly target to reach in PE class based on baseline measures INT2: fixed pedometer target to reach based on research recommended step goals	PE Metrics assessing PE related MC : NASPE (National Association for Sport and Physical Education, 2010). Both INT>CON (p< .001)

Guerrero et al. [48], Canada	Quasi-experimental, community N=9, mean age=9.11±0.60	4 wk	Using imagery training to improve motor skills, also motivation, confidence, perceived physical competence. Four imagery scripts were created targeting FMS and included stimulus and response propositions. Children can access them on a website and were taught how to use. In 1st week, children were briefed with the intervention and completed a sample session before completing additional two imagery training session at home.	CAMSA Results showed that FMS increased from pre- to post-intervention in INT not in CON (p=0.008)
Hajihosseini et al [67], Iran	RCT, school N=41, mean age=12.90±0.5	16 wk/960 min 30 min	Focus on adolescent's enjoyment of and participation in MVPA during PE. Each session included warm-up, fitness training, traditional games, static stretching cool down.	BOT INT>CON for total FMS (p<0.001)
Invernizzi et al. [53]*, Italy	RCT, school N=121, mean age=10.5±0.5	12 wk/1440 min 120 min	Multi-Teaching Styles Approach and Active Reflection (MTA), comprising guided discovery, problem-solving, collaborative learning, direct app of instruction and task demand, and answering questions which emphasise positive engagement in PA to induce autonomy. Conducted by three PGRs without prior experience teaching PE in primary school following three 2-h training sessions. Ongoing feedback and adaptations were provided.	TGMD-2 INT>CON for total FMS (p<0.001)
Jarani et al. [66]*, Albania	CRCT, school	2 sessions pw for 5 month	Two intervention groups applied station/circuit teaching for continuous practice on different exercise or games.	KTK

	N=767, aged 6-10y	45 min	INT1: focused on individuals INT2: focused on involving more than three or four children on each of the four modules.	Both INT>CON. INT2 showed more positive changes in some skills.
Johnson et al [65]*, Australia	RCT, school (lunch time) N=36, mean age=7.9±1.5	6 wk/300 min 50 min	Active Video Games (AVGs)	TGMD-3 No significant intervention effects were observed
Johnstone et al. [58], UK (Scotland)	Pragmatic Evaluation, community N=196, mean age=7.0±1.1	2 sessions pw for 5 month 60 min	PL Local trained play workers (trained by Agile CIC), combined structured games (FMS focussed) and free play.	TGMD-2 Significant time X group effects in total FMS (p=0.04) and locomotor skills (p=0.02). No significant effects in object control skills.
Kalaja et al. [85]*, Finland	Quasi-experimental, school N=446, aged 13y	33 wk/825 min 25 min	Researchers trained teachers on a) FMS; b) intervention planning and use of teaching styles. Four sessions were organised: pre-intervention two-day seminar, pre-intervention two four-hour workshops (cooperative planning process on lesson plans), mid-intervention three-hour workshop. 33 FMS sessions across three block with each block focusing on one dimension of FMS including locomotion, manipulation and balance.	a) flamingo standing test, b) rolling test, c) leapingtest, d) shuttle run test, e) rope jumping test, f) accuracy throwing test and g) figure-8 drib-bling test. All skill scales were standardised in z-scores

				INT>CON in total FMS only. Post intervention skill levels in INT decreased more than CON.
Karabour niotis et al. [96]*, Greece	RCT, school N=45, mean age=6.6±1.8	2 pw for 12 wk/960 min 40 min	Mastery climate. Skill-oriented programme with focus on self-testing activities. FMS curriculum with an increasing allotment of time spent on self-testing activities.	TGMD INT>CON for total FMS, locomotor and object control skills (p<0.001)
Lander et al. [57]*, Australia	CRCT, school N=190, mean age=12.4±0.3	12 wk/1080 min 90 min	Based on CMT or mastery motivational approach, systematic review evidence on characteristics of teacher training (Lander et al 2017). A multimodal training programme was designed to enhance the confidence and competence of PE teachers in FMS pedagogy and assessment. Teacher training include (1) 4-hour face to face interactive workshop/seminar 2)written resources (teacher manuals including protocols and procedures, score sheets, example lesson plans, activity suggestions, and lesson planning and delivery checklists); 3)three onsite teaching observations and 30min consultation afterwards per teacher; 4) regular teacher prompted on-going support.	Victorian FMS teachers' manual assessment. Significant intervention effects in locomotor (p= 0.04, d = 1.6), object control skills (p= <0.001, d = 0.83) and total FMS (p= 0.02, d = 1.36).
Laukkan en et al.	CRCT, school, family based	1 y	SCT and TPB. Multicomponent 1) Researchers provided lectures on PA behaviour change: one-hour MVPA outside school context, relationship	KTK, Throwing and Catching a Ball (TCB) protocol.

[69]*, Finland	N=103, mean age=6.16±1.13	30 min lecture; face-to-face session 30-60 min	between PA and development of MC, school readiness. 2) Face-to-face counselling and goal setting. Parents described family PA habits, and set small goals to reach the target PA level. 3) Phone counselling at months 2 & 5 after face-to-face counselling to promote compliance and discuss modifications; 4) monthly email on seasonal tips and illustrative videos. Feedback after six-month measurements and provide practical advice to improve MC.	TCB showed a nearly significant improvement at six months in INT compared to CON (p = .051), but not at 12 months. Significant time X group X season effect in favour of INT for KTK performance
Mathisen et al. [64], Norway	Quasi-experimental, school N=43, mean age=6.5±0.7	4 wk/ 1200 min 60 min	Task-specific approach, with individualised student activities. Station-based PE sessions consisted jumping, climbing, throwing and warm up.	The three test items (jumping, throwing and running) were taken from the new test battery designed for testing everyday activities for children (Fjørtoft et al. 2011) INT>CON for jumping, climbing and distance throwing (p<0.05)
Matvienko et al. [81], United States	Quasi-experimental, after school N=70, grades K and 1	4 wk/2100 min 90 min	Co-development of intervention with PE teachers. Daily morning walk and after-school session. Sessions include 2 x 15min body awareness, safety and nutrition session; 1 x 30min fitness session (10min fitness and 20min on motor skills including throwing for distance, kicking for accuracy and rope-jumping), supervised non-structured active play.	Fitnessgram throwing distance test. Additional measures specific to the study: rope jumping, kicking INT>CON for jumps over rope, throwing and kicking at both post-trial and FU.

McGrane et al [47], Ireland	CRCT, school N=482, mean age=12.78±0.41	One pw	YPAP (Youth PA promotion) aimed at enabling youth to positively re-evaluate the predisposing factors and enabling factors that influence PA participation. A social-ecological framework was adopted. PE teacher underwent one-day in-service training by researchers consisting of FMS development, assessment, FMS in PE. Lessons plans and DVD lessons sample were provided. Four components: 1)student: focus on FMS in PE; 2)Parent/guardian component: educated about health benefits of PA; 3) teacher component: all school staff participate in two workshops to promote PA participation 4)website component: resources were made available online.	TGMD2, Victoria FMS Manual INT>CON for object control, locomotor, greatest improvement for total FMS.
McKenzie et al. [95], United States	CRCT, school N=709, mean age=9.56	6 month/2160 min	INT1: PE specialists implemented SPARK programme (Sports, Play and Active Recreation for Kids). PE curriculum designed to enhance fitness and sports/motor skills. Lesson plans, details include no. and type of instructional cues for the specific skills were provided. An additional half-hour pw to practice self-management skills. INT2: engage classroom teachers to SPARK, understand and use PE content and develop class management and instructional skills. Extensive training over 2 years intervention period: 32hrs over 11 sessions in 1st year and 9hrs over 3sessions during the 2nd.	Overhand throw, catch, kick INT2>CON for catching and throwing (p<0.01). Total skill percentage gains INT1 21%, INT2 19%, CON 13%

Miller et al. [63]*, Australia	CRCT, school N=168, mean age=11.2±1.0	7 wk	Game centred approach (GCA) addressing skill development, cognitive aspects of how to play games and affective outcomes. Teacher training on GCA, promotion of mastery motivational climate. Design of activities aimed to provide diversity of challenge among varied abilities.	TGMD-2 (object control only) Intervention effects for object control (d=0.96).
Miller et al. [76]*, Australia	RCT, school N=107, mean age=10.7±0.87	6 wk/360 min 60 min	GCA delivered via in-class teacher mentoring. 2.5h information session followed by in-class mentoring for the first 4 wk. Mentor progressively withdrew instructional assistance, providing only feedback in final 2 sessions. Session focus: 1)how to move, focusing on FMS 2)how to play, focusing on decision making and tactical development in game play; 3)how we play: focusing on successful team-work, sportsmanship regardless of performance outcomes.	TGMD-2 (object control only) Group X Time intervention effects for throw (d=0.9) and catch (d=0.4).
Nathan et al. [56]*, Australia	Quasi-experimental, school N=174, mean age=7.9±2.0	2 pw for 10 wk/600 min 30 min	Great Leaders Active StudentS(GLASS) programme. Based on peer leadership component of SCORES intervention and adapted tenet of transformational leadership theory. 20 student leaders received handbooks and 3-h leadership training sessions including peer leadership training, FMS training (including basic teaching cues, feedback and opportunities in practising FMS). At wk5, leaders received 1-h booster session.	TGMD-3 Significant for overall object control skills (d=0.95) and for all individual skills except the kick. Stronger effect among boys.

Nobre et al. [55], Brazil	Quasi-experimental, school	2 pw for 12 wk/480 min	Plyometric training.	KTK
			Progressive increment of intensity during 12wk. Exercise includes lateral jump, squat jump, and high-intensity jumps.	
		20 min		Effective for improving gross motor coordination (d=1.02)
	N=59, aged 7-9y			
Okely etl al. [54]*, Australia	Quasi-experimental, school	4 y	The Physical Activity in Linguistically Diverse Communities (PALDC). Quality Teaching and Learning Materials (QTLM) model and an Action Learning framework to provide a structured approach to school-based professional development where a group of schools all work on the same area of change.	Get Skilled Get Active
				INT>CON for total FMS (p=0.01); and sprint run (p=0.001), vertical jump (p=0.006), catch (p=0.02) and the leap (p=0.004).
	N=862, mean age 8.69±1.70		Each school developed an action plan for the intervention targeting the structure and delivery of FMS and school sport, modifying school environment, developing links with home and local community. Each school had a team of 4-5 teachers with one teacher being the 'champion', a researcher to help with development and implementation of action plan. School teams attended a one-day planning workshop and a two-day workshop on QTLM and an additional final sharing workshop.	
Pesce et al. [75]*, Italy	CRCT, school	6 month/1440 min	'Enriched' PE, centred on deliberate play and cognitively challenging variability of practice. Teachers underwent 4h training pm to prepare teaching module, analyse teaching behaviours and address interdisciplinary issues.	M-ABC
		60 min		INT>CON in all motor coordination assessments including manual

				dexterity, ball skills, static/dynamic balance.
N=920, aged 5-10y, eight schools				
Platvoet et al. [74], The Netherlands	Quasi-experimental, school	Two sessions pw for 4 week/360 min	Goal-directed learning: 1) goal-directed instruction: children were told their performance would be tested. At 1st session demonstration was given. 2) Providing children with choices of exercises to practice. 3) Seven exercises designed by PE teachers	KTK
	N=425, mean age=6.40±0.52	45 min		INT>CON for KTK performance
Rudd et al. [45]*, Australia	Quasi-experimental, school	16 wk/7200 min	Gymnastics curriculum (LaunchPad). Teaching sequence: warm-up, brain challenge, main activity, circuit and cool down	TGMD-2
		120 min		
	N=333, mean age=8.1±1.1			Significant Group X Time effect for stability and object control skills (p < 0.05). No difference was found in locomotor skills or total FMS.
Rudd et al. [44]*, Australia	Quasi-experimental, school	8 wk/960 min		TGMD-2
	N=113, mean age-9.4±1.8	120 min		INT>CON in total FMS for the lower age group; INT>CON in total FMS and coordination for the upper age group.

Salmon et al. [78]*, Australia	CRCT, school N=311, mean age=10y8m, three schools	9 month/855 min	SCT and BCT. Delivered in addition to PE and sports classes. INT1: Behaviour modification on self-monitoring, health benefits of PA, awareness of home and community PA, and sedentary behaviour, decision making and identifying alternatives to screen that included designing their own physical activity games; intelligent TV viewing and reducing viewing time; advocacy of reduced screen time through poster displays and role plays; use of pedometers; and group games. INT2: Mastery of six FMS (run,dodge,vertical jump,throw,strike,kick) with emphasis on enjoyment and fun. INT3: Combination of both	Victoria FMS: A Manual for Classroom Teachers No significant intervention effects on FMS z-scores
SilvaSilveira et al. [46]*, Brazil	Quasi-experimental, after school N=43, mean age=8.17±2.48	12 wk/720 min 60 min	Socioecological model, offering PA sessions, nutritional education and parental support targeting intrapersonal, interpersonal and environmental. Developed by PE teachers, 1 nutritionist and 1 paediatrician. PE sessions taught by 1 PE teacher. Nutritional education: dietary counselling, three daily dietary goals. Parental support: PA sessions offered to all parents.	KTK Significant Time X Group effects for INT (p < 0,001) on KTK performance
Sollerhed et al.	Quasi-experimental, school	4 pw for three years	Increased allocated PE time. Overweight group were given extra voluntary lesson pw, focusing on motor skills and self-esteem	EUROFIT

[77], Sweden	N=132, 7-9y	40 min		INT>CON for motor skill index (p=0.010)
Vernada kis et al. [62], Greece	RCT, school

N=66, mean age=6.35±0.73 | 2 pw for 8 week/480 min

30 min | Dynamical Systems Theory that emphasises the importance of all systems in contributing to a particular behaviour or pattern of behaviours (Thelen and Ulrich, 1991)

INT1: Delivered by a trained motor skill instructor. Speciic lesson plans and task analysis of each skill during sessions.

IN2: Station-based exergames using Xbox

Kinect. Same instructor provided instruction on how to perform the necessary movements in each game. | TGMD-2 (object control only)

Both INT>CON for object control skills (p<0.001) |
| Ye et al. [61], United States | Quasi-experimental, school

N=261, mean age=8.27±0.70 | 9 month

25 min | Alternating PE and exergaming sessions weekly. 12 stations used equipped with 2 exergaming systems including Wii. A trained teacher supervised their participation. | Performance on four skills (kicking, throwing, standing long jump, and hopping). Locomotion score is calculated from mean T-scores (50+10*Z-score) for both long jump and hopping. Object control score is calculated from mean T-scores of both kicking and throwing.

Both INT and CON improved their total FMS (p < 0.01), with CON |

demonstrating greater improvement (p = 0.01).

*Studies reported process evaluation measures and carried onto Phase 2 analysis

References	Process evaluation measures and their collection methods (highlighted with _underlined italic_) and results
Andruschko et al. [52]	**RQ:** Assess the feasibility and acceptability of the intervention components and activities
	Recruitment and retention:19/20(95%) retained. Recruitment less than hypothesised, due to the school environment and students being required to participate in activities. Future studies could possibly address this through making the program available for all students rather than exclusively for a specific sub-group._
	Dose delivered: Assessed via _% of sessions delivered_ for each component: Component 1 Sports session (100%;17/17); Component 2 Behaviour modification session (98%;46/47); Component 3 After-school sport session (75%; 15/20). Hypothesised rates of implementation were met for Component 1 and 2. **Reach**: Assessed through _attendance rates_. Component 1,2 and 3 with attendance rates of 80%, 79% and 44% respectively.
	Participant responses: _Enjoyment_ assessed via _questionnaires_, enjoyment on component 1 and 3 was high, with mean scores of 4.0 and 4.7 out of 5 respectively.
	Barriers: Through _researcher observation_, poor attendance for Component 3 was due to unavailability of public transport for students.
Barnett et al. [94]	**Implementation process:** Assessed via _System for Observing Fitness Instruction Time (SOFIT)_: Compared to control groups, the changes in intervention PE contexts: a) increase in time spent on skill training; b) no change in time spent on management/instruction; c) decrease in time spent on fitness, and d) a decrease in time spent on games.
Barnett et al. [72]	**RQ:** Children's perceptions of the acceptability of using an AVG, play-based sports programme to increase children's actual and perceived object control skills
	Dose received: Assessed via _structured observations_. Research assistants recorded time spent in game, administration, and time off task per child and session. Intervention dose (278mins) were significantly lower than previously effective intervention (480min).

	Participant responses: *Assessed* FGs. Post-trial, seven FGs conducted with intervention children explored factors influencing participation and outcomes. Questions around the enjoyment of AVG, perceived relationship between AVG and real-life equivalents. Transferability to real life activities and whether AVG could or did assist in real life skill development or sports competence as well as recommendations for improvement for intervention. Children reported finding participation enjoyable and fun. Children favoured AVGs containing a competitive element, such as playing against another player or via single-player games involving individual performance monitoring.
	Moderator: Prior to the intervention, parents were surveyed to provide SES, weekly AVG game play time, and enrolment in organised sports/activities outside of school. *Exploratory moderating analyses (prior ball sports experience)* were conducted, results suggest small increase in control girls without prior ball sports experience and large increase in OC skills for intervention girls with prior experience.
Boyle-Holmes et al. [82]	**RQ:** Curricula comparison between intervention and control arms
	Implementation processes: recorded by teachers with *log data (documentation on how and what teachers taught)* **Dose delivered:** 44 lessons (75% of the curriculum) were taught by teachers in intervention group. **Fidelity:** All NASPE content standards, amounts of class time spent on lesson components were similar between intervention and control arms. Intervention teachers reported using a written lesson plan for more than 80% of their PE lessons, comparison teachers using less than 50% of the time. Correlates of curriculum fidelity and reported curriculum modifications and adaptations for teachers in both study arms appeared balanced.
	Facilitators: a well-organized written curriculum guide, teacher training, administrator support, adequate educational supplies, and adequate teaching environments.
Chan et al. [98]	**RQ:** Assess if the intervention was delivered and implemented as planned
	Fidelity: (1) Assessed via *teachers' lesson plans*. All lessons were delivered. Protocol adherence in both arms were achieved.

	(2) Assessed via *on-site researcher observations* against Assessment for Learning (AfL) checklist. Two class observations were conducted. Intervention teachers displayed gradual practical understanding of AfL, improving competence in using TGMD criteria. **Adaptations**: *Feedback and reinforcement* were provided after each of the two observations and 1-hr mid intervention meeting. All attended meeting reported teaching support was highly appropriate to update and develop FMS knowledge. One questioned the increased time needed for planning AfL in face of limited class time and large class sizes.
	Participant responses: **(1)** Students involvement was assessed via the *practice handbook completed by students and their parents* with 50% completion and returned rates. **(2)** Post-intervention teacher satisfaction on 6-hr workshop were assessed via *questionnaires*. High satisfaction were reported. They strongly agreed the workshop increased FMS knowledge (5), increased AfL knowledge (4.8); enabled FMS application (4.9); enabled AfL application (4.4); helped teacher to improve FMS (4.8); enhanced teaching confidence (4.7); motivated teachers to learn more (4.8). **(3)** Student engagement in class were assessed via *researcher observations*. Students were sensitive to skill errors and encouraged to make progress and compete with previous efforts.
Cliff et al. [83]	**RQ:** Explicit design of process evaluation. The main focus of the process evaluation was the following intervention components: attendance, fidelity in delivery, facilitator evaluation, level of participation by parents and/or children, and parents' understanding and perception of the program and materials as well as quality assurance (independent observations).
	Reach: Assessed via *attendance rate*. 72% and 77% for PA group and PA+DIET group, respectively. Attendance was highest during the first 5 weeks. PA refresher attendance rate was 51%. Follow-up phone calls received was 64%.

Fidelity: **(1)** Assessed via *structured observations* by both trained facilitators and independent observers. Agreement between two types of observations was high.

The average adherence to the prescribed activities was above 98%.

Participant responses: **(1)** Programme satisfactions were assessed via *parent questionnaires*.

Participants agreed or strongly agreed that the timing and venue of the program and the choice of facilitators were appropriate. Parents indicated that their child particularly enjoyed the throw (85%) and kick (82%) activities. The skills that children enjoyed the least were the hop (36%), jump (42%), and leap (42%). Parents commented that their child enjoyed these activities least because the child lacked confidence in these skills. Some children found these skills harder to master, and some became frustrated because they could not see improvements in skill mastery as clearly within the given time frame of the program.

More than 85% of parents agreed or strongly agreed that their children's ability to perform all the skills had improved. Most improved skills perceived by parents were throwing (95%), bouncing (92%), catching (96%), and kicking (93%). Overall, parents reported that their child had improved physical activity levels (93%), self-confidence (90%), motivation to be active (83%) and more active daily (88%).

(2) Assessed via *structured observations*.

Facilitators noted that hop, jump, leap were less enjoyed due to the intensive physical effort to complete. Object control skills were appealing to children to engage with. Overall, programme was enjoyed by children and led to noticeable improvements in confidence and competence to perform FMS. Group cohesion was reported to be difficult sometimes because of some activities' being more appropriate for younger children (5-7 years) than for older children (8-9), or vice versa, and the presence of siblings.

(3) Percentage compliance of weekly 90mins practicing activities was assessed via *parent questionnaires*.

Approximately 70% of these participants complied and an average of 94 (±50) min was spent practicing the home activities. However, more than half (60%) found it difficult to find time for the home activities.

1) Difference on compliance with home activities between sites were observed.

	Anecdotal evidence from discussion between the facilitators suggested that the differences may be partially attributable to overreporting at one site as the provision of incentives was contingent on the completion of ≥90 min of home challenge activities, and therefore parents may have felt tempted to over report. **(2) Barriers** regarding PA programme: unsuitable timing of the programme, presence of siblings, lack of homogeneous groups, inconsistent attendance, low participation in take-home activities
Cohen et al. [97]	**RQ:** Explicit process evaluation design to complement the outcome data
	Reach: Assessed via *attendance*. Teacher's attendance of one day training and whole school workshop was 69.2% and 87.7%, respectively. Student attendance: 9/13(69.2%) full day training. Children's attendance for workshop was 88.5%. **Fidelity: (1)** School's compliance with PA policies assessed via *interviews* with school principals. Compliance with policy 1-6 are 75%, 100%, 25%, 75%, 25%, and 25%, respectively. **(2)** PE fidelity assessed via a *lesson observation checklist* developed for the intervention. The checklist assessed teachers' adherence to the recommended PE lesson structure and included the following components with a binary response (yes or no): 1) introduction, wherein i) the teacher reviews previous lesson and ii) the teacher explains lesson focus; 2) warm-up, wherein i) lesson involves general movement-based warm-up and ii) warm-up includes dynamic and/or static stretching; 3) skill development, wherein i) a teacher or student demonstrates the skill, ii) lesson involves skill exploration, and iii) lesson involves guided discovery; 4) skill application, wherein i) lesson involves modified games and ii) lesson involves full-sided games; and 5) closure, wherein i) lesson includes cool-down, ii) the teacher uses questioning to check for student understanding, and iii) the teacher reinforces key skill components, and if the teacher was using the SCORES teaching resource. Adherence to recommended PE lesson plan progressed through three observations during the intervention period.
	Dose received: Assessed via *student leadership accreditation*. 145 (81.9%) achieved the SCORES Yellow Leader award, 105 children achieved the SCORES Red Leader award (59.3%), and 73 children achieved the SCORES Blue Leader award (41.2%).

	Participant responses: (1) Teachers and students' satisfaction were assessed via _questionnaires_.
	Teachers found professional learning workshops enjoyable 4.9(0.3) and FMS information useful 4.8(0.4).
	(2) Parental involvement was assessed via _questionnaire_ on reading newsletters, completion of FMS homework.
	FMS homework was completed once per week 3.6(1.8). Parents found newsletter useful 3.8(0.7).
	(3) Teacher, student, parent satisfaction with all intervention component assessed via _process evaluation questionnaire_ post intervention.
	Children were satisfied with the programme 2.7(0.6) (3pt Likert) and 58.7% reported joined a local sporting club.
	Unintended consequences: no injuries or adverse effects were found.
Duncan et al. [50]*	**Reach:** Adherence to the programme and compliance with the intervention were assessed _via record sheets_.
	Any child who missed more than 2 sessions was not included in final analysis.
Graf et al. [88]	**Fidelity: (1)** Assessed via _site visits/observations_ in the first year to ensure all aspects of intervention were applied. Schools described as committed if they offered extra activities several times a week or held a health lesson at least once a month.
	(2) Assessed via _interviews with teachers_ on how intensively they fulfilled the programme. The health education sessions lasted 20-45min from once per semester to twice a week. PA during lessons took place from twice a week to three times per morning. Workshops were attended irregularly. Overall, implementation of the programme decreased from 1st to 4th year.
	Authors acknowledged that they should have examined health knowledge after the intervention, nutrition habits, ethnic and socio-economic aspects of the children and their families. As all of these cultural variables may affect the outcomes of any intervention.
Gu et al. [49]	**Participant responses:** INT children were asked to _self-report_ their own step counts to their personal weekly log as the self-monitory approach.
Invernizzi et al. [53]	**RQ:** Authors hypothesised overall MTA (integrated approach for PE) could provide a more positive overall experience of PE along with a higher level of positive perceptions of lessons, and therefore should be more effective for fitness and motor competence development, enjoyment and to increase the amount of PA performed outside the school context than the standard PE practice

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	Fidelity: Assessed via _video analysis of PE lessons_ by three PE experts using the Instrument for Identifying the Teaching Styles (IFITS). One lesson per teaching block was randomly selected. Experts were trained for 6h with coding. Analysed features include total time, action time, resting time, time dedicated to personal reflection, and duration of teaching style.
	Coherence between teaching styles reported and style actually employed observed. INT teachers used guided discovery (60.4%) and problem solving (39.6%) while CON only used learned initiated (100%). INT used command (39.5%) and reciprocal (26.7) while CON only used command (100%).
	Participant responses: (1) Children's engagement in PE were assessed via _video analysis of lessons_.
	INT children spent more time doing PE than CON (+26.8%). Majority of time were spent in action (78.9% and 72.3% for INT and CON). INT inactive for limited amount of time (3.9%) while CON rested longer (27.7%).
	(2) 28 Children's (14 INT, 14 CON) perception of PE lessons were assessed via _semi-structured interviews_. Only 35.7% in INT preferred games compared to CON where 78.6% preferred free play and games. 64.3% in INT were more in favour of newly learned exercises and the knowledge acquired and 42.9% enjoyed endurance training. 28.6% of CON reported dissatisfaction with frequent quarrelling while playing and repetitive exercises. 64.3% INT reported no dissatisfaction and 35.7% reported dissatisfaction because they wanted to play basketball and dodgeball more.
	(3) Children's perception of PE teachers were assessed via _semi-structured interviews_. In INT, 78.6% liked the trained PE teachers for their teaching skills especially their ability to explain activities clearly and provide encouragement.
	(4) Teacher's self-perception of teaching styles assessed via _semi-structure questionnaires_ post-study. 100% INT teachers reported using problem solving and guided discovery categories of production teaching style. 66.7% of CON teachers reported guided discovery and individual-based choice, and all used learner initiated approach. For reproduction teaching styles, 66.7% of INT reported command style, and all used practice, reciprocal and inclusion process teaching styles. All CON teachers used command, practice and inclusion process, while 66.7% reported reciprocal style.
Jarani et al. [66]	**Reach:** Student adherence was assessed via _attendance_ (missing out on a maximum of four lessons during the 5-month period). Attendance rate 93%

Johnson et al [65]*	**Dose received**: Researchers completed a _game record form_ on the amount of time(mins) children spent playing each sport/game during intervention sessions. Time was mostly spent playing games with striking skills (54.3h), followed by object control skills (15.6). Golf was the most played sport (17.2h), then baseball (14.6h) and table tennis (13.2h). Other activities accounted for 15.4h. Remaining time was spent on skills not related to striking and other object control skills.
	Moderator: Information were collected via _parent questionnaires_ including parent background, education, employment, children's prior experience organised ball sports experience.
Kalaja et al. [85]	**Fidelity:** Assessed via _researcher observation_ every fifth less of each teacher against lesson plan that developed in conjunction with teacher's inputs. Teachers weekly self-report. No remarkable deviance were detected.
Karabourniotis et al. [96]	**RQ:** Calculate the percentages of time allotted to the activities within content areas (self-testing, games, and dance)
	Fidelity: Random _observations_ by two observers, using the Academic Learning Time-Physical Education protocol. The rate/minute approach was used to assess a) time which children spent in activities of general content, b) time spent in game c) time spent on rhythm activities and d)time in self-testing activities. No results were reported.
Lander et al. [57]	**RQ:** Explicit process evaluation design
	Recruitment and retention: All students consented with 95% retention rate. All intervention teachers were retained and attended the training and consultation sessions. **Fidelity** Early, mid and late intervention, adherence to SAAFE (Supportive, Active, Autonomous, Fair and Enjoyable) teaching principles were assessed via _direct observations_ and scored on a 5pt likert scale, resulting score 3-15 per teaching principle. Results suggested an upward trend from 1st to 3rd observation point, most change occurred from 2nd to 3rd after feedback and two 30minute individualised consultations. Greatest fidelity observed in 'supportive' and least in 'autonomous'. Adherence to SAAFE teaching principles created a mastery climate required for children's skill acquisition and improvement.

	Participant responses: (1) Teachers competence for assessing and instructing FMS were assessed at pre and post intervention via _self-report questionnaire_ (adapted from Primary School PE questionnaire Morgan and Hansen, 6pt Likert scale). INT teacher's competence improved whereas control teachers remained stable. FMS reporting, program evaluation greatly improved, On average, 2pt improvement on FMS assessment and 1pt on confidence when teaching and assessing FMS. Decrease in perceived barriers to effective FMS assessment and instruction. **(2)** Teacher satisfaction were assessed via _questionnaire_ post intervention, information included provision of training, resources, onsite consultation and ongoing support. All teachers were satisfied or very satisfied with 4 hr training workshop, amount and quality of resources provided; and onsite/ongoing consultation.
Laukkanen et al. [69]	**RQ:** Whether seasonal variation played a role in the effects of counselling on changes in PA and MC in children
	Reach: Every parent (n=69) received a lecture and face to face counselling with goal setting. 93% and 74% were reached for phone discussions at 2 and 5 months.
	Participant responses: Parents satisfaction were assessed via _questionnaires_. Parents rated individual discussion as the most important study tool (32%), then feedback from measurement results (19%), lecture(18%), phone discussions (3%), printed materials(4%), emails(4%), and project web pages(0%).
	Moderator: Seasonal variation was examined using _ANOVA_. Group × Time × Season interaction in the KTK (D= 23.9, p = .009) indicated a significant study effect on the KTK when taking the influence of season into account **Barriers** to goal implementation: assessed via _telephone discussions_. Parents reported barriers on weekdays were weather(38%), hurry and needing to do other tasks (30%); tiredness (17%); On weekend, barriers were hurry and needing to do other tasks(35%), weather(21%) and tiredness.

Miller et al. [63]	**Fidelity**: Evaluation of the instruction style using *lesson observation sclaes* (Turner and Martinek, 1992). Lesson was judged against statements to obtain the % of agreement. To ascertain if 1) instruction style was in line with a skill based or GCA 2) instruction fidelity undertaken by INT teachers was in line with the intervention's true nature. Baseline coding: CON(13% game/83% skills) vs INT(13%game/63% skill), indicating lessons were in greater agreement with skill based format in both groups. Post trial, CON (21% game/72% skills), INT (75% game/0% skills). This implied that INT teachers successfully presented the GCA curriculum after the mentoring process and taught GCA based lessons that were more active than their baseline lessons from the same syllabus strand.
	Authors suggested interview data was obtained regarding teacher interaction with the professional learning program and views on the feasibility of the approach but were beyond the scope of the paper to provide analysis of these data.
Miller et al. [76]	**RQ:** Hypothesized that INT participants have higher PE enjoyment levels over the 7-week study period
	Fidelity: Teacher Instruction style evaluated in both INT and CON, using lesson observation scales (Turner and Martinek, 1992). Two PE lessons per teacher were observed by the lead researcher at week 5 and 6. Lesson judged against three skill-based format statements and four game-based format statements to obtain % of agreement for each. It is used to indicate if instruction style :1) was in line with a skill based or game centred approach 2) was in line with the true nature of the intervention for INT teachers. Pre-intervention coding of lesson observation scales displayed identical code agreement among INT and CON (13% game/92% direct), indicating lessons were more skills-based instruction. Post-intervention: INT(88% game/0%direct) CON(19% game /42% direct) indicating INT shifted greater to GCA, in line with the intention. Results indicate teachers are able to 1)present GCA in the intended way after the mentoring process and 2)teach GCA based lessons that were more active than their baseline lessons from the same syllabus strand.
	Mediator: PA enjoyment (mediator identified through Salmon et al. 2009) was assessed using modified version of the Factors Influencing the Enjoyment of PE questionnaire (Motl et al 2001). No signification group x time interaction effect. No mediation analysis was performed. Authors suggested the questionnaire did not specifically target the types of PA, thus may not be sensitive enough to detect true intervention effects

Nathan et al. [56]	**RQ:** Intervention on student leadership behaviours and peer leader's self-efficacy
	Dose delivered: 19/20 session delivered, one cancelled due to weather **Reach**: all peer leaders received training sessions, booster sessions and at least two observational feedback and all resources.
	Mediator: (1) Students peer leadership skills were assessed using adapted _Transformational Teaching Questionnaire_ completed by teachers. INT peer leaders scored higher. **(2)** Student leader's self-efficacy was assessed using _self-report questionnaire_ which assessed their listening ability and consideration of others, organisation and motivation of others, and group speaking. No intervention effects were found on leadership self-efficacy. **Participant responses:** Peer leaders acceptability of the programmed assessed via _questionnaire_ related to a) programmed enjoyment, training received, length and being a leader 2) perceived usefulness of resources and feedback provided 3) perception that programme helped them to be a better leader and students in the group enjoyed the programme. Results indicated high satisfaction. Authors concluded that future trials, qualitative data collection with teachers and FG with children are needed.
	Moderator: Sex was explored as a potential moderator of intervention effects using an interaction term. It emerged to be a significant moderator of the intervention effect on the strike.
Okely etl al. [54]	**RQ:** To understand change process of the intervention
	Participant responses: (1) Satisfaction and perception were assessed via interviews with INT staff to gather feedback and their understanding of the change process in schools, PE curriculum and FMS. _informal observationa_l data were collected by research staff on the intervention effect on school environment and links with home and local community.

	Interview data showed the most success in understanding the change process among teachers, though not successful in enhancing other teachers' understanding. Minimal changes were made regarding link between school and home and local community. Some of the changes were embedded into daily routine such as parent newsletters.
	Cross-contamination: _Interview_ with CON principal and teachers suggested one of the staff were aware of the details of the intervention and there was no threat of contamination. _Informal researcher observations_ found considerable variation in school implementation and attribute this as a possible facilitator to intervention success. **Barriers on school implementation:** lack of support from school executive, high staff turnover, negative attitudes, and lack of equipment and facilities. **Barriers on link between school and home:** High number of parents did not speak English, and the high levels of television viewing and internet use at home.
Pesce et al. [75]	**RQ:** Authors set out preliminary analyses to control for potential covariates of the qualitative characteristics of PE lessons.
	Fidelity: Assessed via _video analysis_ of PE sessions by two independent raters to 'quantify' the qualitative characteristics of teaching and estimate their fit with the approach proposed. Quantified as % of events for time unit(20s) during PE. Teaching strategies were (Rink, 2006): interactive teaching, peer teaching, cognitive strategies, cooperative learning. In generalist-led traditional PE lessons, interactive teaching was prioritised, whereas in lessons led by specialists (INT), cognitive teaching strategies as problem solving and teaching through questions prevailed, more than half of the total teaching time. More differentiated use of teaching strategies in INT.
Rudd et al. [45]	**Fidelity**: six out of 16 lessons were observed using _observation checklist_ adapted from school's teacher peer assessment tool. Including information on general teacher initiated behaviour and traits, lesson preparation, lesson presentation, safety, and behaviour management. Lessons were observed and graded on a 4-point Likert scale with 1(poor); 2(fair); 3(good); and 4(excellent). Results were not discussed.

Rudd et al. [44]	**Fidelity**: 192 gymnastic lessons were delivered with 10% (n=20) _observed_ to ensure delivery is as intended. RA coding a) whether all five stages of LaunchPad lesson plan were covered, with a score of one awarded to each stage b) instructor delivery of the five sections within appropriate time frame, with a score. These two scores were summed to give total fidelity score out of 10. To examine the fidelity of the LaunchPad curriculum delivery, two one-way ANOVA's were conducted (lesson content and lesson timing), with instructor type (PE teacher, class teacher and coaches) and school as independent factors. No significant difference was observed between coaches', teachers' and PE teachers' adherence to delivery of the lesson plans and no significant difference between the three schools in how the teachers, PE teachers and coaches delivered the intervention.
Salmon et al. [78]	Explicit process evaluation design.
	Dose delivered/received: _Documentation_ of the intervention delivery quantity. Most of the intervention was successfully delivered to the children in the RCT. **Fidelity**: _Documentation_ of the intervention delivery quality. INT teachers monitored the amount of material or content to be covered and also evaluated each lesson with each class for appropriateness of the material, children's enjoyment of the lesson, and children's active participation in the lesson. Found the programmes were delivered as intended.
	Participant responses: Programmes evaluated by participating children, their parents and INT teachers via _post intervention surveys_. Most children reported enjoying FMS class with increased interest in PA. 92% boys and 70% girls enjoyed games and sports, 76% boys and 92% girls reported enjoying specific and varied PA. Overall 42% in BM and BM/FMS thought programme made a difference. 78% parents in BM or BM/FMS felt their child enjoyed the BM programme. 45% they had noticed change. 34% reported child now watch less TV. 51% reported children were enthusiastic. 88% recalled receiving contract to sign, 62% reporting discussed the contract. 49% reported children in BM/FMS or FMS talked about FMS programme, 47% reported enjoyed the class. 34% to 51% noticed improvement in FMS. Teachers rated each lessons appropriateness based on student's level of understanding and ability, teacher's

	perception of student's enjoyment and whether in FMS, students' opportunities for PA were maximised. Most were rated highly appropriate. Enjoyment rated 4.5 and 4.4. FMS lessons were given an average of 4 for maximising students opportunity to be physically active in the lesson. **Mediator**: Children's self-report PA enjoyment were assessed. There were significant average differences in physical activity enjoyment between baseline and post intervention, with children in the FMS group reporting higher average enjoyment scores over time compared with those in CON. Effects were maintained with the inclusion of physical activity enjoyment data across all four time points. **Unintended consequence**: Results determined by examining intervention effects on children's self-reported happiness with their body shape and body weight whether in the last month they had changed their eating to try to lose weight or to try to gain weight. No effects were observed.
	Moderator: Gender was found to have moderated the intervention effects for participation in and enjoyment of PA, and FMS. **Cross-contamination**: Awareness and understanding of intervention among parents and children in control was also assessed. Between 70 and 80% of INT parents indicated that they had heard of 'Switch-Play', compared with 44% of CON parents (p = 0.028), indicating the low likelihood of cross contamination.
SilvaSilveira et al. [46]	**Reach**: Parental support were assessed via _record_. a) provision of transport to PA facilities (100%) attendance) b) participation with children (82%) c) watching children during PA (95%)

Email invitation to principal investigators

Dear xxx

My name is Jiani Ma, a cotutelle PhD student at Coventry University and Deakin University, Australia. My PhD research is aiming to explore variations in FMS intervention functioning by conducting process evaluations for different FMS intervention projects. Your intervention on xxx provides an opportunity for learning in this regard. In this research a systems science method-Collective Intelligence will be applied with key stakeholders to decide on key answerable research questions regarding process evaluation, and therefore informing the evaluation plan. Your knowledge, experience and perspective on (project name) will contribute largely to our understanding of effectiveness of FMS interventions. In return, this study might add value to your project by exploring the future sustainability of the intervention.

Thank you for your time. Please let me know if you will be interested. I will be more than happy to discuss further.

Best regards,

Jiani

Email invite to potential participants

Dear xxx

My name is Jiani Ma, a cotutelle PhD student at Coventry University and Deakin University, Australia. In collaboration with the (project team), we are organising a one day Collective Intelligence workshop focussed on the understanding and solutions to improving effectiveness and sustainability of interventions aiming to improve student's fundamental movements skills and physical activity. Widely recognised in our field, ineffective research-practice translation is a major challenge to population health improvement. We would like to ground this work in what you believe is critical and important in this context. We deeply value your diverse knowledge, experience and perspective and would be delighted if you could attend our workshop.

The workshop will be facilitated by myself applying an innovative systems science approach - Collective Intelligence to support our group discussion, which methodology was featured in various EU projects for

supporting groups to address complex issues. If you would like to find out more, you are welcome to contact me (see contact details below).

I look forward to your reply.

Best regards,

Jiani Ma

PhD student

Coventry University

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Email: maj33@uni.coventry.ac.uk

A. Time

Shortage of time in teaching staff and primary care providers

An insufficient amount of time afforded to us in school setting

A demand for time in the curriculum, impacting time allotted for interventions

B. Government and Institutional

Shortage of political support (school, local government) for FMS interventions

A lack of institutional structures to incorporate programmes sustainability

Refusal of government to offer greater time for PE/sport in schools

C. Curricular conflicts

Failure to emphasise the importance of FMS/PA to the level of academic achievement in subjects such as Maths and English

Conflicts between PE and major prioritised English and Maths curriculum

PE competing with demand from core subjects for curricular time

Interference between intervention goals and staff goals (short-term)

Conflict between school targets and research targets

D. Design and Implementation

Working around school's schedules for testing and focus groups was difficult

Inadequate preparation by PE teachers in advance of the lessons(s) to bring about meaningful change

Inadequate interventions are implemented (e.g. to focus on specific skills for boys and girls)

Interference from external sources (i.e. matches, exams, field trips) leading teachers and/or students missing lessons and lack of continuity in the delivery of the intervention

Failure to realise a one size fits all intervention does not work for everyone

Failure to keep contact with head teacher or stakeholder

E. Research challenges

Failure to recruit schools/children to interventions

Lack of honesty from participants in their completion of Perceived Motor Competence data forms

Challenging to manage the number of schools involved

Difficulty in obtaining research teams to attend schools

Large volume of data to be scored which was very time consuming

Conflict between monitoring fidelity and allowing the project to stand alone as it would have to in practice

F. Knowledge and Appreciation

Unwillingness of parents/carers to participate/interact with projects/interventions

Inadequate appreciation for Professional Learning or FMS from the teaching staff

Lack of teacher knowledge of FMS and PA in children

Lack of awareness of effective interventions amongst professionals and practitioners

Lack of stakeholders knowledge and understanding concerning the benefits for children development derived by FMS interventions

G. Conflicts and purposes within PE

Shortage of pedagogical emphasis on improving Perceived Motor Competence on its own in the intervention

Lack of clarity from a subject perspective around what the results mean

Potential conflict within the aims of PE and therefore what it should be fulfilling (long-term)

Lack of PE assessment

Conflicting interpretations among PE teachers of the aims and the purpose of FMS interventions

Conflicting between performance testing and basic movement testing, in high performance environments

H. Resources and Funding

Inadequate resources within schools

Personnel and monetary cost to analysing and implementing results

Shortage of school resources and time

A constantly shifting funding environment meaning new money is always being chased

Inadequate funding to make interventions sustainable

Lack of funding to support implementation phase

Conflict between different projects using the same space in the school

Cost of necessary equipment

I. Staffing

Shortage of staff to support interventions, therefore prevents the 'adoption' of an intervention going forward

Lack of PE teacher or trained expert working in the school continuously

Lack of confident and skilled generalist classroom teachers

A high staff turnover

J. Efficacy and attitude

Resistance to change (PE teachers)

Unwillingness by PE teachers to implement strategies that they are not familiar with

Lack of confidence continue to adopt elements of interventions once researchers have left

K. Training

Lack of initial training and Continuing Professional Development (Interventions seen as 'specialist' by teachers and as some already lack confidence to deliver curricular PE)

Lack of Continuing Professional Development for PE teachers (i.e. minimal contact time with PE teachers) and therefore inadequate training

Inadequate subject knowledge within PE if to be implemented by school staff

We as researchers can implement the intervention but key to me is that the practitioners (teachers) need to be involved in the delivery, their time and expertise doesn't always allow for this though

Lack of insufficient training of people providing FMS sessions

L. Testing challenges

Interference of skill performance from one student to the next- i.e. Students occasionally mimic performance of other class members resulting in similar criteria being failed

Failure of test subjects to engage with demonstration from researchers

M. Intervention efficacy

Lack of evaluation to evidence intervention efficacy

Lack of interventions effectiveness evaluation in terms of their frequency and duration (weeks), and follow-up on their effectiveness

1.Curricular Conflicts

Establish the significance/importance of PE as a core subject

Encourage PE curriculum development and its importance

Demand programme reports from PE and assessment in PE

Promote similarities between intervention goals and staff goals

Identify shared goals between schools and researchers

Promote movement opportunities throughout the whole school day so it is embedded through educating staff/sharing practice of good examples

Demonstrate a holistic benefit of implementing a movement-based curriculum to drive change

Develop a school movement plan/policy to cover curricular and co-curricular, active transport and homework

Design intervention goals to be measurable by staff and relate their goals

Conduct research to drive information/knowledge around the measurable goals to achieve a whole of objectives

Create common research and school goals/targets

Change school ethos around PE and school mission/values

Promote the importance of PE/FMS/PA

Encourage schools to recognise the need for PE to be a core subject, allowing sufficient time for interventions

Audit space use and plan/organise/develop ways to use staff/resources/space more effectively

Encourage explorations of a variety of spaces/environments

Promote awareness/understanding/education of FMS and its impacts it can have on core subjects e.g. language, cognition, social skills

Change school targets based on scientific evidence

Develop sustainable interventions co-designed between teaching staff and researchers so goals are shared, achievable, sustainable and feasible

Establish a working group to organise the evidence base to inform step 2 and 3

Develop evidence-based framework and identify areas of future research to build further base

Develop policy and promote, implement and evaluate it

Build evidence base for the importance of PE/FMS in children for lifelong health to inform policies

To refine school policies in light of the shared values, ethos and goals through observations, auditing and evaluating

To understand school values and ethos to drive shared goals and promote them

2. Government and institutional options

Demand policy development to increase the significance of PE in schools

Establish policy frameworks associated with measurable outcomes (evaluation technique)

Educate policy holders on the importance by evidence-based practice drawn from high quality interventions/evaluations which have all stakeholder input (shared/collective knowledge)

Encourage recognition of PE and FMS importance by government at national and local level

Create resources e.g. FMS guidelines/assessments from evidence base which can be embedded into PE curriculum policy

Set up a task force –multi –education, health to develop, implement and evaluate policy

Promote the evidence/findings from the above task force to change government level policies

Build evidence for potential support provision of time for PE and FMS

Encourage all stakeholders to promote the evidence base to policy holders through impact. E.g. working group

Demand better training for teachers to ensure better structures for intervention sustainability are achieved

Organise appropriate CPD/days to incorporate appropriate teaching training

Create a policy which prioritise PE as core subject to curriculum by which schools are measured by and promote it

Establish appropriate evaluation techniques to identify the efficacy and sustainability of programmes

Develop and implement policy to put child health and development at the forefront by increasing the importance of PE in schools and directing appropriate funding and resources to local councils to build and deliver

Build sufficient evidence base to support the greater provision for PE and FMS

Develop structures to ensure sustainability of programmes

Coventry University

PLAIN LANGUAGE STATEMENT

DEAKIN UNIVERSITY

TO: Participant

Date:

Full Project Title: Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skills interventions

Principal Researcher: A/Prof. Lisa Barnett   Prof. Michael Duncan

Student Researcher: Miss Jiani Ma

Associate Researchers: Dr. Natalie Lander, Dr. Emmar Eyre

You are being invited to take part in this research project led by a PhD student researcher Jiani Ma. Before you decide to take part it is important you understand why this research is being conducted and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?

This research project is a collaboration between researchers at Deakin University, Australia and Coventry University, United Kingdom. The purpose of the study is to conduct a computer-mediated group consultation, aiming to understand the multifaceted influences on interventions aiming to improve children's Fundamental Movement Skill (FMS) and/or Physical Activity (PA) and identify solutions to overcome barriers to implementing and sustaining effective FMS interventions.

Why have I been chosen to take part?

You are invited to participate in this study because you are a researcher/practitioner/teacher having relevant experience and knowledge on this topic.

What are the benefits of taking part?

The possible benefits of the study include improving our understanding of the complex characteristics of implementation settings and understanding the interdependent influencing factors that act as barriers to FMS intervention success.

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Are there any risks associated with taking part?

This study has been reviewed and approved through Coventry University and Deakin University's formal research ethics procedure. There are no significant risks associated with participation.

Do I have to take part?

No – it is entirely up to you. Participation in this research project is voluntary. **If you do not wish to take part you are not obliged to.** Deciding not to participate will not affect your relationship with Deakin University or Coventry University. Once you have read this form and agree to participate, please sign the attached consent form. If you do decide to take part, please keep this Plain Language Statement and complete the Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate. Please note down your participant number (which is on the Consent Form) and provide this to the lead researcher (Miss Jiani Ma) if you seek to withdraw from the study at a later date. You are free to withdraw your information from the project dataset at any time until the data are destroyed 6 years after study completion. You should note that your data may be used in the production of formal research outputs (e.g. journal articles, conference papers and reports) and student researcher Jiani Ma's doctoral thesis prior to this date and so you are advised to contact the university at the earliest opportunity should you wish to withdraw from the study. To withdraw, please contact the lead researcher (contact details are provided below). Please also contact the Research Support Office [email hls.rso@coventry.ac.uk; telephone +44(0)2477658718] so that your request can be dealt with promptly in the event of the lead researcher's absence. You do not need to give a reason. A decision to withdraw, or not to take part, will not affect you in any way.

What will happen if I decide to take part

We would like to organise a time to have a one-day Collective Intelligence (CI) workshop with you. The workshop will take place on line via Zoom at a time that is convenient to you. The workshop will last from xx to xx, with coffee and lunch breaks provided. You will be invited to generate barrier statements in advance of the workshop via email, as a response to the trigger question: "*From your understanding and previous involvement in FMS interventions, what do you consider are the key barriers to the adoption, implementation and institutionalisation of effective FMS interventions targeting children and adolescents?*". During the workshop, you will be facilitated to vote for critical barriers and group discussions to structure the selected barriers and generate solutions accordingly. For record keeping and recalling your contribution to the discussion, we would like your consent to also record this session. The recording will not be transcribed. Hence, no identifiable personal information will be used in data analysis and results dissemination.

Data Protection and Confidentiality

Your data will be processed in accordance with the General Data Protection Regulation 2016 (GDPR) and the Data Protection Act 2018. All information collected about you will be kept strictly confidential. Unless they

are fully anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by all members of the research team. All electronic data will be stored on a password-protected computer file on Coventry University Server. All paper records will be stored in a locked filing cabinet at Coventry University. Your consent information will be kept separately from your responses in order to minimise risk in the event of a data breach. The lead researcher will take responsibility for data destruction.

Data Protection Rights

Coventry University is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance with the General Data Protection Regulation and the Data Protection Act 2018. You also have other rights including rights of correction, erasure, objection, and data portability. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer - enquiry.ipu@coventry.ac.uk

What will happen with the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name.

Making a Complaint

If you are unhappy with any aspect of this research, please first contact the lead researcher, (Miss Jiani Ma). If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Human Research Ethics Office, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: +61(0) 9251 7129, research-ethics@deakin.edu.au

Please quote project number [HEAG-H xxx_20xx].

Jiani Ma

PhD student

Coventry University

Coventry CV1 5FB

Email: maj33@uni.coventry.ac.uk

In your letter please provide information about the research project, specify the name of the researcher and detail the nature of your complaint.

Coventry University

Consent Form

DEAKIN UNIVERSITY

TO: *Participant [No. xxx]*

Date:

Full Project Title: Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skills interventions

You are invited to take part in this research study for the purpose of collecting data on understand the multifaceted influences on interventions aiming to improve children's Fundamental Movement Skill (FMS) and/or Physical Activity (PA) and identify solutions to overcome barriers to implementing and sustaining effective FMS interventions.

Before you decide to take part, you must **read the accompanying Plain Language Statement.**

Please do not hesitate to ask questions if anything is unclear or if you would like more information about any aspect of this research. It is important that you feel able to take the necessary time to decide whether or not you wish to take part.

If you are happy to participate, please confirm your consent by circling YES against each of the below statements and then signing and dating the form as participant.

1	I confirm that I have read and understood the <u>Plain Language Statement</u> for the above study and have had the opportunity to ask questions	Yes	No
2	I understand my participation is voluntary and that I am free to withdraw my data, without giving a reason, by contacting the lead researcher and the Research Support Office <u>at any time</u> until the date specified in the Plain Language Statement		
3	I have noted down my participant number which may be required by the lead researcher if I wish to withdraw from the study		

4	I understand that all the information I provide will be held securely and treated confidentially		
5	I am happy for the information I provide to be used (anonymously) in academic papers and other formal research outputs		
6	I agree to take part in the above study		

Thank you for your participation in this study. Your help is very much appreciated.

Participant's Name	Date	Signature
Researcher	Date	Signature

1. Curricular Conflicts	Synthesised option statement
Theme 1A (Prioritise PE, PA and FMS in schools)	Change school ethos and values around PE through learning workshops and mission documents that promote awareness and understanding of FMS and its impact on core school outcomes including cognitive and social skills
Establish and encourage the significance/importance of PE as a core subject and promote the importance of FMS/PA	
Organise workshops or create documents explaining why FMS/PA is important for children and that it actually supports learning on Maths and English	
Change the perception of PE in terms of its identity. It isn't an cogntive based subject (like maths and english) but instead a subject that promotes learning in through and about movement. This shifts it to an ecological subject of learning in development. Through colaborations with researchers, schools will lead to change in policy over an extended period of time.	
Change school ethos around PE and school mission/values	
Promote awareness/understanding/education of FMS and its impacts it can have on core subjects e.g. language, cognition, social skills	
Theme 1B (Assessments and targets in PE)	
Demand programme reports from PE and assessment in PE	Establish specific, mandated targets on FMS and PA and demand these to be achieved and reported by schools, in order to direct intervention time and resources and encourage programme uptake by schools
Establish specific, mandated targets for all schools to have to achieve; without a specific target, time/resources will always be diverted away from research/intervention	
Boradly speaking if PE had a greater role within the curriculum i.e. had specific targets to be met, schools would be more receptive towards interventions/projects that could help to improve the PA/FMS of children within their school	
Theme 1C (Shared goals)	
Identify shared goals between schools and researchers and promote and establish collaborative work of research team with the school and align their aims, research may indirectly support the aims of the school	In advance of programme implementation, generate goals shared, measurable in a collaboration between schools, researchers and policy makers, and build coalitions and partner
Create common research and school goals/targets and design intervention goals to be measurable by staff and relate their goals	

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Conduct research to drive information/knowledge around the measureable goals to achieve a whole of objectives	relationships to support implementation efforts
Develop sustainable interventions co-designed between teaching staff and researchers so goals are shared, achievable, sustainable and feasible	
Promote collaborations between policy makers and researchers e.g. data on PA/movement competency/weight status	
Develop a mutual understanding of intervention targets before the beginning of the intervention and discuss with schools about possible implications and how to deal with them	
Conduct observations, auditing and evaluating to refine school policies in light of the shared values, ethos and goals	

Theme 1D (Embed movement culture in schools so it doesn't interfere with other demands)

Promote movement opportunities throughout the whole school day so it is embedded through educating staff/sharing practice of good examples	Use and promote a whole-school approach to embed movement opportunities throughout the whole school day, including curricular, extracurricular, cross-curricular, active transport, and homework
Develop a school movement plan/policy to cover curricular and co-curricular, active transport and homework	
Create ways to translate PE content in time that does not interfere with other subject (e.g. making sport material available in recess time in the period when children are learning a specific sport, giving chance to practice skills (e.g. juggling) in safe spaces during break time between lessons	
Develop cross curricular activities i.e. possible ways to incorporate elements such as literacy/numeracy within PE lessons	

Theme 1E (Impact statement)

Demonstrate a holistic benefit of implementing a movement based curriculum to drive change	Report impact from the programme and disseminate knowledge in relation to quality of life, health, and learning outcomes
Disseminate at different levels about the importance of child physical and movement development and potential impact on quality of life and other important heath reated outcomes	
Change school targets based on scientific evidence	

Theme 1F (physical environment)

Audit space use and plan/organise/develop ways to use staff/resources/space more effectively	Evaluate, adapt, and create the physical structures, equipment, and school resources to support programme implementation
Encourage explorations of a variety of spaces/environments	
2. Government and Institutional	
Theme 2A (policy development)	
Demand policy development to increase the significance of PE in schools, to the same standard as other core subjects i.e. specific targets to be met and inclusion within OFSTED	Establish a multi-sector task force to develop, implement, and evaluate child health and development policies and programmes that support PE in schools by directing appropriate funding and resources to local councils
Set up a task force–multi –education, health to develop, implement and evaluate policy	
Create a policy which prioritise PE as core subject to curriculum by which schools are measured by and promote it	
Develop and implement policy to put child health and development at the forefront by increasing the importance of PE in schools and directing appropriate funding and resources to local councils to build and deliver	
Develop policy and promote, implement and evaluate it	
Theme 2B (build evidence base)	Promote recognition and importance of PE and FMS at national and local level through educating policy holders based on evidence drawn from high quality research
Promote understanding at government level, and in turn, school-level understanding of the mental, physical and social benefits of physical activity	
Educate policy holders on the importance by evidence based practice drawn from high quality interventions/evaluations which have all stakeholder input (shared/collective knowledge)	
Encourage recognition of PE and FMS importance by government at national and local level	
Build evidence base for the importance of PE/FMS in children for lifelong health to inform policies	
Theme 2C (promote evidence base)	
Promote the evidence/findings from the above task force to change government level policies	Build and communicate robust evidence with stakeholders to encourage uptake of PE and FMS at government level
Build evidence for potential support provision of time for PE and FMS	
Encourage all stakeholders to promote the evidence base to policy holders through impact. e.g. working group	

Theme 2D (translate evidence base)	
Establish policy frameworks associated with measureable outcomes (evaluation technique) Develop FMS specific targets or outcomes within the curriculum, this would mean that schools would have to make these outcomes a specific target and direct resources to meeting said targets	Translate evidence base into practical solutions coupled with evaluation techniques and measurable outcomes to create clear FMS guidelines, programme methods, and assessments to be embedded in PE curriculum
Establish a working group to organise the evidence base to inform evidence building	
Develop evidence based framework and identify areas of future research to build futher base	
Create resources e.g. FMS guidelines/assessments from evidence base which can be embedded into PE curriculum policy	
Create an evidence-based concept which can be brought into and promoted easily as said before (e.g. movement culture)	
Theme 2E (professional development for teachers)	
Demand better training for teachers to ensure better structures for intervention sustainability are achieved	Demand and organise better training for teachers
Organise appropriate CPD/days to incorporate appropriate teaching training	
Theme 2F (build collaboration between research and policy holders)	
Establish more research collaboratoions between government and university bodies to promote joined-up thinking	Build collaborations between research, schools and policy holders to promote joined-up thinking
University as a means to reach governmental bodies which listen to their relevant university development	
Build collaborations with schools under a common aim to encourage their uptake	
Theme 2G	
Establish appropriate evaluation techniques to identify the efficacy and sustainability of programmes	Improve and change the current evaluation practice to incorporate more appropriate techniques, change the priority of what determines an intervention success and conduct more long term and follow-up evaluation to monitor sustainability
Change the priority of what determins an intervention success	
Conduct long, long term evaluation with the same "children+adults" (same participant group)	

Develop structures to ensure sustainability of programmes	Develop structures to support programme sustainability, including developing knowledge hub and partner relationships, educating undergraduates, and promoting programme integration into curriculum
Build a "Central Hub" of knowledge and include links for NGB/University etc	
Undergraduate programmes to bring in structure and familiarity with intervention programmes	
Promote integration of the intervention through exisiting curriculum	
3. Conflicts and Purposes within PE	
Theme 3A (create intervention and its evaluation with stakeholders input)	
Conduct stakeholders meetings to clarify intentions of FMS interventions to not create opportunities for interpretation	Conduct stakeholders meetings to clarify intervention aims and results and consult stakeholders on ways to translate intervention findings into practical settings
Conduct stakeholders meetings to clarify the meaning of results or provide opportunities for questions/feedback	
Create ideas on the focus points the assess and how to assess (e.g. A delphi poll around PE practitioners and experts)	
To create ways in which those leading the intervention and the PE teachers can discuss and communicate each of the results to better inform the teachers of the findings	
Ask relevant stakeholders whether we need a PE assessment and why - to ascertain the reason behind its creation - assessment, importance of PE in curriculum etc.	
Communication between both parties (researchers and stakeholders) to outline what each will entail and help appreciate the need for both - perhaps when best appropriate to focus on either or	
Theme 3B (Innovation on interventions)	
Create resources for promotion of games that develop FMS so that children have fun but also develop FMS	Develop theory-based interventions and resources as well as adapt pedagogical approaches
Moving away from direct instruction and towards more novel pedagogical approaches e.g. Nonlinear pedagogy	
Develop an intervention based on achievement goal theory and assess its effect on PMC	
no. 3 - explore existing pedagogies ability to support competence	
Theme 3C (assessment)	

Highlighting to children what we are looking at in order to provide context and allow them to reflect on their own progress/performance over the course of an intervention/term	Apply and prioritise PE/skills assessment for children and provide context-specific feedback to allow them to reflect on their progress and performance.
Apply testing that is adequate to the population examined and the aims of the testing	
Define what the most common aims are and create a curriculum based on those aims – FMS, fitness, health, games, sportsmanship	
Develop assessments where children's movement skills are measures and assessed in PE – rather than through reductionist measures that are devoid from context	

Theme 3D (professional development for teachers)

CPD for PE teachers may need to be part of intervention in order to provide further rationale for intervention to teachers	Strengthen CPD for teachers and include intervention and educational aims in the training
Providing mode details and material for teachers to clarify the PE aims in the different key stages and how they could be tested (e.g. further material attached to each Key stage educational aim)	

4. Efficacy and Attitude	

Theme 4A (building structures to support sustainability)

Promote continuity of message of FMS from primary to post-primary years and follow a full life span approach	Create practical and appropriate resources and build structures to promote continuity of FMS messages following a lifespan approach and provide practitioners confidence and rewards to carry out their work
Producing documents and sufficient resources and guidance that provide practitioners with confidance to carry out ideas	
Build a rewards system whereby everyone's wellbeing is enhanced when participating in such interventions	
Resources that are sustainable, beneficial, practical and developmentally appropriate through the years	

Theme 4B (professional training)

Greater level of training/CPD for teachers to help them understand the theory and rationale behind what we are trying to do	Strengthen CPD for teachers and include intervention and educational aims in the training

Theme 4C (collaborative efficacy)

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Co-delivery of projects i.e. led by practitioners and teachers, this way teachers get support with delivery and are able to learn new skills without being left on their own to deliver a project	Provide support for practitioners and teachers to co-lead the delivery of projects

5.Research Challenges	

Theme 5A	
Establish a cultre of field researchers in undergraduate university programmes	Integrate intervention science and associated field work in undergraduate teaching programmes

Theme 5B	
Create a teacher feedback method to report fidelity	Establish a feedback method for teachers to report fidelity on programme delivery

Theme 5C (collaboration)	
Establish links between our department and other departments in a way that helps the resarch via new tools, methods or expertise	Establish cross-disciplinary collaborations in research to access new tools, methods and expertise.

Theme	
Build relationships with/between different stakeholders in the research process i.e. universities/schools/NGBs. i.e. access to students in return for resources etc. (via reciprocity)	Promote publicity and impact of the intervention programme to potential stakeholders and build reciprocal relationships with them to involve them in future research
Build up relationships/networks with local schools to help them understand the work we do and involve them in the research we carry out	
Promote the programme and make it more 'known' to encourage schools and clubs to want to take part	

6. Intervention Evaluation	

Theme 6A (methodology)	
Create evaluation programmes with minimum 5-year follow-up and sustainability data	Conduct more rigorous and comprehensive evaluation including pilot research, long term follow-up that yields sustainability data, and evaluation of what determines intervention success
Conduct pilot studies where possible problems are explored in a small scale	
Change the priority of what determines in intervention success(i.e. currently not enough on "knowledge and understanding"	

Theme 6B	
Encourage integration of programmes and interventions with pre-existing school curriculum and syllables	Encourage integration of programmes and interventions with pre-existing school curriculum and syllables
Theme 6C	
Promote the use of common outcome metrics in PA and FMS across all stakehodlers, i.e. joined-up thinking	Promote common outcome metrics in PA and FMS across all stakehodlers
Theme 6D	
More inter/intra-university collaborations which could support longer impact and wider joined-up thinking	Promote collaborations between research institutes for wider impact
7. Knowledge and Appreciation	
Theme 7A (create resources)	
Create fun games that children can play, learn and practice at home and in school	Create appropriate resources and disseminate them in different formats to be shared with stakeholders, including guidelines on creating suitable skill learning environments, fun games for children to practice FMS, social marketing of programme benefits on children's development and skill specific curriculum programmes.
Create FMS content using social figures (athletes, influencers etc.)	
Create posters and charts highlighting the effectiveness of interventions/skill acquisition to pu up in schools for students and teachers to see everyday	
Promote messages to encourage FMS/PA links, development and reasons why.	
Create and promote the idea of a "movement culture" to ensure alignment and buy in (via buzzword)	
Create specific curriculum programs for primary teachers to be teaching PE in primary school and creation of courses for teachers to stay aligned with new knowledge in the fie	
Create guidelines School environments/facilities can vary, guidelines for how to create "demanding" environments need to be adaptable	
Create different dissemination documents in different format (e.g. video, written document) to be shared with school or to be made accessible to stakeholders	
Theme 7B (create learning collaborative)	
Establish teacher/coach/parent/carer etc. prior knowledge of FMS/PA	Create a learning collaborative for stakeholders to share their

	knowledge and experience regarding FMS and existing FMS resources, as well as to link with researchers to disseminate importance of FMS and best practice
Promote a multi-stakeholder approach to an intevention perhaps using health and wellbeing cards, activity journals etc.	
Set up communities of practice to share information etc.	
Create an online forum available to teachers and parents promoting the importance of FMS. Ensure it is shared and publicised in schools and clubs	
Create a central hub of knowledge that is accessbile to all and targeted	
Share existing FMS resources amongst a wider range of stakeholder (clubs, primary, secodary, disabilitiy schools)	
Build a system that to link experts to stakeholders (e.g in some countries politicians regularly meet with researchers)	
Theme 7C (training on FMS and pedagogies)	
Planning effective coaching and teaching programme that nurture appropriate pedagogical practice	Plan and implement effective pre-service and in-service teacher training programme to include relevant pedagogies and techniques, learning workshops on knowledge and understanding of FMS
Promote knowledge of relevant peadagoies among teachers when they enter the profession?	
Provide workshop and information transfer to explain the importance of FMS, in order to enhance knowledge and understanding	
Develop CPD and intervention related training - understanding the techniques and how to improvechildren's skills	
Theme 7D (research)	
Develop and implement appropriate research methods to examine enjoyment of FMS interventions	Conduct research on participant understanding of and engagement in intervention programmes and create solutions to overcome perceived barriers and misconceptions
Develop conversations on why this is the case? Should their interest be more focused on retaining focus and challenging students - benefit future provision and practice and understanding of children's FMS etc.	
Organise discussions with teaching staff on what can be done to overcome the perceived barriers (discuss why teaching staff have an inadequate appreciation - what are their perceived barriers? What can be done to shift their perceptions?)	
Theme 7E (build structure to support)	

Build the knowledge together at once student, teachers, parents, coaches-all for one type knowledge awareness	Create norms of knowledge building and continuous learning to support students, teachers, parents, and coaches
Build a culture where knowledge outweighs "content"	
Establish continuous rather than "one off" specific CPD content for teachers on FMS and PA	
Theme 7F (mobilise parents)	
Role/influence of parents often overlooked in intervention design - what role/information do parents need in relation intervention being delivered?	Expand programme reach to parents and mobilise parental engagement in interventions
Create ways to interact with parents without interfering with their time schedule such as online and easy to access platforms where they can access materials and information	
Develop links with parents to promote their engagement in interventions no. 2 - ask parents what would help them engage with the interventions? At what level do they need to engage? Is their engagement purely as gatekeeper to their children? Or should they have a deeper engagement? If the former, what would attract them to engage in the recruitment process?	
Theme 7G (tap into the debate on the correct technique to move)	
The idea of correct technique in children's motor development is misguided. There maybe a more functional ways to navigate the performance environment and children should be nudged toward finding these different solutions	Challenge the idea of correct technique in children's movement and encourage children to explore under guidance
Challenge people's perceptions of what a "wrong technique" is. Is there such a thing as a wrong technique if the outcome goal is achieved?	
8.Resources and Funding	
Theme 8A (quality PE)	
Create a list of what is considered basic necessities for PE? The schools would potentially use some of their PE premium to make sure they have the necessary equipment available.	Create a checklist of essentials for quality PE which guides schools planning on provisions
Theme 8B (research planning)	
Plan research based on available resources	

Plan strategically in the RQ you ask that are balanced against resources	Conduct research planning based on available resources including proposing suitable research questions, creating cost-effective solutions in research activities such as training teachers to collect research data
Plan action-based research where staff within school receives a training anr provides intervention so costs are minimised - potentially training teachers to help researchers in data collection too if feasible	
Create strategies with school to find resousces and time	
Create greater links with research team - provide information and support	
Theme 8C (collaboration)	
Create communities of practice where we seek out new knowledge and development together in universities instead of chasing grants.	Create communities of practice among research institutes and consult stakeholders on bids for funding
Discussions between research team and stakeholder - potential for bids to be written to obtain further funding - what for? Equipment? Staff? etc.	

*Left: introduction to Project FLAME, its alignment with the national curriculum, and benefits; middle: Detailed intervention delivery process and Q&A for the project delivery; right: 'one-stop-shop for all project resources, including digital resources, skill-specific contents, external cues, and games, this page is created for each of the six skills

Q1 What is your gender?

○ Male (1)

○ Female (2)

○ Prefer not to say (3)

Q2 What is your age?

○ Under 21 (1)

○ 21-25 (2)

○ 26-30 (3)

○ 31-35 (4)

○ 36-40 (5)

○ 41-45 (6)

○ 46-50 (7)

○ 50+ (8)

Q3 Years of teaching experience (please respond using Arabic numbers only, e.g. 10)

_____

Q4 What year group are you currently teaching?

_____

Q5 What school you are working at?

_____

Start of Block: Self-efficacy scale

Q6 This section is designed to help us understand your confidence in planning, teaching, and assessing Fundamental Movement Skills in physical education. Please rate how certain you are that **you can do the things** in regard to each statement provided below.

	Cannot do at all	Moderately can do	Highly certain can do
	0 10 20 30 40 50 60 70 80 90 100		

Statement	Rating
Plan effective lessons to achieve FMS related student learning outcomes ()	50
Apply appropriate FMS content knowledge in my teaching (e.g. motor development and skill acquisition theory) to achieve learning outcomes ()	50
Apply appropriate FMS pedagogical content knowledge in my teaching (e.g. teaching models, instructional frameworks to deliver FMS) to achieve learning outcomes ()	50
Implement general teaching and learning strategies to meet the needs of PE class ()	50
Actively engage students in learning of FMS ()	50
Design lesson contents to meet differing student needs (e.g. multiple exposures for FMS learning, differentiated teaching strategies) ()	50
Choose developmentally appropriate curricular strand to develop FMS within the lesson ()	50
Identify students' varying levels in FMS proficiency ()	50
Use FMS assessment as part of the teaching and learning cycle in PE ()	50
Report on students outcomes in FMS ()	50
Manage the class when teaching FMS (e.g. managing disruptive behaviours) ()	50
Integrate reflective FMS teaching practices ()	50
Provide feedback to help students develop FMS within the lesson ()	50
Access appropriate FMS resources to effectively teach FMS lessons ()	50

Q1 What is your name? (Your response will be anonymised)

_____

Q2 How many Project FLAME lessons have you delivered during the six-week period?

○ 1

○ 2

○ 3

○ 4

○ 5

○ 6

○ More than 6, please specify (6) _____

Q3 This section is designed to help us understand your confidence in planning, teaching, and assessing Fundamental Movement Skills in physical education. Please rate how certain you are that **you can do the things** in regard to each statement provided below.

	Cannot do at all	Moderately can do	Highly certain can do

0   10   20   30   40   50   60   70   80   90   100

Plan effective lessons to achieve FMS related student learning outcomes ()	
Apply appropriate FMS content knowledge in my teaching (e.g. motor development and skill acquisition theory) to achieve learning outcomes ()	
Apply appropriate FMS pedagogical content knowledge in my teaching (e.g. teaching models, instructional frameworks to deliver FMS) to achieve learning outcomes ()	
Implement general teaching and learning strategies to meet the needs of PE class ()	
Actively engage students in learning of FMS ()	
Design lesson contents to meet differing student needs (e.g. multiple exposures for FMS learning, differentiated teaching strategies) ()	
Choose developmentally appropriate curricular strand to develop FMS within the lesson ()	
Identify students' varying levels in FMS proficiency ()	
Use FMS assessment as part of the teaching and learning cycle in PE ()	
Report on students outcomes in FMS ()	
Manage the class when teaching FMS (e.g. managing disruptive behaviours) ()	
Integrate reflective FMS teaching practices ()	
Provide feedback to help students develop FMS within the lesson ()	
Access appropriate FMS resources to effectively teach FMS lessons ()	

Q4 Considering the contents/resources of Project FLAME

	Completely disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Completely agree (5)
Project FLAME meets my approval. (1)	○	○	○	○	○
Project FLAME is appealing to me. (2)	○	○	○	○	○
I like Project FLAME. (3)	○	○	○	○	○
I welcome Project FLAME. (4)	○	○	○	○	○

Q5 Considering Project FLAME's influences on your teaching practice and PE classes

	Completely disagree (1)	disagree (2)	Neither agree nor disagree (3)	Agree (4)	Completely agree (5)
Project FLAME seems fitting. (1)	○	○	○	○	○
Project FLAME seems suitable. (2)	○	○	○	○	○
Project FLAME seems applicable. (3)	○	○	○	○	○
Project FLAME seems like a good match. (4)	○	○	○	○	○

Q6 Considering the delivery of Project FLAME

	Completely disagree (1)	disagree (2)	Neither agree nor disagree (3)	Agree (4)	Completely agree (5)
Project FLAME seems implementable. (1)	○	○	○	○	○
Project FLAME seems possible. (2)	○	○	○	○	○
Project FLAME seems doable. (3)	○	○	○	○	○
Project FLAME seems easy to use. (4)	○	○	○	○	○

Q7 Would like to be invited for a 30-min interview to discuss your experience with Project FLAME? If yes, the interview will be arranged to a time that is convenient to you.

○ Yes (1)

○ No (2)

Q8 Would you continue to use Project FLAME resources or contents in your future practice?

○ Yes, please briefly tell us what element of Project FLAME you plan on continuing to use (1) _____

○ No, please briefly tell us why (2) _____

Q9 Any other comments?

_____

Q1 What is your gender?

Male (1)
Female (2)
Prefer not to say (3)

Q2 Which school are you in?

_____

Q3 Which year are you in?

Year 1 (1)
Year 2 (2)
Year 3 (3)

Q7 **Think of the Project FLAME PE lessons that you took part in the past six weeks, and answer the following questions**

Q4 How long did you usually practice movement skills in one Project FLAME PE lesson?

0-5 minutes (1)
5-10 minutes (2)
10-15 minutes (3)
15-20 minutes (4)
20+ minutes (5)
A whole lesson (6)

Q5 Have you been shown how to perform movement skills correctly by your teacher?

Yes (1)
No (2)
Maybe (3)

Q6 How often were you shown the correct performance of movement skills during the six-week of Project FLAME?

Always (1)
Very often (2)
Sometimes (3)
Rarely (4)
Never (5)

Q7 Did your teacher use QR code or YouTube videos to show you how to perform skills correctly?

Yes (1)
Maybe (2)
No (3)

Q8 How often were you given feedback on your skill performance during the six-week of Project FLAME

Always (1)
Very often (2)
Sometimes (3)
Rarely (4)
Never (5)

Q9 I am aware of the learning cues and criteria to perform movement skills correctly for (please tick all that apply)

Throw (1)
Skip (2)
Dribble (3)
Horizontal jump (4)
Kick (5)
Vertical jump (6)

Q10 I have been provided with the resource/QR codes to practice movement skills in my own time (e.g. at home)

Yes (1)
Maybe (2)
No (3)

Q11 In a sentence or two, describe a Project FLAME PE lesson that you liked the most (think about what games you played? what skills you practiced?)

_____

Q12 Read the following statements, and indicate your level of agreement

	Completely disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Completely agree (5)
Project FLAME PE lessons are fun (1)					
Project FLAME introduces me to new activities (2)					
Project FLAME PE lessons are useful (3)					

Q13 I still find it hard performing these movement skills (tick all that apply)

Throw (1)
Skip (2)
Dribble (3)
Horizontal jump (4)
Kick (5)
Vertical jump (6)

Q14 I am getting better at performing these movement skills (tick all that apply)

Throw (1)
Skip (2)
Dribble (3)
Horizontal jump (4)
Kick (5)
Vertical jump (6)

Q15 How often do you practice movement skills in your own time (outside of school) using what you have learnt in Project FLAME?

None (1)
Once a week (2)
2-3 times a week (3)
3-5 tims a week (4)
Everyday (5)

Q16 I am going to practice movement skills in my own time in future, using what I have learnt in Project FLAME

Definitely won't (1)
Probably won't (2)
Probably will (3)
Definitely will (4)

Q17 What could have been done to make Project FLAME more useful for you?

_____

Q18 What could have been done to make Project FLAME more fun to you?

_____

Q19 Did you enjoy taking part in Project FLAME?

1 (1)
2 (2)
3 (3)
4 (4)
5 (5)

APPENDIX 16 PROJECT FLAME WEEKLY PE TEACHER LOG

Q1 Which week of the Project FLAME is this log documenting for?

○ Week 1 Throw (1)

○ Week 2 Skip (2)

○ Week 3 Dribble (3)

○ Week 4 Horizontal Jump (4)

○ Week 5 Kick (5)

○ Week 6 Vertical Jump (6)

Q2 Which school are you working at?

_____

Q3 Has the Project FLAME been implemented this week?

○ Yes (1)

○ No (2)

Q4 How many Project FLAME lesson(s) did you deliver this week?

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 4+ (5)

Q5 Which year group did you deliver Project FLAME lesson(s) to this week?

○ Year 1 (1)

○ Year 2 (2)

○ Year 3 (3)

Q6 On average, I included Project FLAME for the following duration of my PE lesson

○ 0-5 minutes (1)

○ 5-10 minutes (2)

○ 10-15 minutes (3)

○ 15-20 minutes (4)

○ 20+ minutes (5)

○ a whole lesson (6)

Q7 **Think of the most representative Project FLAME lesson you delivered this week, and answer the questions below. There is no right or wrong answer. Your answer is important for us to learn how you made Project FLAME work for you.**

Q8 Was the lesson focused on the FMS for this week (e.g. focussed on throw in Week1)?

○ Yes (1)

○ No, and briefly explain why (2) _____

Q9 Was FMS developed further as part of the developmentally appropriate curricular strand?

○ Yes (1)

○ No, and briefly explain why (2) _____

Q10 Were students visually shown the correct performance of the movement skills by you, to the best of your understanding?

○ Yes (1)

   ○ No, and briefly explain why (2) _____

Q11 Were students visually shown the correct performance of the movement skills by digital resources (e.g. videos access by QR codes)?

○ Yes (1)

   ○ No, and briefly explain why (2) _____

Q12 Did you share and teach the performance criteria/features of quality, as relevant to the selected movement skills (e.g. when throwing, wind-up is initiated with downward movement of hand/arm)?

○ Yes (1)

○ No, and briefly explain why (2) _____

Q13 Did you share and teach the movement through the use of external movement-based cues (e.g. throwing like the NIKE logo)?

○ Yes (1)

○ No, and briefly explain why (2) _____

Q14 Did you identify potential errors among students when they perform the movement?

○ Yes (1)

   ○ No, and briefly explain why (2) _____

Q15 Did you have adequate equipment and resources in your lesson to implement the Project FLAME?

○ Yes (1)

○ No, and briefly explain why (2) _____

Q16 Please note down here how you altered/adapted the project to fit the need of your lesson and student needs, and how you overcame the barriers to ensure the smooth delivery.

_____

_____

Q17 On average, what proportion of students were enthusiastically engaged in/enjoying the Project FLAME activities during the lesson?

☐ None (1)

☐ A few (2)

☐ Some (3)

☐ Most (4)

☐ All (5)

☐ Please note down any observations you may have (6)

_____

Q18 Were students provided with the digital resources (e.g. QR codes) to practice this week's movement skill in their own time?

○ Yes (1)

○ No (2)

Q19 Please indicate how satisfied are you with delivering this week's Project FLAME activities

1 (1)
2 (2)
3 (3)
4 (4)
5 (5)

Q20 LASTLY, PLEASE DESCRIBE ANY IMPORTANT OBSERVATIONS THAT INFLUENCED THE DELIVERY OF THE PROJECT THAT ARE NOT COVERED BY PREVIOUS SECTIONS OF THIS FORM.

APPENDIX 17 TEACHER'S INTERVIEW GUIDE

Questions	Prompts	Logic
Tell me a little about your school?	size, student population, existing facilities, where PE is normal held	Introduction and context
What is your role at the school?	experience, how long at the school	Introduction and context
How well did the training prepare you to implement Project FLAME and teach motor skills to your student?	In what way? In hindsight is there anything in addition which you would have liked? (e.g. handbook, online resources etc.) What worked well What didn't work so well How could we improve the training	Appropriateness
Were you clear about the purpose of Project FLAME and what it involved and what your involvement would be?	Duration, scope, intricacy and number of steps involved and whether it reflects a clear departure from previous practices	Appropriateness
What was it about the project (if anything) that appealed to you? Why?	Was there anything which didn't appeal/you were less keen on?	Acceptability
Can you talk me through the process used to deliver the programme/teach your students?	(Talk me through a Project FLAME lesson you delivered) How, if at all, is this different to how you were originally intending on implementing the programme? Why is that, what are the reasons for these changes? Is this different to how you would normally deliver your lessons – if so how? Do you think it improved your delivery and/or student outcomes?	Fidelity/Adaptability
Did you adapt the program in any way to suit your school and students? Either in terms of the frequency/ duration of use or equipment /materials used to implement it? (different components of project FLAME)	(Use interviewee's responses on adaptation as prompts) What do you think would have happened to the implementation (and pupil participation) had these changes not been made?	Fidelity/Adaptability

Which do you think are the essential components of the project, what are the non-negotiables in terms of implementing the programme? Why is this?		Fidelity, sustainability
Do you feel you were able to successfully implement the programme? What makes you feel this way? Did you experience any barriers or challenges to the delivery of the program - if so what were they, and are they within/outside of your control? Did you overcome the barriers - if so how – if not what assistance would have enabled you to overcome them	How confident do you think your colleagues feel about implementing the programme	Self-efficacy, adaptability, sustainability
Do you feel that this program could be sustained in your teaching practice and in your school - why / why not How confident are you that you will be able to use the intervention in long term?	How confident do you think your colleagues feel about using the intervention in long term	Self-efficacy, sustainability
What sort of impact, positive or negative, do you think the program has/had on your students?(FMS outcomes, engagement, enjoyment, perceived confidence) And what about on staff, school, and wider community?	Have you heard stories about the experiences of student participants, can you describe briefly? When and how did you first become aware the changes on the students that may be induced by the project?	Participant need and engagement
What has their reaction been like in terms of enjoyment, engagement?		Participant need and engagement
How satisfied are you with the implementation, in terms of level of use and uptake by students? What engagement/uptake look like.	How has participation among students changed, if at all, since launch? What do you think are the reasons for this?	Participant need and engagement
Have there been any background factors or changes within the school since launch, which have influenced	What kind of changes will be needed to accommodate the intervention? Can you describe the	Feasibility

the way you have implemented the programme?	process that will be needed to make these changes?	
What role, if any, do you see Project FLAME fulfilling in the school in the future?	Any conflicts with PE? Can you describe how the programme will be integrated into current process?	Sustainability
With the benefits of hindsight, what if anything, would need to be done differently to better implement Project FLAME	Could programme be made more accessible/attractive to a school in order to engage? To a student in order to engage? If so, in what ways, what would need to change?	Sustainability

	Social Research Ethics Committee (SREC) # ETHICS APPROVAL FORM * srec@ucc.ie https://www.ucc.ie/en/research/about/ethics/

Introduction

UCC academic staff and postgraduate research students who are seeking ethical approval should complete this approval form. Ethical review by the Social Research Ethics Committee (SREC)[i] is required where the methodology is not clinical or therapeutic in nature and proposes to involve:

direct interaction with human participants for the purpose of data collection using research methods such as questionnaires, interviews, observations, focus groups etc.;
indirect observation with human participants for example using observation, web surveys etc.;
access to, or utilisation of, anonymised datasets;
access to, or utilisation of, data or case files/records concerning identifiable individuals;
conducting Internet Research or research online.

SREC @ UCC considers itself an enabling committee, promoting strong research ethics amongst UCC's community of staff and student researchers. We are open to all types of research in the social research domain and if your research approach does not readily fit into this research form, do not be discouraged. Please add additional relevant notes to convey what you think is pertinent about the ethical aspects of your study.

Application Checklist

This checklist includes all of the items that are required for an application to be deemed complete. In the event that any of these are not present, the application will be returned to the applicant **without** having been sent for review. Please complete the checklist below, and ensure that your application includes all of these prior to submission. Thank you and best of luck with your research. If you require additional guidance, [click here](#).

	Delete as applicable
All relevant files are combined into **one PDF** file (SREC application form, consent/assent forms, information sheets, data collection instruments, permission letters, etc.)	Yes / No
Completed SREC Application Form	Yes / No

Information Sheet(s) / Information Statement (i.e. at the beginning of an electronic survey) included	<mark>Yes</mark> / No
Consent Sheet(s) / Consent Statement (i.e. at the beginning of an electronic survey) included	<mark>Yes</mark> / No
Data Collection Instrument: Psychometric Instruments / Interview Guide / Focus Group Schedule / Survey Questionnaire / etc. included	<mark>Yes</mark> / No
Copy of permission letters to undertake research from relevant agencies/services included (if available)	Yes / No / <mark>NA</mark>
If this is a resubmission, all the revised and new text is highlighted in yellow	Yes / No / <mark>NA</mark>
Have you applied for ethical approval for this project from another UCC ethics committee?	Yes / <mark>No</mark>
If you are under academic supervision, your supervisor(s) have approved the wording of and co-signed this application prior to submission	Yes / No / <mark>NA</mark>

APPLICANT(S) DETAILS

Name of UCC applicant(s)	Dr. Wesley O'Brien	**Date**	17/11/2020
Name of Department / School / Research Institute / Centre / Unit / College	Sports Studies and Physical Education Programme, School of Education.	**Contact No.**	021-490-2319
Correspondence Address	2 Lucan Place, Western Road, Cork	**Email Address**	wesley.obrien@ucc.ie
Course Code/Name and year of course (students only)	N/A	**Name of supervisor(s)** (students only)	N/A
Is this a resubmission?	Yes / <mark>No</mark>	SREC Log No. (if a resubmission): This new study is building on Log 2015-007, submission entitled "Project FLAME: Fundamental and Functional Literacy for Activity and Movement Efficiency"	

Obtaining ethical approval from SREC does not free you from securing permissions and approvals

from other institutional decision-makers and agency ethical review bodies. These bodies may accept the SREC approval, but researchers are responsible for ensuring they are compliant in advance of collecting data.

Project working title	A two-arm pragmatic non-randomised trial assessing strategies for improving the implementation of Project FLAME

If this is a collaborative project / community-based participatory research project / *joint* application with another agency, please complete this additional section:

Names of research partners / civil society organisations collaborating on this project (this section must be completed for participatory / community-based participatory research studies)	Centre for Sports, Exercise and Life Sciences, Coventry University, Coventry, UK School of Health and Social Development, Deakin University, Geelong, Australia Institute of Physical Activity and Nutrition (IPAN), Deakin University, Geelong, Australia Strategic Research Centre, Research for Educational Impact (REDI), Deakin University, Geelong, Australia
Agency contact person and position	N/A
Agency address	N/A
Details of the partnership (Please identify clearly the roles and responsibilities held by each party in the partnership in relation to the different aspects of the research).	Each of the named collaborators (as above) on this project will be partially involved in the design, development and implementation of the project. The collaborators will have involvement within the overall study design, data management and analysis, and interpretation of results.

ETHICAL APPROVAL SELF-EVALUATION

		YES	NO
	If your answer falls into any of the shaded boxes below, please address each point later in the application form	Use X or NA to mark selection	
1	Do you consider that this project has significant ethical implications?		X
2	Will you describe the main research procedures to participants in advance, so that they are informed about what to expect?	X	
3	Will participation in this project be voluntary?	X	
4	Will you obtain informed consent in writing from participants?	X	
5	Will you tell participants that they may withdraw from the research at any time and for any reason, and (where relevant) omit questionnaire items / questions to which they do not wish to respond?	X	
6a	Will data be treated with full confidentiality / anonymity (as appropriate)?	X	
6b	Does your project require you to carry out a Data Protection Impact Assessment (DPIA) in compliance with UCC Data Protection Policy?		X
7	Will data be securely held for a minimum period of ten years after the completion of a research project, in line with the University's *Code of Research Conduct* (2016)?	X	

8	If results are published, will anonymity be maintained and participants not identified? (see Q. 30 below regarding open data considerations, if relevant)	X	
9	Will you debrief participants at the end of their participation (i.e. give them a brief explanation of the study)?	X	
10	Will your project involve deliberately misleading participants in any way?		X
11	Will your participants include children / young persons (under 18 years of age)?	X	
12	If yes to question 11, is your research in compliance with the UCC *Child Safeguarding Statement* which sets out the legal requirements under the Children First Act 2015?	X	
13	Will your project require you to carry out "relevant work"[ii] as defined in the National Vetting Bureau (Children and Vulnerable Persons) Acts 2012 to 2016?		X
14	Do you require official Garda Vetting through UCC before collecting data from children or vulnerable adults? (Please note that having a Garda Vetting through another body is not sufficient; a separate UCC Garda Vetting is always required.)		X
15	Will project participants include people with learning or communication difficulties?		X
16	Will project participants include patients / service users / clients? A service user or client is a person who is served by or uses the services under consideration as part of this research.		X
17	Will project participants include people in custody?		X
18	Will project participants include people engaged in illegal activities (e.g. drug taking, illegal Internet behaviour, crime, etc.)?		X
19a	Is there a realistic risk of participants experiencing either physical or psychological distress?		X
19b	Is there a realistic risk of the researcher experiencing either physical or psychological distress?		X
20	If yes to question 19a, has a proposed procedure for linking the participants to an appropriate support, including the name of a contact person, been given? (see Q. 33)	NA	
21	If yes to question 19b, has a proposed procedure/support structure been identified?	NA	
22	Are the research participants students with whom you have some current/previous connection (module coordinator, research supervisor, professional tutor, etc.)?		X
23	Will the research participants receive payment / gifts / voucher / or other incentives for participating in this study?		X
24	If your research is conducted on the internet, does it involve human participants? (e.g. through web surveys, social media, accessing or utilising data (information) generated by or about the participant/s; or involve observing human participants in their online interactions/behaviour). If yes, please review and utilise the UCC policy for conducting Internet Research.	X	

DESCRIPTION OF THE PROJECT

*Ethical review requires that you **reflect** and seek to **anticipate** ethical issues that may arise,*

rather than reproduce copious text from existing research proposals into these boxes.

*Entries should be **concise** and relevant to the point / question.*

25. Very brief description of your study (15-25 words max.)

[e.g. This is a qualitative study of primary school teachers' attitudes towards religious teaching using focus groups to collect original data]

This is a mixed methods study comprising of school physical education teachers and students in their uptake and engagement with the Project FLAME intervention.

26. What is your study about? (100-200 words max.)

Although the evidence supporting the efficacy of these intervention strategies is compelling, it is mainly established through controlled trials (Eddy et al., 2019, Morgan et al., 2013). However, in order to achieve health benefits at the population level, effective interventions must be sustainably implemented over time and under real-world conditions (McKay et al., 2019). Given the low level of competency observed persistently worldwide, motor competence interventions need to be designed and tested with real-world implementation in mind (Ma et al., 2020, Koorts et al., 2019). Only one study has planned to test scaling-up and implementation of an efficacious intervention to improve motor competence (i.e. SCORES intervention) (Lonsdale et al., 2016). However, the study did not apply implementation models as a planning tool which was recommended in a recent systematic review to ensure implementation success of school-based interventions (Cassar et al., 2019). Project FLAME is a well-developed intervention programme aiming to improve Irish adolescents' movement competence and has recently been trialled in controlled conditions. This study aims to develop, select and evaluate implementation strategies to improve the uptake of and engagement with the Project FLAME in a naturalistic setting.

27. What are your research questions?[iii] (The research questions are the overall aim(s)/objective(s) of your study)

Objective 1: To evaluate teacher's self-efficacy on delivering and implementing Project FLAME intervention activities in physical education (e.g., teaching fundamental movement skills).

Objective 2: To evaluate adolescent and teacher engagement in and adherence to the Project FLAME intervention.

Objective 3: To evaluate the acceptability and feasibility of the implementation strategies to inform further the refinement of Project FLAME.

28. Who are the participants in your study? (recruitment methods including details of how you will engage with participants, number, age, gender, exclusion/inclusion criteria, detail permissions to be sought / secured already, and how will you recruit participants?)

Participants in this study will be students and teachers from post-primary schools in the Cork area. To be eligible, schools must (1) have not previously participated in the Project FLMAE non-randomised or randomised controlled trials, (2) not be currently participating in any other intervention aimed at physical activity behaviours and movement competence, (3) have internet access.

Inclusion criteria for Teachers

Qualified post-primary school Physical Education (PE) Teacher.

All PE teachers must be teaching a minimum of one PE class per week to Junior Cycle students in post-primary schools.

All PE teachers must have access to an indoor or outdoor PE space for pedagogical delivery.

Exclusion Criteria for Teachers

Teacher not qualified with a PE post-primary school specialism subject.

PE teachers only teaching Senior Cycle students in post-primary schools.

If PE teachers do not have access to an indoor or outdoor PE space for pedagogical delivery.

Inclusion criteria for Students (under 18 years of age)

- Students have given signed assent alongside consent from their parent/guardian for participation in the study

- have access to the internet outside of school (e.g. a mobile device with data or Wi-Fi at home).

Exclusion criteria for Students (under 18 years of age)

- Students who have not given signed assent and/or parent/guardian's consent has not been given

Recruitment

Prior to commencing data collection, the leading researchers will visit or electronically meet the school principals and the liaison PE teacher(s) in each participating school, where a full briefing of the data collection process will be outlined. Subsequent to the granted approval from school principals, consent forms and information sheets will be distributed to each respective student class group and eligible teacher.

Informed parental/guardian consent and child assent will be required to partake in the study. Schools and participants will be informed that participation will be entirely voluntary, and that they are free to withdraw of their own volition at any time. In terms of the research rigour inherent to school-based measurements, it is important to note that the principal Investigators for this study are all qualified secondary school specialist PE teachers, as recognized by the Teaching Council of Ireland**.**

29. Concise statement of _anticipated_ ethical issues raised by your project. How do you intend to deal with them? Please address _all_ items where your answers fell into a shaded box in the self-evaluation above. (350 words max.)

This research and data collection will take place entirely online, with the use of online surveys and interviews, as well as web analytics (through Google Forms and/or Office 365 Forms). With reference to the UCC Guidance Document for Conducting Ethical Internet Research, we are addressing the following topics while completing this application:

Intrusiveness

The proposed research will not be intrusive to the online community. All researchers will be "passive" participants in the community and will only be actively involved in the online forum that's designed to provide ongoing consultation to study participants.

Perceived privacy

The level of perceived privacy of the online community will be high. Involvement in the research will be completely voluntary. The relevant links to the online surveys and access to online platforms will be distributed to a closed group requiring registration. The website/online platform used will have privacy and data protection notice and all researchers will be cognisant of when using.

Child Protection

The study will involve child participants (under the age of 18) and therefore will be conducted In line with the UCC Child Protection Policy. Researchers who work with youth participants directly shall be subject to Garda Vetting prior to contact with the participants.

Potential harm

There will be no intrusion of the researchers during the current study. The publication of research results will not have the potential to harm individuals or the online community as a whole.

Informed consent

Informed consent from community members will be required at the beginning of data collection and before the participants complete the online surveys. This consent form will be included in the first page of the online data collection form.

Confidentiality

Anonymity and confidentiality of participants will be protected through the entire research process. The individual's anonymity will be agreed upon through the online consent forms obtained at the initial stage of the research. All

participants in the online surveys will be invited to give informed consent. Questionnaires will have a "force response question" whereby participants will not be able to proceed until indicating that they understand and consent. Since this research will take place entirely online, no further circumstances that anonymity might be threatened (i.e. face to face discussions with small or individual focus groups) exist. All participants will be assigned a unique ID number, which will correspond across all instruments and time points used to collect data.

Platform/Community   Knowledge

We have read the Terms of Use of the internet sites (Google Forms and/or Office 365 Forms) and we do not feel that we need to seek permission to conduct research on the site. These sites are specifically designed to conduct online surveys.

Data Acquisition

We will not be using data scraping techniques to acquire data from the online community or internet site. The data acquisition method we will be using (online surveys) can be considered ethical.

---

30. Data. (Please provide your answers to these questions in the white area below)

(a) How will you collect your data? Provide a brief description and justification of methods and data collection measures to be used. (If conducting an online survey/questionnaire, what survey platform do you plan to use?)

(b) If you are creating audio/video recordings, who will perform the transcription? (If transcription is being outsourced the transcription service needs to be trustworthy, reliable, and confidential. Ensure that data transfer is done securely. Recorded data must be deleted from a mobile recording device. When will the data recordings be deleted from the recording device and who will be assigned responsibility for this?)

(c) What type of data will you be storing? (Briefly describe the <u>type</u> of data you plan to collect).

(d) How and where will you store your data?^{iv} (Provide details about both physical <u>and</u> electronic documents. See page 7, Electronic Data Storage for guidance on data storage).

(e) For how long will you store the data? (A minimum storage period of 10 years is required)
(f) Who will you share the data with? (*Sample* prompts: If you plan to make your raw research dataset available publicly as part of the open data movement, or if you are required to do so as part of funding/journal requirements, please address your protocol here (make explicit links to Q. 32 below and show that you have addressed this in your consent form and information sheet). For collaborative/community-based participatory research, please address issues such as shared ownership of data, will data be transferred (how?), publication of findings, etc. If your funder contractually requires you to give them access to the 'raw' dataset, examine relevant implications, including appropriate anonymisation, protocols for secure access to the dataset, etc.).
(g) If you are planning to analyse an existing dataset, please outline how the original consent process allows for your data analysis.

(h) If you are planning to request access to health/case files/personal records that were not created for research purposes, please address Data Protection considerations, provide a strong rationale and comprehensively address associated ethical issues.

(i) If you ticked yes to Q.6b in the SREC Checklist (above), have you submitted your DPIA?

(a) Quantitative data will be collected before and after six-week trial period with PE teachers, with the use of online surveys in Google Forms and/or Office 365 Forms. Web analytics data will be collected throughout the six-week trial period.

(b) Recordings of interviews will be collected with PE teachers. All qualitative data will be transcribed verbatim by a member of the research team and anonymised to protect the identities and views of the participants.

(c) Recordings, transcripts and web analytic results will be stored in an anonymised electronic format.

(d) Data will be stored on encrypted UCC OneDrive system and subsequently on the UCC server.

(e) The complete dataset will be securely stored for a minimum of ten years and then destroyed.

(f) We are not going to make the raw dataset available publicly for any reason. Since this research is a collaborative research between institutions, the raw dataset will be accessible to the leading and named researchers from these institutions only through One Drive provided by University College Cork. It will be made clear that all laptops and PCs used to access data must be encrypted and password protected. In terms of sharing the data, a monthly report with preliminary results and findings will be provided to the key researchers involved within the project.

(g) We are not planning to analyse an existing dataset.

(h) We are not planning to request access to health/case files/personal records that were not created for research purposes.

(i) N/A

31. **Arrangements for informing participants about the nature of the study** (e.g. information sheets, letters of invitation, social media information, participant recruitment, focus group welcome/schedule, withdrawal, etc.)
Prior to commencing data collection, the leading researchers will visit or electronically meet the school principals and the liaison PE teacher(s) in each participating school, where a full briefing of the data collection process will be outlined. Subsequent to the granted approval from school principals, consent forms and information sheets will be distributed to eligible teachers and each respective student class group. Informed parental/guardian consent and child assent will be required to partake in the study.

32. How you will ensure that participants provide informed consent? (cf. Question 4 - attach relevant form(s); address special considerations in terms of children / young people / vulnerable persons / adults who have difficulty in making decisions unaided)

As all student participants are children (under the age of 18), informed consent will be sought from parents and guardians for the children's participation. The assent of the child will also be sought, and no child will participate without the informed consent of both the parent and the assent of the child themselves.

33. Outline of debriefing process at the end of the data collection process (cf. Question 9). **If you answered Yes to Questions 19a or 19b, give details here. State what you will advise participants to do if they should experience problems (e.g. who to contact for help – provide name and contact details where required.)**

General findings will be shared with the schools of the participants following the collation and publication of data regarding general attitudes towards the project and the resulting plans to develop the project. Any individual who experiences problems during or following participation in the project will be advised to contact the researchers and or the teacher/principal of their respective schools.

34. Estimated start date and duration of project (by months)

It is estimated that this research will last for four months, January 2021 to December 2021. February 2020 to May 2020.

35. Additional information of relevance to your application

36. Declarations (clickable links to policies and codes quoted here are on the next page)	Delete as applicable
I/we agree that should there be unexpected ethical issues arising during the course of this study, that I/we will utilise my/our professional/disciplinary code of ethics, and/or notify UCC SREC, where appropriate.	Yes / No
I/we have consulted the UCC *Code of Research Conduct* (2019) and believe my/our proposal is in line with its requirements.	Yes / No
I/we have consulted the UCC *Child Protection Policy* and believe my/our proposal is in line with its requirements.	Yes / No / NA
I/we have consulted the UCC GDPR guidelines and declare that our project is GDPR compliant. Where required under the UCC GDPR Guidelines, I have submitted a DPIA.	Yes / No Yes / No / NA
I/we have consulted the UCC Garda Vetting Guidelines, and where appropriate, researchers on this project have valid Garda vetting through UCC (having a valid Garda Vetting through another body is insufficient).	Yes / No / NA

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37. Signatures – Reminder all academic supervisors (where applicable) must approve the contents of this application	
UCC Applicant(s)	**Academic Supervisor / Principal Investigator /Tutor** (where applicable)
This item has been removed due to third party copyright. The unabridged version of the thesis can be viewed at the Lanchester library, Coventry University	
Date: 17th November 2020	Date:

PLAIN LANGUAGE STATEMENT

TO: Teachers

Date:

Full Project Title: A two-arm pragmatic non-randomised trial assessing strategies for improving the implementation of Project FLAME

UCC Researcher: Dr. Wesley O'Brien, Dr. Diarmuid Lester

External Researchers: Miss Jiani Ma**,** A/Prof. Lisa Barnett, Prof. Michael Duncan Dr. Natalie Lander, Dr. Emma Eyre

This study is concerned with assessing the implementation of the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention for improving motor competence development in Irish adolescents. You are being invited to take part in this online survey because your school has been selected for training in the Project FLAME intervention, and you are a current physical education (PE) teacher. This Plain Language Statement is to provide you with details of this research project, as openly and as clearly as possible. You are advised to read it carefully so that you can make a fully informed decision regarding your participation in the study. Should you require clarity on any information provided in this document, please do not hesitate to ask questions. Once you have come to an understanding of what this project entails and you agree to participate in it, you can then sign the consent form provided.

What is the purpose of the study?

This research project is a collaboration between researchers at University College Cork, Ireland, Coventry University, United Kingdom and Deakin University, Australia. This study aims to assess the implementation of the Project FLAME.

What are the benefits of taking part?

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The possible benefits of the study include improving the real-world applicability and translatability of the Project FLAME intervention, and contributing to the current body of knowledge on teacher's practice regarding fundamental movement skills and functional movement.

What are the potential risks?

There are no foreseeable or known risks for participation in the present study.

What will happen if I decide to take part

Your participation will be comprised of four parts should you agree to take part: (1) You will be asked to complete teaching logs following the completion of each PE session featured with Project FLAME intervention. You will receive a reminder and template for teacher's log each intervention week. The teaching log should take less than 15 minutes to complete; (2) You will be asked to complete a teacher's questionnaire (online) at both the beginning and end of the intervention period, exploring your experience and self-efficacy in delivering and implementing intervention activities. The questionnaire should take less than 15 minutes to complete; (3) You will receive an invitation via the online questionnaire to be further interviewed, if you indicate your interests, you will be contacted by a member of the research team to schedule an online interview. The interview will last no longer than 30 minutes; (4) Your engagement with the online platform that hosts Project FLAME information and resources will be recorded, including your viewing activities and comments.

Should you indicate your interest to be interviewed, we would like to organise a time to have a short interview with you via telephone or any other online tools might suit you. The interview will take approximately 30 minutes of your time. To make sure that we accurately capture your answers, we would like your consent to also record our conversation. During the interview, we will restate and summarise all information that you provide to us to ensure accuracy. Following the interview, our conversation will be transcribed verbatim by a member of the research team. Your name will not be linked to the transcript. A pseudonym will be used to maintain your confidentiality.

Do I have to take part?

No – it is entirely up to you. Participation in this research project is voluntary. **If you do not wish to take part you are not obliged to.** Deciding not to participate will not affect your relationship with University College Cork, Deakin University or Coventry University. If you do decide to take part, please keep this Plain Language Statement and complete the Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate. Please note down your participant number (which is on the Consent Form) and provide this to the lead researcher (Dr. Wesley O'Brien) if you seek to withdraw from the study at a later date. You are free to withdraw your information from the project dataset at any time until the data are destroyed 10 years after study completion. You should note that your data may be used in the production of formal research outputs (e.g. journal articles, conference papers and reports) and student

researcher Jiani Ma's doctoral thesis prior to this date and so you are advised to contact the university at the earliest opportunity should you wish to withdraw from the study. To withdraw, please contact the lead researcher (contact details are provided below). Please also contact the University College Cork office of the Vice President for Research & Innovation [email uccresearch@ucc.ie; telephone 021-4903501] so that your request can be dealt with promptly in the event of the lead researcher's absence. You do not need to give a reason. A decision to withdraw, or not to take part, will not affect you in any way.

Data Protection and Confidentiality

Your data will be processed in accordance with Irish and European Data Protection legislations. All information collected about you will be kept strictly confidential. Unless they are fully anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by all members of the research team listed in this document. All electronic data will be stored on the University College Cork OneDrive system and subsequently on the University College Cork server. All paper records will be stored in a locked filing cabinet at University College Cork. Your consent information will be kept separately from your responses in order to minimise risk in the event of a data breach. The lead researcher will take responsibility for data destruction.

Data Protection Rights

University College Cork is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance with Irish and European Data Protection legislations. You also have other rights including rights of correction, erasure, objection, and data portability. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.dataprotection.ie . Questions, comments and requests about your personal data can also be sent to University College Cork's Information Compliance Manager: Office of Corporate & Legal Affairs, University College Cork, Western Road, Cork. [email: foi@ucc.ie; telephone 0214903949.

Making a Complaint

If you are unhappy with any aspect of this research, please first contact the lead researcher, (Dr. Wesley O'Brien). If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

University College Cork office of the Vice President for Research & Innovation, 4th Floor Block E, Food Science Building, University College Cork. [email uccresearch@ucc.ie; telephone 021-4903501]

Please also inform the collaborating institution at the following:

The Human Research Ethics Office, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: +61(0) 9251 7129, research-ethics@deakin.edu.au

Please quote project number [HEAG-H xxx_20xx].

Dr. Wesley O'Brien

Telephone: 021-4902319

Email: wesley.obrien@ucc.ie

In your letter please provide information about the research project, specify the name of the researcher and detail the nature of your complaint.

Consent Form

TO: Teachers

Date:

Full Project Title: A two-arm pragmatic non-randomised trial assessing implementation strategies for improving the uptake of Project FLAME

You are invited to take part in this research study for the purpose of assessing the implementation of the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention on motor competence development in Irish adolescents.

Before you decide to take part, you must **read the accompanying Plain Language Statement.**

Please do not hesitate to ask questions if anything is unclear or if you would like more information about any aspect of this research. It is important that you feel able to take the necessary time to decide whether or not you wish to take part.

If you are happy to participate, please confirm your consent by circling YES against each of the below statements and then signing and dating the form as participant.

1	I confirm that I have read and understood the Plain Language Statement for the above study and have had the opportunity to ask questions	Yes	No
2	I understand my participation is voluntary and that I am free to withdraw my data, without giving a reason, by contacting the lead researcher and		

	the Research Support Office <u>at any time</u> until the date specified in the Plain Language Statement		
3	I understand that all the information I provide will be held securely and treated confidentially		
4	I am happy for the information I provide to be used (anonymously) in academic papers and other formal research outputs		
5	I agree to take part in the above study		
6	I understand I will be given a separate consent form in the questionnaire for my participation in the interview		

Thank you for your participation in this study. Your help is very much appreciated.

Participant's Name	Date	Signature
Researcher	Date	Signature

PLAIN LANGUAGE STATEMENT

TO: Parent

Date:

Full Project Title: A two-arm pragmatic non-randomised trial assessing implementation strategies for improving the uptake of Project FLAME

UCC Researcher: Dr. Wesley O'Brien, Dr. Diarmuid Lester

External Researchers: Miss Jiani Ma, A/Prof. Lisa Barnett, Prof. Michael Duncan Dr. Natalie Lander, Dr. Emma Eyre

This study is concerned with assessing the implementation of the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention on motor competence development in Irish adolescents. You are being invited to take part in this online survey because your school has been selected for training in the Project FLAME intervention, and you are a current student. This Plain Language Statement is to provide you with details of this research project, as openly and as clearly as possible. You are advised to read it carefully so that you can make a fully informed decision regarding your participation in the study. Should you require clarity on any information provided in this document, please do not hesitate to ask questions. Once you have come to an understanding of what this project entails and you agree to participate in it, you can then sign the consent form provided.

What is the purpose of the study?

This research project is a collaboration between researchers at University College Cork, Ireland, Coventry University, United Kingdom and Deakin University, Australia. This study aims to assess the implementation of the Project FLAME.

What are the benefits of taking part?

The possible benefits of the study include improving the real-world applicability and translatability of the Project FLAME, and contributing to the current body of knowledge on teacher's practice regarding fundamental movement skill and functional movement.

What are the potential risks?

There are no foreseeable or known risks for participation in the present study.

What will happen if I decide to take part

Your participation will be comprised of two parts should you agree to take part: (1) You will be asked to complete a questionnaire (online) at the end of the intervention period, exploring your experience and satisfaction in receiving the Project FLAME intervention; (2) Your engagement with the online platform that hosts Project FLAME information and resources will be recorded, including your viewing activities and comments. The questionnaire should take less than 15 minutes to complete.

Do I have to take part?

No – it is entirely up to you. Participation in this research project is voluntary. **If you do not wish to take part you are not obliged to.** Deciding not to participate will not affect your relationship with University College Cork, Deakin University or Coventry University. If you do decide to take part, please keep this Plain Language Statement and complete the Consent Form to show that you understand your rights in relation to the research, and that you are happy to participate. Please note down your participant number (which is on the Consent Form) and provide this to the lead researcher (Dr. Wesley O'Brien) if you seek to withdraw from the study at a later date. You are free to withdraw your information from the project dataset at any time until the data are destroyed 10 years after study completion. You should note that your data may be used in the production of formal research outputs (e.g. journal articles, conference papers and reports) and student researcher Jiani Ma's doctoral thesis prior to this date and so you are advised to contact the university at the earliest opportunity should you wish to withdraw from the study. To withdraw, please contact the lead researcher (contact details are provided below). Please also contact the University College Cork office of the Vice President for Research & Innovation [email uccresearch@ucc.ie; telephone 021-4903501] so that your request can be dealt with promptly in the event of the lead researcher's absence. You do not need to give a reason. A decision to withdraw, or not to take part, will not affect you in any way.

Data Protection and Confidentiality

Your data will be processed in accordance with Irish and European Data Protection legislations. All information collected about you will be kept strictly confidential. Unless they are fully anonymised in our records, your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by all members of the research team listed in this document. All electronic data will be stored on the University College Cork OneDrive system and subsequently on the University College Cork

server. All paper records will be stored in a locked filing cabinet at University College Cork. Your consent information will be kept separately from your responses in order to minimise risk in the event of a data breach. The lead researcher will take responsibility for data destruction.

Data Protection Rights

University College Cork is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance with Irish and European Data Protection legistations. You also have other rights including rights of correction, erasure, objection, and data portability. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.dataprotection.ie . Questions, comments and requests about your personal data can also be sent to University College Cork's Information Compliance Manager: Office of Corporate & Legal Affairs, University College Cork, Western Road, Cork. [email: foi@ucc.ie; telephone 0214903949.

What will happen with the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Key findings will always be made anonymous in any formal outputs unless we have your prior and explicit written permission to attribute them to you by name.

Making a Complaint

If you are unhappy with any aspect of this research, please first contact the lead researcher, (Dr. Wesley O'Brien). If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

University College Cork office of the Vice President for Research & Innovation, 4th Floor Block E, Food Science Building, University College Cork. [email uccresearch@ucc.ie; telephone 021-4903501]

Please also inform the collaborating institution at the following:

The Human Research Ethics Office, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: +61(0) 9251 7129, research-ethics@deakin.edu.au

Please quote project number [HEAG-H xxx_20xx].

Dr. Wesley O'Brien

Telephone: 021-4902319

Email: wesley.obrien@ucc.ie

In your letter please provide information about the research project, specify the name of the researcher and detail the nature of your complaint.

Consent Form

TO: Parent

Date:

Full Project Title: A two-arm pragmatic non-randomised trial assessing implementation strategies for improving the uptake of Project FLAME

You are invited to take part in this research study for the purpose of assessing the implementation of the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention on motor competence development in Irish adolescents.

Before you decide to take part, you must **read the accompanying Plain Language Statement.**

Please do not hesitate to ask questions if anything is unclear or if you would like more information about any aspect of this research. It is important that you feel able to take the necessary time to decide whether or not you wish to take part.

If you are happy to participate, please confirm your consent by circling YES against each of the below statements and then signing and dating the form as participant.

		Yes	No
1	**I confirm that I have read and understood the <u>Plain Language Statement</u> for the above study and have had the opportunity to ask questions**		
2	**I understand my participation is voluntary and that I am free to withdraw my data, without giving a reason, by contacting the lead researcher and the Research Support Office <u>at any time</u> until the date specified in the Plain Language Statement**		
3	**I understand that all the information I provide will be held securely and treated confidentially**		
4	**I am happy for the information I provide to be used (anonymously) in academic papers and other formal research outputs**		
5	**I agree to take part in the above study**		

Thank you for your participation in this study. Your help is very much appreciated.

Participant's Name	Date	Signature

Parents/Guardian's Names	Date	Signature

Researcher	Date	Signature

Hello,

My name is Jiani Ma. I am a student researcher at Coventry University, UK and Deakin University, Australia. I am doing a project for my degree on how to help children and adolescents improve movement skills. In this project, I am collaborating with University College Cork to find out if PE sessions and a web platform will help you to learn more about movement. I would like you and other students in your class to be part of my project.

There are two parts in your participation if you agree: (1) You will be asked to complete a questionnaire (online) about your experience and satisfaction with PE sessions and the web platform; (2) Your engagement with the web platform will be recorded, including your viewing activities and comments on this web forum.

You will not be asked to provide your name at any point of these activities, so no-one will know who you are with the information you tell us. When the project is finished, I will write a report and it might be published as articles.

This project is voluntary, so you can do it or not, and you can change your mind about it later. You just have to tell me or your parents or teacher and we will take you out of the project. You won't have to explain why. If you feel worried about the project, or have any questions, you can talk to me, your parents or your teacher.

Thank you for thinking about helping me to find out your experience. If you are willing to take part, talk it over with your parents who will also have received a letter from me. Please sign the consent form attached to this letter.

Miss Jiani Ma

Child Assent Form

I understand the information letter given to me and I would like to participate in this project.

Participant's Name (printed) ………………………………………………………………………

Signature ……………………………………………………… Date …………………………

FOR RESEARCHERS

Things to consider

IMPLEMENTATION
EVALUATION OF MOTOR SKILL
COMPETENCE INTERVENTION

Essential

Desirable

What information should we gather and how, to understand how the intervention works and under what conditions?

Define

Which mechanism will make the greatest impact?

Who are the key stakeholders we should engage and involve in the evaluation?

Engage

Who are the key stakeholders we should engage and involve to sustain the intervention?

What are the critical barriers to the intervention implementation?

Identify

What are the solutions to address the critical barriers to the intervention implementation?

What are the non-negotiables? How do participants respond? What are the apdataions made?

Evaluate

What does sustained implementation look like?

Journal Paper 1

Paper 1 description

Paper title	It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence
Authors	Jiani Ma[1,2,*], Natalie Lander[3], Emma L.J. Eyre[1], Lisa M. Barnett[4], Inimfon A. Essiet[1,2], Michael J. Duncan[1]
Author affiliations	[1] Centre for Sport, Exercise and Life Sciences, Coventry University, Coventry, UK

[2] School of Health and Social Development, Deakin University, Geelong, Victoria, Australia

[3] School of Arts and Education, Deakin University, Geelong, Victoria, Australia

[4] Institute of Physical Activity and Nutrition, School of Health and Social Development, Deakin University, Geelong, Victoria, Australia |
| Abstract | **Background**: Motor competence is an important predictor of health behaviours. However, levels of motor competence are low in children and adolescents. Many interventions have improved motor competence, yet intervention effects were highly variable. Potential causes for such variations are not fully understood. Process evaluations can assist with the understanding of why an intervention worked or not, but its application and reporting in motor competence interventions have received little attention.

Objectives The primary aim of this review was to investigate the extent to which process evaluations have been conducted and reported in interventions to improve children's and adolescents' motor competence. A secondary aim was to synthesise process evaluation findings to identify characteristics of which intervention programmes can be optimised.

Design The process of conducting and reporting this review adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The review protocol was registered with PROSPERO (CRD42019124412).

Data Sources: A systematic search of seven electronic databases (i.e. MEDLINE [via EBSCOhost], Cochrane Central Register of Controlled Trials [CENTRAL], CINAHL, Academic Search Complete, Education Database, SPORTDiscus and Scopus) with no date restrictions was conducted.

Eligibility Criteria for Selecting Studies Eligibility criteria included (1) a study sample of typically developing children and adolescents aged 5–18 years, (2) an intervention had a clear intent to improve motor competence, (3) an intervention included a control group, (4) a report of motor competence outcome at both pre and post-intervention. Only original articles published in English in peer-reviewed journals were considered.

Methods: A convergent segregated mixed methods approach to analysis was used. Qualitative research findings related to process evaluation were |

	summarised using the UK Medical Research Council's process evaluation framework, in order to provide overarching descriptions on the implementation, mechanism of change and context of interventions. Univariable meta-regressions were performed to ascertain if selected study-level covariates moderated the improvement in motor competence outcomes in interventions.
	Results: The search identified 48 intervention studies. Only 26 studies (54%) reported process evaluation measures. No studies reported (or employed) theoretical frameworks to guide process evaluation. Process evaluation measures relating to implementation were most commonly reported with the most prevalent aspect being fidelity. This was followed by reporting on measures relating to mechanism of change and context of the intervention. Meta-regression results suggest intervention duration, intensity, inclusion of process evaluation aim, sample size and sex as potential moderators.
	Conclusions: Reporting of process evaluation measures may help build our understanding of the optimal characteristics of motor competence interventions. However, process evaluation is under-used and/or under-reported. This review serves as a call for more process evaluations and better reporting in motor competence interventions.
Publication journal	Sports Medicine
DOI Link	https://doi.org/10.1007/s40279-021-01519-5
ISSN	1179-2035
Volume, year and issue	51(12), 2021
Where in thesis the manuscript is used?	Chapter 4

Authorship contribution statement

JM conceived the review, NL, EE, LMB and MD assisted in developing review questions and designed the review methods. JM ran the literature search, screened all identified titles and abstracts, assisted with the full-text screening and the risk-of-bias assessment, led the data extraction and ran the meta-analyses. JM wrote and edited the first draft of the manuscript. NL advised on and assisted with the data analysis and revised and edited the manuscript. EE advised on the full-text screening and data analysis and revised and edited the manuscript. LMB advised on the data analysis and revised and edited the manuscript. IAE assisted with the full-text screening, data extraction and revising the manuscript. MD assisted with the risk-of-bias assessment, advised on the data analysis and revised and edited the manuscript. All authors read and approved the final manuscript.

Author agreement for the use of this collaborative work in Jiani Ma's PhD thesis

Author	Signature

Journal Paper 2

Paper 2 description

Paper title	Using Collective Intelligence to identify barriers to implementing and sustaining effective Fundamental Movement Skill interventions: A rationale and application example

Authors	Jiani Ma[1,2,*], Michael J. Hogan[3], Emma L.J. Eyre[1], Natalie Lander[4], Lisa M. Barnett[2,4], Michael J. Duncan[1]
Author affiliations	[1] Centre for Sport, Exercise and Life Sciences, Coventry University, Coventry, UK
	[2] School of Health and Social Development, Deakin University, Geelong, Victoria, Australia
	[3] School of Psychology, National University of Ireland, Galway, Ireland
	[4] Institute of Physical Activity and Nutrition, School of Health and Social Development, Deakin University, Geelong, Victoria, Australia
Abstract	To have population-level impact, interventions must be effectively implemented and sustained under real-world conditions. Few Fundamental Movement Skill (FMS) interventions are implemented at scale, and even fewer are sustained in a way that allows for ongoing evaluation. There has been increasing recognition of applying systems thinking to investigate the multitude of influences on interventions. To improve research-practice translations, investigations need to incorporate synthesised perspective and collective input from intervention stakeholders. This study trials Collective Intelligence (CI) – an applied systems science approach – to understand barriers to the adoption, implementation and institutionalisation of effective FMS interventions for children and adolescents. A total of 58 barriers were generated and organised into 13 barrier categories. Participants voted to select 10 critical barriers and generated a structural map among the barriers to guide future action mapping. Barriers related to Government and Institutional factors and Curricular Conflicts were structured as fundamental drivers of the system of barriers. By presenting this application example, we aim to underline the considerations and alleviate barriers to conducting much needed implementation and sustainability studies in FMS interventions. CI also adds to the "tool box" to understand the complexity and functioning of public health interventions, such as those targeting physical activity behaviours.
Publication journal	Journal of Sports Sciences
DOI Link	https://doi.org/10.1080/02640414.2020.1841395
ISSN	1466-447X
Volume, year and issue	39, 2021, 6
Where in thesis the manuscript is used?	Chapter 5 Part 1

Authorship contribution statement

JM and MH led the design of the study with all authors contributing to the study design and ethics submission. JM recruited study participants. JM and/or MH led the collective intelligence workshops. All authors reviewed the initial set of barriers and solutions and suggested on the final representation. JM drafted the manuscript with all authors contributing to the review and edit. All authors have critically read and approved the final manuscript. MD and LB provided senior supervision and mentorship on research activity planning and execution.

Author agreement for the use of this collaborative work in Jiani Ma's PhD thesis

Journal Paper 3

Paper 3 description

Paper title	Enhancing the implementation and sustainability of fundamental movement skill interventions in the UK and Ireland : lessons from collective intelligence engagement with stakeholders
Authors	Jiani Ma[1,2,*], Michael J. Hogan[3], Emma L.J. Eyre[1], Natalie Lander[4], Lisa M. Barnett[2,4], Michael J. Duncan[1]
Author affiliations	[1] Centre for Sport, Exercise and Life Sciences, Coventry University, Coventry, UK [2] School of Health and Social Development, Deakin University, Geelong, Victoria, Australia [3] School of Psychology, National University of Ireland, Galway, Ireland

	[4] Institute of Physical Activity and Nutrition, School of Health and Social Development, Deakin University, Geelong, Victoria, Australia
Abstract	Background: To have population-level impact, physical activity (PA) interventions must be effectively implemented and sustained under real-world conditions. Adequate Fundamental Movement Skills (FMS) is integral to children being able to actively participate in play, games, and sports. Yet, few FMS interventions have been implemented at scale, nor sustained in routine practice, and thus it is important to understand the influences on sustained implementation. The study's aim was to use Collective Intelligence (CI)—an applied systems science approach—with stake- holder groups to understand barriers to the implementation of FMS interventions, interdependencies between these barriers, and options to overcome the system of barriers identified.

Methods: Three CI sessions were conducted with three separate groups of experienced FMS intervention researchers/practitioners (N = 22) in the United Kingdom and Ireland. Participants generated and ranked barriers they perceive most critical in implementing FMS interventions. Each group developed a structural model describing how highly ranked barriers are interrelated in a system. Participants then conducted action mapping to solve the problem based on the logical relations between barriers reflected in the model.

Results: The top ranked barriers (of 76) are those related to policy, physical education curriculum, and stakeholders' knowledge and appreciation. As reflected in the structural model, these barriers have influences over stakeholders' efficacy in delivering and evaluating interventions. According to this logical structure, 38 solutions were created as a roadmap to inform policy, practice, and research. Collectively, solutions suggest that efforts in implementation and sustainability need to be coordinated (i.e., building interrelationship with multiple stakeholders), and a policy or local infrastructure that supports these efforts is needed.

Conclusions: The current study is the first to describe the complexity of barriers to implementing and sustaining FMS interventions and provide a roadmap of actions that help navigate through the complexity. By directing attention to the ecological context of FMS intervention research and participation, the study provides researchers, policymakers, and practitioners with a framework of critical components and players that need to be considered when designing and operationalising future projects in more systemic and relational terms. |
Publication journal	International Journal of Behavioral Nutrition and Physical Activity
DOI Link	https://doi.org/10.1186/s12966-021-01214-8
ISSN	1479-5868
Volume, year and issue	18, 2021, 144
Where in thesis the manuscript is used?	Chapter 5 Part 2

Authorship contribution statement

JM and MH led the design of the study with all authors contributing to the study design and ethics submission. JM recruited study participants. JM and/or MH led the collective intelligence workshops. All authors reviewed the initial set of barriers and solutions and suggested on the final representation. JM drafted the manuscript with all authors contributing to the review and edit. All authors have critically read and approved the final manuscript. MD and LB provided senior supervision and mentorship on research activity planning and execution.

Author agreement for the use of this collaborative work in Jiani Ma's PhD thesis

APPENDIX 24 FULL ETHICS APPLICATION FORMS

Medium to High Risk Research Ethics Approval

Project Title

Using Collective Intelligence Analysis to identify barriers to improving Fundamental Movement Skill(FMS) proficiency among children: A realist feasibility study of Skill-Ed scale-up

Record of Approval

Principal Investigator

I **request an ethics peer review** and confirm that I have answered all relevantquestions in this checklist honestly.	X
I confirm that I will carry out the project in the ways described in this checklist. I will immediately suspend research and request new ethical approval if the project subsequently changes the information I have given in this checklist.	X
I confirm that I, and all members of my research team (if any), have read and agreed to abide by the Code of Research Ethics issued by the relevant national learned society.	X
I confirm that I, and all members of my research team (if any), have read and agreed to abide by the University's Research Ethics, Governance and Integrity Framework.	X

Name: Jiani Ma ....

Date: 08/05/2019 ....

Student's Supervisor (if applicable)

I have read this checklist and confirm that it covers all the ethical issues raised by this project fully and frankly. I also confirm that these issues have been discussed with the student and will continue to be reviewed in the course of supervision.

Name: Michael Duncan..

Date: 30/05/2019 ....

Reviewer (if applicable)

Date of approval by anonymous reviewer: 31/05/2019

Medium to High Risk Research Ethics Approval Checklist

Project Information

Project Ref	P90462
Full name	Jiani Ma
Faculty	Faculty of Health and Life Sciences
Department	FRC CSELS (Sports, Exercise and Life Science)
Supervisor	Michael Duncan
Module Code	PhD-SELS
EFAAF Number	
Project title	Using Collective Intelligence Analysis to identify barriers to improving Fundamental Movement Skill(FMS) proficiency among children: A realist feasibility study of Skill-Ed scale-up
Date(s)	15/07/2019 - 15/03/2020
Created	08/05/2019 14:27

Project Summary

Skill-Ed was a Randomized Controlled Trial to improve adolescent girls' FMS through a school-based intervention delivered by teachers in Melbourne,Australia.Large effect size wasobserved.Although effective,an acknowledged limitation of the study was the lack of generalisation due to a primarily homogeneous sample.Therefore,a horizontal scale- up,whereby converting the original intervention to a version that can extend the reach by replicating it in another locality,will be conducted in the deprived area in Coventry,England.Evidenced by the previous FMS research,Coventry can provide research settings that are socioeconomically and ethnically diverse which is ideal to examine the interaction between stakeholders and contributing factors play in an intervention.There is an increasing trend of applying system sciences in intervention research.Collective Intelligence (CI) is one of the simulation approaches in system sciences may offer a unique solution to disentangle the complexity of an intervention.In this study,CI will assist in structuring and identifying the unique challenges in improving FMS proficiency among children with the stakeholders in the context of an intervention.

Names of Co-Investigators and their organisational affiliation (place of study/employer)	
Is the project self-funded?	YES
Who is funding the project?	Coventry University
Has the funding been confirmed?	YES
Are you required to use a Professional Code of Ethical Practice appropriate to your discipline?	NO

| Have you read the Code? | NO |

Project Details

What is the purpose of the project?	This developmental qualitative study uses the Collective Intelligence(CI) approach from system science to conduct a multi-level opinion gathering, aiming to inform the future Fundamental Movement Skill (FMS) intervention development as well as to optimize the Skill-Ed Coventry trial. Specifically, the following objectives will be addressed: 1. To gain insight into the barriers to increasing and sustaining FMS proficiency among children through issues prioritization using CI; 2. To identify solutions to overcome the pre-identified barriers through joint problem-solving using CI; 3. To refine logistical, strategic and content aspects of the Skill-Ed intervention through consultation with the target group; 4. To improve participant engagement in the forthcoming trial, ensuring the target group's commitment to the intervention aims.
What are the planned or desired outcomes?	In this study, CI will assist in structuring and identifying the unique challenges in improving FMS proficiency among children with the target group and stakeholders in the context of an intervention. Concurrently, it will also serve as a feasibility study through the co-production between the researchers and the public that has been exemplified in optimising and maximising the intervention functioning (Hawkins et al., 2017). Specifically, with the assist of ISM, various factors that have impacts on improving FMS proficiency and FMS interventions will be interpreted as to whether and how they are related. The ideas informing categories generated in the CI session and consultation results willbe used to address logistical (e.g., frequency, duration), strategic (i.e., recruitment and retention strategies) and

	content aspects of the Skill-Ed trial so they are more likely to be attractive and acceptable to the target population.
Explain your research design	This is a qualitative research using a modelling-based approach. CI is one of the simulation approaches in system science which may offer a unique solution to disentangle the complexity of an intervention. The CI process is a system of facilitation and problem solving that helps groups to develop outcomes that integrate contributions from individuals with diverse views, backgrounds and perspectives (Warfield, 1994). The key component of CI - Interpretive Structural Modelling (ISM) is a context free tool that can be applied in any complex situation (Janes, 1998) and has been applied in identifying and solving problems in public health research (Hogan et al., 2015). However, it has never been applied in the field of intervention development and evaluation or FMS research.
Outline the principal methods you will use	CI process, in the application, is a facilitated group discussion to generate, clarify, structure and interpret ideas around a specific complex issue. The first step in this study is to identify the individuals that will form the group in the CI sessions. According to Warfield (1976),the following three subgroups are needed to reach the optimal outcome of the session: a) Stakeholders who have a stake in the issues being considered; b) Content specialist who have specialized knowledge that is relevant to the issue; c)Structural modellers whose task is to structure the issue with the help of a computer software. In this study, we are going to invite the following participants via purposive sampling: a) four teachers from local schools. Teacher group will be a mix of PE teacher, general teacher and PE coach who are responsible for PE curriculum; b) four parents of 8-11 year old children with interest in improving children's health behaviour; c) four specialists in FMS and intervention research (with one specialist actively involving in the local community work) and d) the lead author and an assistant to facilitate the CI process.

	Two CI sessions will be conducted for a one day workshop, the provisional schedule is adapted from a previous study using CI analysis (Hogan et al., 2015) and described as following: 1. An introduction of basic concepts and methods of assessments of FMS and its related health outcomes including PA will be briefed to the group; 2. A stimulus question to participants will be presented: what are the barriers to improving FMS proficiency among children? 3. Nominal Group Technique (NGT; Delbecq et al., 1975) will be used for participants to write ideas on the post note individually. Guidelines will be provided for the writing of barrier statements. The assistant will facilitate the process to ensure each participant understand and complete the task as prescribed; 4. Barrier statements will be collated and categorized then presented on display walls; 5. Participants will be divided into two sub-groups and examine the categories. They are invited to add to their assigned categories of barriers if they feel key barriers remained which are not yet included; 6. In the second CI session, participants will be invited to generate solutions in response to these barriers using the NGT and presented on the idea wall; 7. With the assistance of ISM software, participants will be invited to select five ideas from the idea wall that they believe are the most important solutions to overcome the barriers;

	8.Participants will be invited to clarify their ideas and discuss with each other.
	9.10-15 most voted solutions will be rendered in ISM to identify the prioritization structure.
	10.In the final part of the session, an introduction and description of the Skill-Ed intervention design will be given to the group. An example of the online training platform designed for Coventry trial will be shown. A detailed plan of intervention implementation and delivery in Coventry will be given. In light of the final structure generated from Step 9, barriers to the delivery and implementation of Skill-Ed will be discussed and a set of practical recommendations will be collectively so

Are you proposing to use an external research instrument, validated scale or follow a published research method?		YES
If yes, please give details of what you are using	The prescribed Interpretive Structural Modelling will be implemented using a Windows software developed by Dr. Benjamin Broome and Dr. Michael Hogan.It is a free download software.	
Will your research involve consulting individuals who support, or literature, websites or similar material which advocates, any of the following: terrorism, armedstruggles, or political, religious or other forms of activism considered illegal under UK law?		NO
Are you dealing with Secondary Data? (e.g. sourcing info from websites, historical documents)		NO
Are you dealing with Primary Data involving people? (e.g. interviews, questionnaires, observations)		YES
Are you dealing with personal or sensitive data?		NO
Will the Personal or Sensitive data be shared with a third party?		
Will the Personal or Sensitive data be shared outside of the European EconomicArea ("EEA")?		
Is the project solely desk based? (e.g. involving no laboratory, workshop or off-campus work or other activities which pose significant risks to researchers or participants)		NO
Are there any other ethical issues or risks of harm raised by the study that have not been covered by previous questions?		NO
If yes, please give further details		

DBS (Disclosure & Barring Service) formerly CRB (Criminal Records Bureau)

Question		Yes	No
1	Does the study require DBS (Disclosure & Barring Service) checks?		X
	If YES, please give details of the serial number, date obtained and expiry date		
2	If NO, does the study involve direct contact by any member of the research team:		
	a) with children or young people under 18 years of age?		X
	b) with adults who have learning difficulties, brain injury, dementia, degenerative neurological disorders?		X
	c) with adults who are frail or physically disabled?		X
	d) with adults who are living in residential care, social care, nursing homes, re-ablement centres, hospitals or hospices?		X
	e) with adults who are in prison, remanded on bail or in custody?		X
	If you have answered YES to any of the questions above please explain the nature of that contact and what you will be doing		

External Ethical Review

Question		Yes	No
1	Will this study be submitted for ethical review to an externalorganisation? (e.g. Another University, Social Care, National Health Service, Ministryof Defence, Police Service and Probation Office)	X	
	If YES, name of external organisation	Deakin University	
2	Will this study be reviewed using the IRAS system?		
3	Has this study previously been reviewed by an external organisation?		

Confidentiality, security and retention of research data

	Question	Yes	No
1	Are there any reasons why you cannot guarantee the full security and confidentiality of any personal or confidential data collected for the study?		X
	If YES, please give an explanation		
2	Is there a significant possibility that any of your participants, and associated persons, could be directly or indirectly identified in the outputs or findings from this study?		X
	If YES, please explain further why this is the case		
3	Is there a significant possibility that a specific organisation or agencyor participants could have confidential information identified, as a result of the way you write up the results of the study?		X
	If YES, please explain further why this is the case		
4	Will any members of the research team retain any personal of confidential data at the end of the project, other than in fully anonymised form?		X
	If YES, please explain further why this is the case		
5	Will you or any member of the team intend to make use of any confidential information, knowledge, trade secrets obtained for any other purpose than the research project?		X
	If YES, please explain further why this is the case		
6	Will you be responsible for destroying the data after study completion?	X	
	If NO, please explain how data will be destroyed, when it will be destroyed and by whom		

Participant Information and Informed Consent

	Question	Yes	No
1	Will all the participants be fully informed BEFORE the project begins why the study is being conducted and what their participation will involve?	X	
	If NO, please explain why		
2	Will every participant be asked to give written consent to participating in the study, before it begins?	X	
	If NO, please explain how you will get consent from your participants. If not written consent, explain how you will record consent		
3	Will all participants be fully informed about what data will be collected, and what will be done with this data during and after the study?	X	
	If NO, please specify		
4	Will there be audio, video or photographic recording of participants?		X
	Will explicit consent be sought for recording of participants?		
	If NO to explicit consent, please explain how you will gain consent for recording participants		
5	Will every participant understand that they have the right not to take part at any time, and/or withdraw themselves and their data from the study if they wish?	X	
	If NO, please explain why		
6	Will every participant understand that there will be no reasons required or repercussions if they withdraw or remove their data from the study?	X	
	If NO, please explain why		
7	Does the study involve deceiving, or covert observation of, participants?		X
	Will you debrief them at the earliest possible opportunity?		
	If NO to debrief them, please explain why this is necessary		

Risk of harm, potential harm and disclosure of harm

	Question	Yes	No
1	Is there any significant risk that the study may lead to physical harm to participants or researchers?		X
	If YES, please explain how you will take steps to reduce or address those risks		
2	Is there any significant risk that the study may lead to psychological or emotional distress to participants?		X
	If YES, please explain how you will take steps to reduce or address those risks		
3	Is there any risk that the study may lead to psychological or emotional distress to researchers?		X
	If YES, please explain how you will take steps to reduce or address those risks		
4	Is there any risk that your study may lead or result in harm to the reputation of participants, researchers, or their employees, or any associated persons or organisations?		X
	If YES, please explain how you will take steps to reduce or address those risks		
5	Is there a risk that the study will lead to participants to disclose evidence of previous criminal offences, or their intention to commit criminal offences?		X
	If YES, please explain how you will take steps to reduce or address those risks		
6	Is there a risk that the study will lead participants to disclose evidence that children or vulnerable adults are being harmed, or at risk or harm?		X
	If YES, please explain how you will take steps to reduce or address those risks		
7	Is there a risk that the study will lead participants to disclose evidence of serious risk of other types of harm?		X
	If YES, please explain how you will take steps to reduce or address those risks		
8	Are you aware of the CU Disclosure protocol?	X	

Payments to participants

	Question	Yes	No
1	Do you intend to offer participants cash payments or any kind of inducements, or reward for taking part in your study?		X
	If YES, please explain what kind of payment you will be offering (e.g. prize draw or store vouchers)		
2	Is there any possibility that such payments or inducements will cause participants to consent to risks that they might not otherwise find acceptable?		
3	Is there any possibility that the prospect of payment or inducements will influence the data provided by participants in any way?		
4	Will you inform participants that accepting payments or inducements does not affect their right to withdraw from the study at any time?		

Capacity to give valid consent

	Question	Yes	No
1	Do you propose to recruit any participants who are:		
	a) children or young people under 18 years of age?		X
	b) adults who have learning difficulties, mental health condition, brain injury, advanced dementia, degenerative neurological disorders?		X
	c) adults who are physically disabled?		X
	d) adults who are living in residential care, social care, nursing homes, re-ablement centres, hospitals or hospices?		X
	e) adults who are in prison, remanded on bail or in custody?		X
	If you answer YES to any of the questions please explain how you will overcome any challenges to gaining valid consent		
2	Do you propose to recruit any participants with possible communication difficulties, including difficulties arising from limited use of knowledge of the English language?		X
	If YES, please explain how you will overcome any challenges to gaining valid consent		
3	Do you propose to recruit any participants who may not be able to understand fully the nature of the study, research and the implications for them of participating in it or cannot provide consent themselves?		X
	If YES, please explain how you will overcome any challenges to gaining valid consent		

Recruiting Participants

Question		Yes	No
1	Do you propose to recruit any participants who are:		
	a) students or employees of Coventry University or partnering organisation(s)?	X	
	If YES, please explain if there is any conflict of interest and how this will be addressed	There is no conflict of interest		
	b) employees/staff recruited through other businesses, voluntary or public sector organisations?		X
	If YES, please explain how permission will be gained			
	c) pupils or students recruited through educational institutions (e.g. primary schools, secondary schools, colleges)?		X
	If YES, please explain how permission will be gained			
	d) clients/volunteers/service users recruited through voluntary public services?		X
	If YES, please explain how permission will be gained			
	e) participants living in residential care, social care, nursing homes, re-ablement centres hospitals or hospices?		X
	If YES, please explain how permission will be gained			
	f) recruited by virtue of their employment in the police or armed forces?		X
	If YES, please explain how permission will be gained			
	g) adults who are in prison, remanded on bail or in custody?		X
	If YES, please explain how permission will be gained			
	h) who may not be able to refuse to participate in the research?		X
	If YES, please explain how permission will be gained			

Online and Internet Research

	Question	Yes	No
1	Will any part of your study involve collecting data by means of electronic media (e.g. the Internet, e-mail, Facebook, Twitter, online forums, etc)?		X
	If YES, please explain how you will obtain permission to collect data by this means		
2	Is there a possibility that the study will encourage children under 18 to access inappropriate websites, or correspond with people who pose risk of harm?		X
	If YES, please explain further		
3	Will the study incur any other risks that arise specifically from the use of electronic media?		X
	If YES, please explain further		
4	Will you be using survey collection software (e.g. BoS, Filemaker)?		X
	If YES, please explain which software		
5	Have you taken necessary precautions for secure data management, in accordance with data protection and CU Policy?	X	
	If NO	please explain why not		
	If YES	Specify location where data will be stored	Data will be stored on University's One Drive
		Planned disposal date	31/12/2021
		If the research is funded by an external organisation, are there any requirements for storage and disposal?		X
		If YES, please specify details		

Languages

Question		Yes	No
1	Are all or some of the consent forms, information leaflets and research instruments associated with this project likely to be used in languages other than English?		X
	If YES, please specify the language[s] to be used		
2	Have some or all of the translations been undertaken by you or a member of the research team?		
	Are these translations in lay language and likely to be clearly understood by the research participants?		
	Please describe the procedures used when undertaking research instrument translation (e.g. forward and back translation), clarifying strategies for ensuring the validity and reliability or trustworthiness of the translation		
3	Have some or all of the translations been undertaken by a third party?		
	If YES, please specify the name[s] of the persons or agencies performing the translations		
	Please describe the procedures used when undertaking research instrument translation (e.g. forward and back translation), clarifying strategies for ensuring the validity and reliability of the translation		

Laboratory/Workshops

	Question	Yes	No
1	Does any part of the project involve work in a laboratory or workshop which could pose risks to you, researchers or others?		X
	If YES: If you have risk assessments for laboratory or workshop activities you can refer to them here & upload them at the end, or explain in the text box how you willmanage those risks		

Research with non-human vertebrates

	Question	Yes	No
1	Will any part of the project involve animal habitats or tissues or non-human vertebrates?		X
	If YES, please give details		
2	Does the project involve any procedure to the protected animal whilstit is still alive?		
3	Will any part of your project involve the study of animals in their natural habitat?		
	If YES, please give details		
4	Will the project involve the recording of behaviour of animals in a non-natural setting that is outside the control of the researcher?		
	If YES, please give details		
5	Will your field work involve any direct intervention other than recording the behaviour of the animals available for observation?		
	If YES, please give details		
6	Is the species you plan to research endangered, locally rare or part ofa sensitive ecosystem protected by legislation?		
	If YES, please give details		
7	Is there any significant possibility that the welfare of the target species of those sharing the local environment/habitat will be detrimentally affected?		
	If YES, please give details		
8	Is there any significant possibility that the habitat of the animals will be damaged by the project, such that their health and survival will be endangered?		
	If YES, please give details		
9	Will project work involve intervention work in a non-natural setting in relation to invertebrate species other than Octopus vulgaris?		
	If YES, please give details		

Blood Sampling / Human Tissue Analysis

	Question	Yes	No
1	Does your study involve collecting or use of human tissues or fluids? (e.g. collecting urine, saliva, blood or use of cell lines, 'dead' blood)		X
	If YES, please give details		
2	If your study involves blood samples or body fluids (e.g. urine, saliva) have you clearly stated in your application that appropriate guidelines are to be followed (e.g. The British Association of Sport and Exercise Science Physiological Testing Guidelines (2007) or equivalent) and that they are in line with the level of risk?		
	If NO, please explain why not		
3	If your study involves human tissue other than blood and saliva, have you clearly stated in your application that appropriate guidelines are to be followed (e.g. The Human Tissues Act, or equivalent) and that they are in line with level of risk?		
	If NO, please explain why not		

Travel

Question		Yes	No
1	Does any part of the project require data collection off campus? (e.g. work in the field or community)		X
	If YES: You must consider the potential hazards from off campus activities (e.g. working alone, time of data collection, unfamiliar or hazardous locations, using equipment, the terrain, violence or aggression from others). Outline the precautions that will be taken to manage these risks, AS A MINIMUM this must detail how researchers would summon assistance in an emergency when working off campus. For complex or high risk projects you may wish to complete and upload a separate risk assessment		
2	Does any part of the project involve the researcher travelling outside the UK (or to very remote UK locations)?		
	If YES: Please give details of where, when and how you will be travelling. For travel to high risk places you may wish to complete and upload a separate risk assessment		
3	Are all travellers aware of contact numbers for emergency assitance when away (e.g. local emergency assistance, ambulance/local hospital/police, insurance helpline [+44 (0) 2071 737797] and CU's 24/7 emergency line [+44 (0) 2476 888555])?		
4	Are there any travel warnings in place advising against all, or essential only travel to the destination? NOTE: Before travel to countries with 'against all travel', or 'essential only' travel warnings, staff must check with Finance to ensure insurance coverage is not affected. Undergraduate projects in high risk destinations will not be approved		
5	Are there increased risks to health and safety related to the destination? e.g. cultural differences, civil unrest, climate, crime, health outbreaks/concerns, and travel arrangements?		
	If YES, please specify		
6	Do all travelling members of the research team have adequate travel insurance?		
7	Please confirm all travelling researchers have been advised to seek medical advice regarding vaccinations, medical conditions etc, from their GP		

Medium Risk Research Ethics Approval

Project title

A two-arm pragmatic non-randomised trial assessing strategies for improving theimplementation of Project FLAME

Record of Approval

Principal Investigator

I request an ethics peer review and confirm that I have answered all relevant questions in this checklist honestly.	X
I I confirm that I will carry out the project in the ways described in this checklist. I will immediately suspend research and request new ethical approval if the project subsequently changes the information I have given in this checklist.	X
I confirm that I, and all members of my research team (if any), have read and agreed to abide by the Code of Research Ethics issued by the relevant national learned society.	X
I confirm that I, and all members of my research team (if any), have read and agreed to abide by the University's Research Ethics, Governance and Integrity Framework.	X
I understand that I cannot begin my research until this ethics application has been approved.	X

Name: Jiani Ma (PhD-SELS)

Date: 18/12/2020

Student's Supervisor (if applicable)

I have read this checklist and confirm that it covers all the ethical issues raised by this project fully and frankly.I also confirm that these issues have been discussed with the student and will continue to be reviewed in the course of supervision.

Name: Prof. Michael Duncan

Date: 16/12/2020

Reviewer (if applicable)

Date of approval by anonymous reviewer: 18/12/2020

Medium Risk Research Ethics Approval Checklist

Project Information

Project Ref	P116006
Full name	Jiani Ma
Faculty	Faculty of Health and Life Sciences
Department	FRC CSELS (Sports, Exercise and Life Science)
Supervisor	Prof. Michael Duncan
Module Code	PhD-SELS
EFAAF Number	
Project title	A two-arm pragmatic non-randomised trial assessing strategies for improving the implementation of Project FLAME
Date(s)	31 Jan 2021 - 31 Dec 2021
Created	09/12/2020 10:03

Project Summary

This is a mixed methods study comprising of school physical education teachers and students in their uptake and engagement with the Project FLAME intervention, in Cork, Ireland.

Names of Co-Investigators and their organisational affiliation(place of study / employer)	Wesley O'Brien (University College Cork), Diarmuid Lester (University College Cork), Conor Philpott (University College Cork), Lisa Barnett (Deakin University), Natalie Lander (Deakin University), Harriet Koorts (Deakin University)
Is this project externally funded?	No
Are you required to use a Professional Code of Ethical Practice appropriate to your discipline?	No
Have you read the Code?	No

Project Details

What are the aims and objectives of the project?	Project FLAME is a well-developed intervention programme aiming to improve Irish adolescents' movement competence and has recently been trialed in controlled conditions. This study aims to develop, select and evaluate implementation strategies to improve the uptake of and engagement with Project FLAME in a naturalistic setting. Following are three study objectives: Objective 1: To evaluate teacher's self-efficacy on delivering and implementing Project FLAME intervention activities in physical education (e.g., teaching fundamental movement skills). Objective 2: To evaluate adolescent and teacher engagement in and adherence to the Project FLAME intervention. Objective 3: To evaluate the acceptability and feasibility of the implementation strategies to inform further the refinement of Project FLAME.
Explain your research design	Participants in this study will be students and teachers from post-primary schools in the Cork area. Prior to commencing data collection, the leading researchers will visit or electronically meet the school principals and the liaison PE teacher(s) in each participating school, where a full briefing of the data collection process will be outlined. Subsequent to the granted approval from school principals, consent forms and information sheets will be distributed to each respective student class group and eligible teacher. Informed parental/guardian consent and child assent will be required to partake in the study. Schools and participants will be informed that participation will be entirely voluntary, and that they are free to withdraw of their own volition at any time. This study will adopt a mixed methods design based on the UK Medical Research Council recommendations. A total of four evaluation domains were identified: (1) fidelity and adaptations (e.g., students and teachers' adherence to the intervention); (2) participant responsiveness (e.g., students and teachers' engagement with the intervention); (3) teacher's self-efficacy in implementing the intervention; (4) acceptability and feasibility (e.g., teacher and students' perceived benefits and practicality of intervention activities)

Outline the principal methods you will use	Quantitative data will be collected before and after six-week trial period with PE teachers, after six-week with students with the use of online surveys. Web analytics data will be collected throughout the six-week trial period to track students and teachers' engagement with the resources. Qualitative data will be collected with teachers after six-week trial period. Recordings, transcripts and web analytic results will be stored in an anonymised electronic format.

Are you proposing to use a validated scale or published research method / tool?	No
Does your research seek to understand, identify, analyse and/or report on information on terrorism or from terrorist organisations, require access to terrorist groups or those convicted of terrorist offences or relate to terrorism policies in other international jurisdictions?	No
Does your research seek to understand, identify, analyse and/or report on information for other activities considered illegal in the UK and/or in the country you are researching in?	No
Are you dealing with Secondary Data? (e.g. sourcing info from websites, historical documents)	No
Are you dealing with Primary Data involving people? (e.g. interviews,questionnaires, observations)	Yes
Are you dealing with personal data?	Yes
Are you dealing with sensitive data (special category data)?	No
Will the Personal or Sensitive data be shared with a third party?	Yes
Will the Personal or Sensitive data be shared outside of the European Economic Area(EEA)?	No
Is the project solely desk based? (e.g. involving no laboratory, workshop or offcampus work or other activities which pose significant risks to researchers or participants)	No
Will the data collection, recruitment materials or any other project documents be in any language other than English?	No
Are there any other ethical issues or risks of harm raised by the study that have notbeen covered by previous questions?	No

DBS (Disclosure & Barring Service) formerly CRB (Criminal Records Bureau)

	Question	Yes	No
1	Does the study require DBS (Disclosure & Barring Service) checks?		X
	If YES, Please give details of the level of check, serial number, date obtained and expiry date (if applicable)		
2	If NO, does the study involve direct contact by any member of the research team:		
	a)　　with children or young people under 18 years of age?		X
	b)　　with adults who have learning difficulties, brain injury, dementia,degenerative neurological disorders?		X
	c)　　with adults who are frail or physically disabled?		X
	d)　　with adults who are living in residential care, social care, nursing homes, re - ablement centres, hospitals or hospices ?		X
	e)　　with adults who are in prison, remanded on bail or in custody?		X
	If you have answered YES to any of the questions above please explain the nature of that contact and what you will be doing		

External Ethics Review

Question		Yes	No
1	Will this study be submitted for ethical review to an external organisation ? (e.g.Another University, Social Care, National Health Service, Ministry of Defence, Police Service and Probation Office)	X	
	If YES, name of external organisation University College Cork, Deakin University		
2	Will this study be reviewed using the IRAS system?		X
3	Has this study previously been reviewed by an external organisation?		X

Confidentiality, security and retention of research data

	Question		Yes	No
1	What data are you collecting / using / recording?	Recordings of interviews will be collected with PE teachers. Quantitative data will be collected through questionnaires and web analytics with teachers and students. Demographic information of participants, such as gender, age, education, and years of teaching experience will be collected. Participant's namewill not be collected.		
2	Are there any reasons why you cannot guarantee the full security and confidentiality of any personal or confidential data collected for the study?			X
	Please provide an explanation	No. Anonymity and confidentiality of participants will be protected through the entireresearch process. I qualitative data will be transcribed verbatim by the student researcher (Miss JIANI MA) and anonymised to protect theidentities and views of the participants. All datawill be re-identifiable. All identifiers will be removed from the data after data collection. All participants will be assigned a unique ID number, which will correspond across all instruments and time points used to collect data. In reporting results, no names or identifiable details will be included.		
3	Is there a significant possibility that any of your participants, and associated persons, could be directly or indirectly identified in the outputs or findings from this study?			X
	Please provide an explanation	No, data will be viewed and analysed within the research team in an anonymised electronic format. Therefore, no identifiable information will be included in the outputs and findings from this study.		
4	Is there a significant possibility that a specific organisation or agency or participants could have confidential information identified, as a result of the way you write up the results of the study?			X
	Please provide an explanation	No, all schools and teachers recruited will be anonymised hence non-identifiable.		
5	Will any members of the research team retain any personal of confidential data at the end of the project, other than in fully anonymised form?			X
	Please provide an explanation	We do not intend to retain or reuse any data at the end of this project.		
6	Will you or any member of the team intend to make use of any confidential information, knowledge, trade secrets obtained for any other purpose than the research project ?			X
	Please give an explanation	No. Results from this research will be used for research purposes only.		
7	Have you taken necessary precautions for secure data management, in accordance with data protection and CU Policy		X	

8	Specify location (physical and electronic) where data will be stored	As the primary location of data collection is in Cork, Ireland, data will be stored on encrypted University College Cork (UCC) OneDrive system and subsequently on the UCC server. All signed consent forms should be stored in a secure location under lock and key on UCC campus.		
9	Will you be responsible for destroying the data after study completion?		X	
	If NO, who will be responsible for this?			
	Please explain how any identifiable and anonymous data will be destroyed	The complete dataset will be securely stored for a minimum of ten years and then destroyed.		
	Planned disposal date	31 Dec 2030		

Participant Information and Informed Consent

	Question	Yes	No
1	Will all the participants be fully informed BEFORE the project begins why the study is being conducted and what their participation will involve ?	X	
	Please explain why		
2	Will every participant be asked to give written consent to participating in the study, before it begins ?	X	
	If NO, please explain how you will get consent from your participants.If not written consent, explain how you will record consent		
3	Will all participants be fully informed about what data will be collected, and what will be done with this data during and after the study ?	X	
	If NO, please specify		
4	Please explain what recordings (audio, visual or both) will be made and how you will gain consent for recording participants	Audio recordings will be made with teachers in this study. This will be given in participant information sheet and consent form.	
5	Will all participants understand that they have the right not to take part at any time, and/or withdraw themselves and their data from the study if they wish?	X	
	If NO, please explain why		
6	Will every participant understand that there will be no reasons required or repercussions if they withdraw or remove their data from the study?	X	
	If NO, please explain why		
7	Does the study involve deceiving, or covert observation of, participants ?		X
	Will you debrief them at the earliest possible opportunity?		
	If NO to debrief them, please explain why this is necessary		

Payments to participants

	Question	Yes	No
1	Do you intend to offer participants cash payments or any kind of inducements, or reward for taking part in your study ?		X
	If YES, please explain what kind of payment you will be offering(e.g.prize draw or store vouchers)		
2	Is there any possibility that such payments or inducements will cause participants to consent to risks that they might not otherwise find acceptable ?		
	If YES, please explain)		
3	Is there any possibility that the prospect of payment or inducements will influence the data provided by participants in any way ?		
	If YES, please explain)		
4	Will you inform participants that accepting payments or inducements does not affect their right to withdraw from the study at any time ?		

Capacity to give valid consent

Question		Yes	No
1	Do you propose to recruit any participants who are:		
	a) children or young people under 18 years of age?	X	
	b) adults who have learning difficulties, mental health conditions, brain injury, advanced dementia, degenerative neurological disorders ?		X
	c) adults who are physically disabled and cannot provide written and/or verbal consent		X
	d) with adults who are living in residential care, social care, nursing homes, reablement centres, hospitals or hospices ?		X
	e) with adults who are in prison, remanded on bail or in custody?		X
	If you have answered YES to any of the questions above please explain overcome any challenges to gaining valid consent	Informed parental/guardian consent and child assent will be required to partake in the study. Schools and participants will be informed that participation will be entirely voluntary, and that they are free to withdraw of their own volition at any time.	
2	Do you propose to recruit any participants with possible communication difficulties, including difficulties arising from limited use of knowledge of the English language ?		X
	If YES, please explain how you will overcome any challenges to gaining valid consent		
3	Do you propose to recruit participants who may not be able to fully understand the nature of the study, the foreseen implications or cannot provide consent?		X
	If YES, please explain how you will overcome any challenges to gaining valid consent		

Recruiting Participants

	Question		Yes	No
1	Who are the participants?	Participants in this study will be students and teachers from post-primary schools in the Cork area. To be eligible, schools must (1) have not previously participated in the Project FLMAE non-randomised or randomised controlled trials, (2) not be currently participating in any other intervention aimed at physical activity behaviours and movement competence, (3) have internet access. To be eligible, teachers must be qualified post-primary school Physical Education (PE) Teacher, have a minimum of one PE class per week to Junior Cycle students in post-primary schools, have access to an indoor or outdoor PE space for pedagogical delivery. To be eligible, students must: have given signed assent alongside consent from their parent/guardian for participation in the study, have access to the internet outside of school (e.g. a mobile device with data or Wi-Fi at home).		
2	How are participants being recruited? Please provide details on all methods of recruitment you intend to use	Prior to commencing data collection, researchers from the collaborating institution (UCC) will visit or electronically meet the school principals and the liaison PE teacher(s) in each participating school, where a full briefing of the data collection process will be outlined. Subsequent to the granted approval from school principals, consent forms and information sheets will be distributed to each respective student class group and eligible teacher. Coventry researchers will not visit schools for recruitment. Informed parental/guardian consent and child assent will be required to partake in the study. Schools and participants will be informed that participation will be entirely voluntary, and that they are free to withdraw of their own volition at any time. In terms of the research rigour inherent to school-based measurements, it is important to note that the principal Investigators for this study are all qualified secondary school specialist PE teachers, as recognized by the Teaching Council of Ireland.		
3	Do you foresee any conflict of interest?			X
	Please explain how will this conflict of interest be addressed			

Online and Internet Research

	Question	Yes	No
1	Will any part of your project involve collecting data via the internet or social media?	X	
	If YES, please explain how you will obtain permission to collect data by these means	Online questionnaires using MS Forms will have a "force response question" whereby participants will not be able to proceed until indicating that they understand and consent. When participants register and log in the website (for web analytics) for the first time, a "force response questions" whereby participants will be informed that the usage andengagement with the website would be recorded, participants will be given choice to opt out.	
2	Will this require consent to access?		X
	If NO, please explain how you will get permission/ consent' to collect this information?		
3	Will you be collecting data using an online questionnaire/ survey tool? (e.g. BoS, Filemaker)?	X	
	If YES, please explain which software and how you are ensuring appropriate data security	An online survey platform (MS Form) will be used. The level of perceived privacy of the online community will be high. Involvement in the research will be completely voluntary. The relevant links to the online surveys and access to online platforms will be distributed to a closed group requiring registration. The website/online platform used will have privacy and data protection notice and all researchers will be cognisant of when using.	
4	Is there a possibility that the study will encourage children under 18 to access inappropriate websites, or correspond with people who pose risk of harm ?		X
	If YES, please explain further		
5	Will the study incur any other risks that arise specifically from the use of electronic media ?		X
	If YES, please explain further		

Information gathered from human participants

Question		Yes	No
Primary			
1	Does your project involve primary data collection from human participants via questionnaires, focus groups, interviews, psychological tests, photography/videography etc.?	X	
	If YES, Please detail the information to be collected and methods that will be used. Quantitative data will be collected before and after six-week trial period with PE teachers, after six-week trial period with students. Web analytics data will be collected throughout the six-week trial period.		
2	Is there the possibility of physical or psychological harm to the researcher(s) or the participants?		X
	If YES, please explain the possible harm and action taken to reduce/remove the risk		
3	Are any specific exclusions needed to prevent possible harm to participants (e.g. excluding people with known mental health problems)?		X
	If YES, please explain exclusions needed and how these will be carried out		
4	Are any of the questionnaires or other tests being used in the research diagnostic for specific clinical conditions?		X
	If YES, Please explain how you will take steps to reduce or address these risks		