Conceptual development: How do early educators and teachers support children's early thinking in STEM?

Laureate Professor Marilyn Fleer
Monash University

https://doi.org/10.37517/978-1-74286-715-1-15

Laureate Professor Marilyn Fleer holds the Foundation Chair of Early Childhood Education and Development at Monash University. She was awarded the 2018 Kathleen Fitzpatrick Laureate Fellowship by the Australian Research Council and was a former President of the International Society of Cultural-historical Activity Research (ISCAR). Additionally, she holds the positions of Honorary Research Fellow in the Department of Education, University of Oxford, and a second professorial position in the KINDKNOW Centre, Western Norway University of Applied Sciences. Marilyn has been bestowed the title of Honorary Professor at the Danish School of Education, Aarhus University. She was presented with the 2019 Ashley Goldsworthy Award for outstanding leadership in university–business collaboration, and was recently elected as a fellow of the Australian Academy of Social Sciences, and inducted into the Honour Roll of Women in Victoria as a change agent.

Abstract

As national and state-based reforms in early education roll out across Australia, concern for building a well-qualified workforce to meet growing demand has intensified. In parallel with the reforms, teachers and educators are reminded by the recently released 2022 Early Years Learning Framework to design programs that support intentionality in play-based learning. However, the literature shows that despite the concept of intentional teaching being around since 2009, difficulties with how to do this remain. This presentation takes up this challenge, by 1) sharing the collective findings of 6 Australian Research Council–funded research projects into play and learning in STEM; and 2) presenting an evidence-informed model of a Conceptual PlayWorld that resulted from this foundational research. The model is currently being released across Australia (and internationally) to support educators and teachers to create the conditions for conceptual development in children's play. The model will be shared via video recordings alongside findings from a spectrum of research that has been funded through the ARC Laureate Fellowship Scheme over 5 years.

Introduction

As national and state-based reforms in early education roll-out across Australia, concern for building a well-qualified workforce to meet growing demand has intensified. In parallel with the reforms, teachers and educators are reminded by the recently released 2022 Early Years Learning Framework (Australian Children's Education and Care Quality Authority, 2022) to design programs that support intentionality in play-based learning. However, the literature shows that despite the concept of intentional teaching having been around since 2009, difficulties with how to do this remain. This paper takes up this challenge by briefly describing the development of an evidence-informed model called a Conceptual PlayWorld, followed by an explanation of this model as an intervention for amplifying STEM learning. The paper concludes with examples of practices shown in websites across range of platforms and advocates for research-informed teaching.

The development of an evidence-informed model

We know from extensive research into the intentional teaching of concepts in early childhood settings across a broad range of discipline areas, that teachers struggle with how to plan for bringing concepts into play-based settings. This is evident in mathematics (for example, Disney & Li, 2022), in science (for example, Fleer, 2017), and in engineering (for example, Fleer, 2020a). What these studies generally show is that teachers do not feel confident (MacDonald et al., 2021) or competent (Stephenson et al., 2021) in their knowledge of the concepts they wish to intentionally teach. Surprisingly, this problem has been reported in the literature for over 3 decades (Garbett, 2003). However, the central problem remains alive and well within early childhood education practices across countries (Fleer, 2021a; Ma et al., 2023). So why has this problem been so persistent? We suggest that the problem has been conceptualised in relation to the 'person' rather than the system in which the 'teacher' is embedded.

When the problem is conceptualised within a system, the focus moves from the person and their confidence and competence, to an examination of the tools and resources available to teachers to intentionally teach STEM concepts in play-based programs.

With this premise in mind, the problem of how to bring concepts into children's play was tackled through a series of Australian Research Council–funded projects. Table 1 captures a summary of that research over time. Column 1 shows the years and grant type 2005–23; Column 2 shows the study; and Column 3 shows how the outcomes have collectively built an evidence-informed model called a Conceptual PlayWorld for the teaching of STEM in early childhood settings.

This research was funded by the Australian Research Council (ARC), which is Australia's most prestigious research funding body, and where all applications are rigorously peer reviewed and only the highest quality proposals are funded. The Discovery Project (DP) scheme is designed to support blue-sky research and the Linkage Projects (LP) brings researchers and industry partners together to solve pressing problems. The Laureate Fellowship (FL) scheme supports the top researchers in Australia to take ground-breaking research forward.

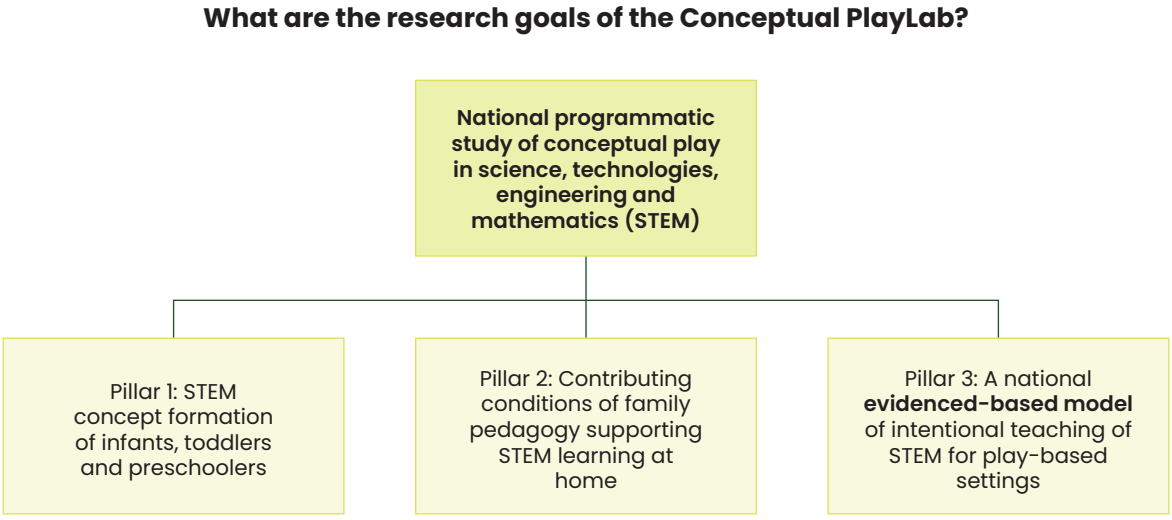
Table 1 Summary of ARC DP programmatic research over time: How to design STEM learning through play

ARC DP	**Programmatic research over time: How to design motivating STEM learning through play**	
DP 5	The sociocultural construction of science learning. Learning of **scientific concepts within situated playful encounters** in early years context	Conceptual play
DP 11	**Conceptual play**: Foregrounding imagination and cognition during concept formation in early years science education	Affective imagination
DP 13	**Affective imagination** in scientific education: Exploring the emotional nature of scientific and technological learning and engaging children and teachers	Digital play
DP 14	An investigation into the relations between **imaginary situations** and scientific abstraction in preschool digital play	Conceptual PlayWorlds
DP 18	**PlayWorlds**: Researching development of executive functions (working memory, emotion regulation, planning and cognitive flexibility)	Motivating conditions for EF
DP 18	**Conceptual PlayWorlds**: Researching play, imagination and science teaching	PD model for multimodal learning of CPW
FL 18–23	This programmatic study is researching imagination in play and imagination in science, engineering and technology. Building a world-class research program and research capacity in science, engineering and technologies education.	Ongoing

DP, Discovery Project; LP, Linkage Projects; FL, Laureate Fellowship

Over the past 5 years, a Conceptual PlayWorld model has been central to the intervention research (Row 7) that is currently being funded by the Australian Research Council Laureate Fellowship scheme. Our team of researchers in the Conceptual PlayLab are tackling the problem of STEM in early childhood through programmatic research. Figure 1 summarises the programmatic research.

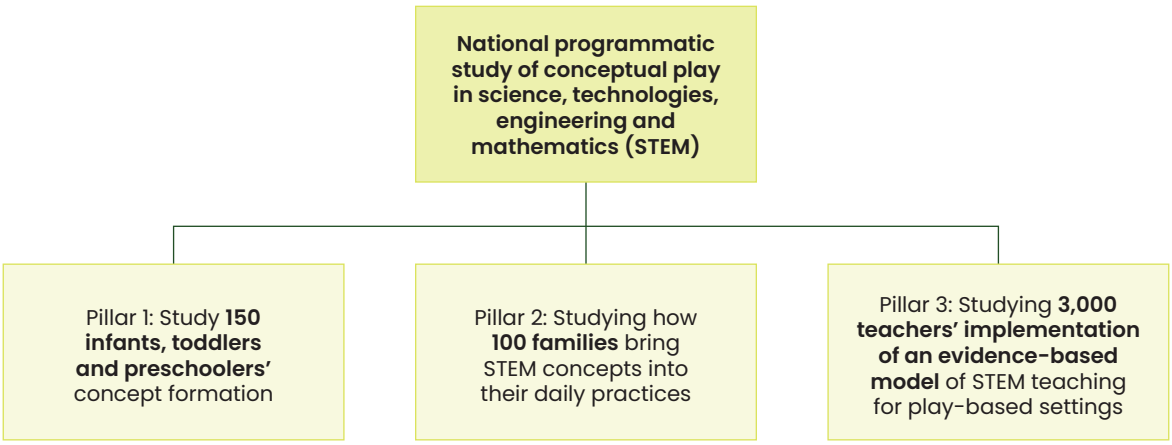
Figure 1 Overview of the goals of the programmatic research of the PlayLab



The programmatic research to date has generated data between 2019 and 2023 and is expected to conclude in 2024.

This paper gives an overview of the programmatic research, the data types and quantities generated to date, and what research has progressively rolled out in relation to the intentional teaching of STEM concepts from birth to 11 years (see Figure 2).

Figure 2 Study design of the programmatic research of the PlayLab



The research was expanded in 2022–23 to include the primary school sector because of demand from practice to bring into schooling playful learning to engage children and excite them to learn STEM concepts.

There are 3 pillars of research that focus on conceptual learning of children (Pillar 1), the engagement of STEM learning by families at home and in the community (Pillar 2), and the teachers' intentional teaching of STEM (Pillar 3).

For Pillar 1, the research has yielded an accumulation of digital data constituting 262.5 hours gathered through more than 85 site visits during 2018–23. Researchers visited 4 sites, 15 rooms (childcare, preschool and school) and 14 teachers . While the total of children is still to be added, we estimate that overall 210 children were involved in this part of the research. This builds on the pre-2019 base research, which gathered 890 hours of digital data. Both teachers and educators used a Conceptual PlayWorld model of teaching to create imaginary play situations for children aged from 0.5 months to 12 years. Data gathering continues through 2023.

For Pillar 2, 79 children and families were involved in the research, which generated an accumulated 117 hours 11 minutes of digital data between 2020 and 2023 across 8 sites (Conceptual PlayWorld live Zoom sessions, family homes, playgroups, the Royal Botanical Gardens). More than 80 Zoom sessions were recorded and over 30 on-site data collection visits were conducted. Additionally, the Makerspace Conceptual PlayWorlds will be implemented in playgroups in late 2023. It is anticipated that there will be 20 sessions with approximately 200 families to generate approximately 30 hours of data. In total there are 150 families and a total of 140 hours of digital data expected.

For Pillar 3, there were 3 kinds of professional development delivery. These involved the completion of pre- and post-surveys associated with intentional teaching of a Conceptual PlayWorld and teacher confidence and competence in STEM. The first approach involved teachers completing a self-paced online professional development set of modules. The second involved Zoom delivery of a one-hour presentation explaining the Conceptual PlayWorld model, followed by one-hour break-out rooms to workshop teacher-designed Conceptual PlayWorlds using a planning proforma, which were then implemented over a 10-week period with support via a private FaceBook group, leading to a recorded interview-oriented sharing session via Zoom. The third approach was a mixed methods on-site delivery of professional development (PD) with follow-up interviews via Zoom. A total of 1773 teachers have participated in one of these delivery modes to date.

Conceptual PlayWorld as an intervention for amplifying STEM learning

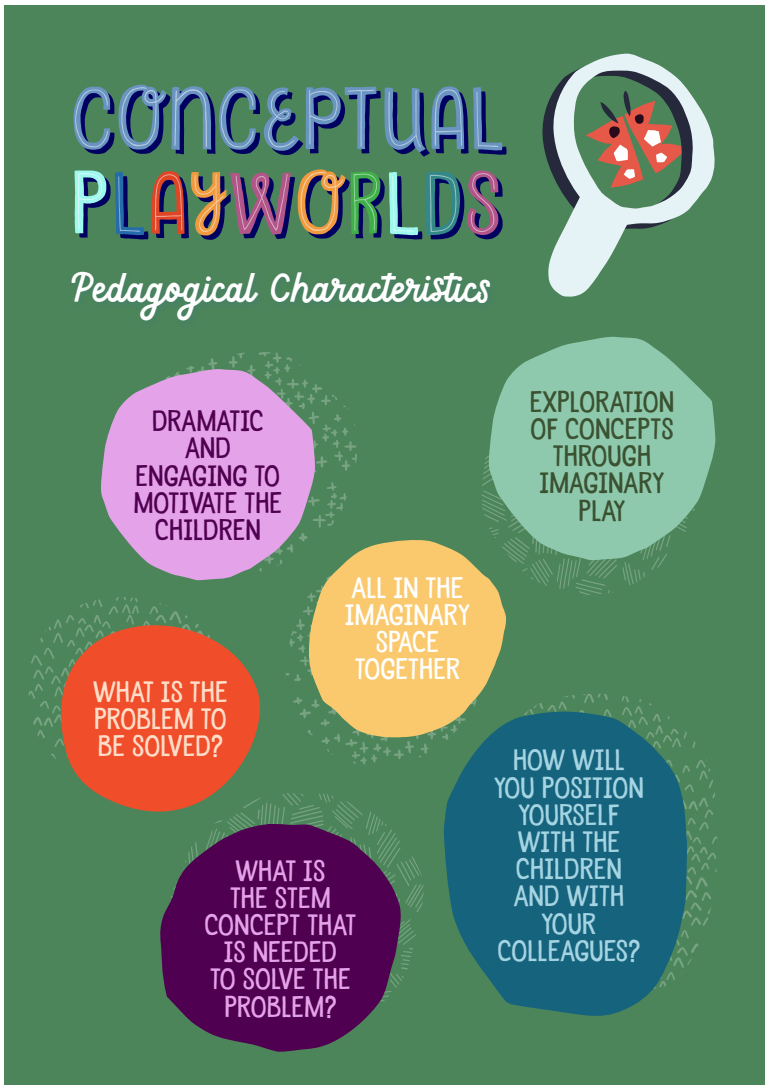
In 2011, a model of play was identified from research (see Table 1) called Conceptual play (Fleer, 2011). This form of play underpins the pedagogical model of practice of the Conceptual PlayWorld (Fleer, 2018). But knowing this was not enough to effect change in the intentional teaching of STEM concepts in play-based settings (Fleer et al., 2021). Further research was undertaken (Fleer, 2019a), which drew upon Vygotsky (1966) and Lindqvist's (1995) cultural-historical model of play for bringing drama and development in children's play. But Lindqvist's model and the foundational research undertaken over a full year of data collection into the aesthetics of play did not focus on concept development (Fleer, 2020b). However, we found that her model was helpful in planning an educational experiment (Hedegaard 2008; Fleer, 2021a) where it was possible to identify the motivating characteristics of imaginary play and the learning of STEM (Fleer, 2019a; 2021b). This ultimately led to the identification of how the 5 key pedagogical characteristics changed teacher practices. Conceptual PlayWorld (Fleer, 2018) became important for subsequent research into the intentional teaching of STEM concepts from birth to 5 years (for example, Fragkiadaki et al., 2021; Stephenson et al., 2021; Utami et al., 2020).

The 5 planning characteristics that acted as our intervention are:

1. selecting an engaging story
2. creating an imaginary Conceptual PlayWorld space
3. teachers and children entering and exiting the Conceptual PlayWorld together
4. problems arise in the Conceptual PlayWorld that need to be solved using concepts
5. teachers take different roles in the Conceptual PlayWorld to actively support children's play development through subject positioning.

When these characteristics are implemented in practice, they are all interconnected as is shown in Figure 3.

Figure 3 The interconnected nature of a Conceptual PlayWorld for the intentional teaching of STEM in the early years (Copyright PlayLab)



The following tables with their website addresses showcase examples of the practices that are unique across different age periods. Collectively, these tables show how the 5 characteristics remain, but when implemented into teachers' practice, they bring forward the unique development of the children.

Table 2 Early years of school

Characteristic	A Conceptual PlayWorld of *Charlotte's web* by E. B. White (Copyright PlayLab)
1. Selecting an engaging story	https://www.youtube.com/watch?v=7OKAHPErmvY
2. Creating an imaginary Conceptual PlayWorld space	https://youtu.be/JxkRG54L4rg
3. Teachers and children entering and exiting the Conceptual PlayWorld together	https://youtu.be/ImKzH02-v1o
4. Problems arise in the Conceptual PlayWorld that need to be solved	https://youtu.be/C6MMblawmJA
5. Teachers take different roles in the Conceptual PlayWorld to actively support children's play development through subject positioning	https://youtu.be/30I_BeqmjYU

Table 3 Preschool period

Characteristic	A Conceptual PlayWorld of *Rosie's walk* by Pat Hutchins (Copyright PlayLab)
1. Selecting an engaging story	https://youtu.be/yRbq7T0W4g4
2. Creating an imaginary Conceptual PlayWorld space	https://youtu.be/ASFU0Itk-Ts
3. Teachers and children entering and exiting the Conceptual PlayWorld together	https://youtu.be/zXgFO7tGWYE
4. Problems arise in the Conceptual PlayWorld that need to be solved	https://youtu.be/XBInamq2FFk
5. Teachers take different roles in the Conceptual PlayWorld to actively support children's play development through subject positioning	https://youtu.be/9ww_xOqZXwI

Table 4 Infants and toddlers

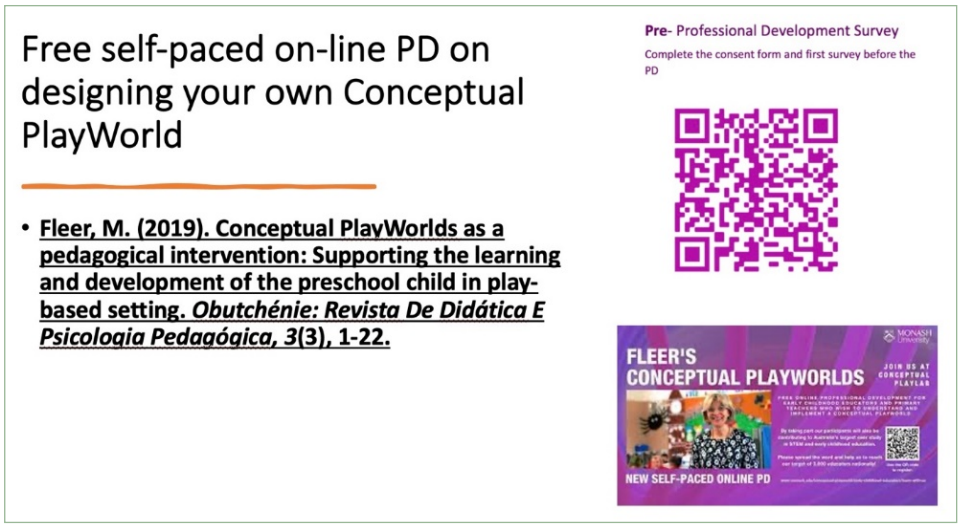
Characteristic	A Conceptual PlayWorld of *March of the ants* by Ursula Dubosarsky (Copyright PlayLab)
1. Selecting an engaging story	https://youtu.be/oeR8kBfQ8SQ
2. Creating an imaginary Conceptual PlayWorld space	https://youtu.be/V9XrP8TCQrQ
3. Teachers and children entering and exiting the Conceptual PlayWorld together	https://youtu.be/1LZoaphpvzk
4. Problems arise in the Conceptual PlayWorld that need to be solved	https://youtu.be/RGFl3sWq91w
5. Teachers take different roles in the Conceptual PlayWorld to actively support children's play development through subject positioning	https://youtu.be/8qne1aC_xSo

Our research showed that when teachers used a Conceptual PlayWorld model to plan and implement their programs, it did not change their practices (Fleer et al., 2021), but the conditions changed dramatically for children (Fleer, 2021b), particularly for girls (Stephenson et al., 2021).

Conclusion

The research is ongoing and as we bring forward the results, the findings will continue to be showcased on our website as a series of working papers. On a continuing basis, the research outcomes will be translated into videos of practices, and these can be found on our YouTube channel. Finally, the self-paced online PD remains available for teachers (Figure 4). In doing this PD, teachers are not just learning about how to plan and implement an evidence-informed model of practice, but they are contributing to generating new knowledge to support other teachers in the intentional teaching of STEM concepts in the early years.

Figure 4 Self-paced professional development



References

Australian Children's Education and Care Quality Authority. (2022). *Belonging, being and becoming: The Early Years Learning Framework for Australia (V2.0)*. Australian Government Department of Education for the Ministerial Council.

Disney, L., & Li, L. (2022). Above, below, or equal? Exploring teachers' pedagogical positioning in a playworld context to teach mathematical concepts to preschool children. *Teaching and teacher education, 114,* 103706. https://doi.org/10.1016/j.tate.2022.103706

Fleer, M. (2011). 'Conceptual Play': Foregrounding imagination and cognition during concept formation in early years education. *Contemporary Issues in Early Childhood, 12*(3), 224–240. https://doi.org/10.2304/ciec.2011.12.3.224

Fleer, M. (2017). Scientific Playworlds: A model of teaching science in play-based settings. *Research in Science Education, 49*, 1257–1278. https://doi.org/10.1007/s11165-017-9653-z

Fleer M. (2018). Conceptual PlayWorlds: The role of imagination in play and learning. *Early Years, 41*(4), 353–364. https://doi.org/10.1080/09575146.2018.1549024

Fleer, M. (2019a). Conceptual PlayWorlds as a pedagogical intervention: Supporting the learning and development of the preschool child in play-based setting. *Obutchénie: Revista De Didática E Psicologia Pedagógica, 3*(3), 1–22. https://doi.org/10.14393/OBv3n3.a2019-51704

Fleer, M. (2019b). A tapestry of playworlds: a study into the reach of Lindqvist's legacy in testing times. *Mind, Culture, and Activity, 27*(1), 36–49. https://doi.org/10.1080/10749039.2019.1663215

Fleer, M. (2020a). Engineering playworld—A model of practice to support children to collectively design, imagine and think using engineering concepts. *Research in Science Education*, 1-16. https://doi.org/10.1007/s11165-020-09970-6

Fleer, M. (2021a). How an educational experiment creates motivating conditions for children to role-play a child-initiated PlayWorld. *Oxford Review of Education, 48*(3), 364–379. https://doi.org/10.1080/03054985.2021.1988911

Fleer, M. (2021b). How conceptual PlayWorlds in preschool settings create new conditions for children's development during group time. *Learning, Culture and Social Interaction, 28*. https://doi.org/10.1016/j.lcsi.2020.100461

Fleer, M., Fragkiadaki, G., & Rai, P. (2021). Collective imagination as a source of professional practice change: A cultural-historical study of early childhood teacher professional development in the motivated conditions of a Conceptual PlayWorld. *Teaching and Teacher Education, 106*, 103455. https://doi.org/10.1016/j.tate.2021.103455

Fragkiadaki, G., Fleer, M., & Rai, P. (2021). The social and cultural genesis of collective imagination during infancy. *Learning, Culture and Social Interaction, 29*, 100518. https://doi.org/https://doi.org/10.1016/j.lcsi.2021.100518

Garbett, D. (2003). Science education in early childhood teacher education: Putting forward a case to enhance student teachers' confidence and competence. *Research in Science Education, 33*(4), 467–481. https://doi.org/10.1023/B:RISE.0000005251.20085.62

Hedegaard, M. (2008). The educational experiment. In M. Hedegaard, M. Fleer, J. Bang, & P. Hviid (Eds.), *Studying children: A cultural-historical approach* (pp. 181–201). Open University Press.

Lindqvist, G. (1995). *The aesthetics of play: A didactic study of play and culture in preschools*. PhD Thesis, Uppsala University, Sweden.

MacDonald, A., Danaia, L., Sikder, S., & Huser, C. (2021). Early childhood educators' beliefs and confidence regarding STEM education. *International Journal of Early Childhood, 53*(3), 241–259. https://doi.org/10.1007/s13158-021-00295-7

Ma, Y., Fleer, M., Li, L., & Wang, Y. (2023). A cultural-historical study of how a conceptual playworld creates conditions for personally meaningful mathematics in the Chinese kindergarten context. *European Early Childhood Education Research Journal,* 1–16. https://doi.org/10.1080/1350293X.2023.2200020

Stephenson, T., Fleer, M., & Fragkiadaki, G. (2021). Increasing girls' STEM engagement in early childhood: Conditions created by the conceptual playworld model. *Research in Science Education*. https://doi.org/10.1007/s11165-021-10003-z

Utami, A. D., Fleer, M., & Li, L. (2020). Shift in teachers' pedagogical practices in play-based programme in Indonesia. International Journal of Early Years Education, 28(4), 397–412. https://doi.org/10.1080/09669760.2020.1777846

Vygotsky, L. S. (1966). Play and its role in the mental development of the child. *Voprosy psikhologii, 12*(6), 62–76. https://doi.org/10.2753/RPO1061-040505036

Acknowledgements

ARC grants allowed for funding research assistance in the first period (2005–2018 inclusive) and for the formation of the PlayLab with Conceptual PlayLab team leaders: Senior Research Fellows Dr Anne Suryani and Dr Prabhat Rai; Research Fellow Dr Sue March; and Research Officer Ebony Hall.