RESPONSIBLE INNOVATION:
DESIGNING SCHOOLS FOR TOMORROW’S LEARNERS

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The authors gratefully acknowledge Ms Antoinette White, who provided research assistance to this project.

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EXECUTIVE SUMMARY

In response to global policy initiatives focused on school environments that support the teaching and learning of 21st century skills, education systems in many countries are investing in the innovative design and construction of schools to facilitate new ways of teaching and learning. In Australia, state governments are making significant investments in school infrastructure. The Victorian Department of Education has committed over $6 billion toward school infrastructure, with a projected 100 new schools to be built between 2019 and 2026. In New South Wales, the government has invested $6.7 billion, with promises to deliver 190 new and upgraded schools.

There is now a growing body of research that focuses on the complex relationships between physical spaces, educational practices and learning. Despite widespread agreement that innovative learning environments can support better learning outcomes and increased well-being for staff and students, newly designed schools do not always realise these desired outcomes. A key reason for this is the poor alignment between the intentions of the school design and the needs, values and practices of users in diverse contexts.

This paper draws on empirical findings from recent international research that includes the perspectives and the experiences of those who design and use these learning environments. We apply the four dimensions of a Responsible Innovation Framework developed by Stilgoe, Owen and Macnaghten – anticipation, reflexivity, inclusion and responsiveness – to gain a more specific understanding of what Responsible Innovation in school design might involve and identify what might help to guide future innovation.

Our analysis shows that embedding professional learning, evidence and participatory practices in the innovation processes are important for engaging users in the design and can support successful transition and occupancy of innovative environments in schools. Flexibility and school autonomy are key for adapting designs for occupation and for sustainability in diverse contexts. Our analysis also confirms the importance of transparent values-based decision frameworks for aligning education agendas with school designs and educational practices.

Teachers continue to be the primary focus for adapting practices and improving student learning and agency in schools, but our review also highlights the critical role of school leadership. It is clear that the effectiveness of innovative learning environments, regardless of the specific context or challenges, depends on effective leadership practices. Leaders who are committed to creating effective and equitable school environments must continually refine and improve practices, which necessarily includes building professional capacity in their team and improving their own leadership capabilities.

We offer five recommendations for policy-makers, to help guide future innovations in school design by supporting governments, educational system planners, architects and school leaders to consider the suitability of school design in terms of its alignment with its users. We also suggest directions for further research to help fill significant gaps in our understanding of Responsible Innovation within the school building sector.

It is hoped that engaging in Responsible Innovation will result in school learning environments that are well-designed, well used and sustainable. With an applied research focus, we can develop a robust body of evidence to support good practice in the design and use of innovative learning spaces.
INTRODUCTION

Major international policy initiatives have proposed that schooling should prepare students as lifelong learners with competencies necessary for success in the 21st century. (1,2) Schools are, therefore, required to support learners to design their own learning (learner agency) and collaborate with others. In our rapidly changing world, this presents significant challenges for educational systems that are responsible for educating a growing and increasingly diverse student population and preparing them for an unknown future.

In response to this challenge, educational systems in many countries are investing in the innovative design and construction of schools to facilitate new ways of teaching and learning. Examples include Building the Education Revolution infrastructure program in Australia; Building Schools for the Future program in England and Wales; and Innovative Learning Environments in Canada and New Zealand. In these countries, schools have been designed to foster the aims of 21st century learning and also to adapt to the needs of tomorrow’s learners.

Innovation and responsibility in school design

Innovation in school design has become a key feature of international education policy. There are competing debates on which designs will achieve the policy intent and architects around the world have been rethinking innovation in the physical design of school environments. The prevailing design philosophy emphasises the provision of open, flexible, aesthetically pleasing and comfortable learning spaces that are integrated with technology and that can be organized in various ways to foster a wider range of teaching and learning experiences. (3) These new learning spaces have been variously referred to as innovative learning environments, modern learning environments, flexible learning environments, or new generation learning spaces. Compared with what we would consider to be traditional schools, where students are in a single class led by one teacher, innovative learning environments are designed so that students will spend more time collaborating with one another and working individually to design their own learning. These forms of active learning are expected to translate into beneficial learning outcomes, such as improved knowledge retention and academic performance. (4,5)

Understanding whether these physical spaces make a difference to learning is complex and not yet fully understood. (6) Although there is some evidence that these innovative physical spaces can influence educational practices and students’ perceptions of their own learning (4), the research findings are far from straightforward. Moreover, some schools are failing to align their leadership, management and teaching practices with the pedagogical models embedded in the school design. (7,8,9) Studies show that different forms of leadership influence the organisational, social and cultural aspects of individual schools, which in turn can influence how the physical spaces are used in different contexts. (7,10,11,12)

Education systems are faced with a number of challenges, not least of which is balancing society’s demands for more schools that will meet current and future needs of learners with economic responsibilities, including managing the investment into the future. Systems which situate decision making amongst those responsible for delivery appear to create greater opportunities for developing innovation by making better use of local knowledge and resources. (13) This creates another weighty challenge for educational authorities, who must be accountable for ensuring infrastructure and outcomes are equitable while also supporting the autonomy of schools as they adapt learning environments to their own context.

The analysis we present here is timely given the significant investment in school infrastructure being made across the country. The Victorian Department of Education has committed over $6 billion toward school infrastructure, with a projected 100 new schools to be built between 2019 and 2026. (14) Current population trends for Victoria indicate continued high growth rates over the next 30 years, with several high growth corridors in metropolitan and regional areas. (15) New South Wales and Queensland similarly expect relatively high population growth. (16) In New South Wales, the government has invested $6.7 billion, with promises to deliver 190 new and upgraded schools. According to the NSW Department of Education, the mission underlying this investment is: ‘to provide school infrastructure solutions by working together with all our stakeholders to create learning environments across NSW that serve our future needs and make us all proud’. (17)
Accommodating the learning needs of a diverse and increasing population requires forward-thinking and coordinated planning systems. To guide future decisions, we need to understand how innovations in school design align with the needs of different users (students, teachers, principals, and community members). We also need to consider how today’s schools might have to respond to changed conditions in the future.

Innovations in the design of learning environments have helped teaching and learning adapt to meet the challenges of our rapidly changing world. (18) Responsible Innovation is an emerging concept that aims to balance economic, social, cultural and environmental needs during innovation to develop responsible solutions to existing and future challenges. (19) Around the globe there have been growing and significant efforts toward implementing Responsible Innovation. Two recent examples include the OECD’s Recommendation on Responsible Innovation in Neurotechnology and the CSIRO’s Responsible Innovation Initiative.

The OECD Recommendation on Responsible Innovation in Neurotechnology was adopted in December 2019 to provide guidance to governments and innovators to ‘anticipate and address the ethical, legal and social challenges raised by neurotechnologies while promoting innovation in the field.’

Australia’s national science agency, CSIRO’s Responsible Innovation Initiative states: ‘Responsible Innovation asks us about the kind of future we want to create and determines how we are going to achieve it, while ensuring we design and deliver socially-responsible science and technology for all Australians.’

The five-year AUD$5.75 million investment ‘has been created to drive innovation’ while ‘furthering our understanding of the challenges for society that are emerging from the development of these new areas of science.’

Since its inception Responsible Innovation has been variously defined and debated in both policy and scholarly contexts. (20) A fundamental idea emphasised by most approaches to Responsible Innovation is inclusion. (21) Frameworks developed to shape Responsible Innovation processes include incorporating stakeholder views to build knowledge; anticipating and managing future needs; (22,23) and seeking better alignment between the goals of the innovation and the values of users. (24)

The Responsible Innovation framework developed by Stilgoe, Owen and Macnaghten (22) has been widely adopted and applied to a wide range of cultural and political contexts. It provides four dimensions: anticipation, inclusion, reflexivity and responsiveness.

**Anticipation** involves systematic thinking aimed at increasing resilience, while revealing new opportunities for innovation and the shaping of agendas for socially-robust risk research.

**Reflexivity** at the level of institutional practice, means holding a mirror up to one’s own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held.

**Inclusion** involves consciously seeking public and stakeholder voices to question the framing assumptions not just of particular policy issues but also of the participation processes themselves.

**Responsiveness** is a requisite of Responsible innovation that enables the shape or direction to adapt in response to stakeholder and public values and changing circumstances.

This framework anticipates multiple effects of change on the basis of inclusive participation that values diverse stakeholder perspectives and encourages reflexivity. (25) These dimensions seem particularly applicable as a way to frame and assess users’ experiences of newly designed schools. There are examples of Responsible Innovation framing and guiding education policy and development in higher education (26), science education (27), and engineering education (28). Our aim here is to determine whether this Responsible Innovation framework can be applied to the context of innovation in school design.

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METHOD

The following questions guided our research:

1. How are the dimensions of Responsible Innovation applied in the design and occupation of the newly built schools?
2. What are the reported educational needs and outcomes/challenges/processes?
3. What elements of the Responsible Innovation model can be adapted to support the future design processes of schools?

We systematically collected 8,000 empirical papers, narrowing to a final subset of 29 articles that focused on participant experiences in new build schools.

We used the Stilgoe, Owen, and Macnaghten framework as an analytical tool to code the content of the empirical findings and to identify recurring themes and common and divergent points of interest across the papers. We compared and contrasted which educational needs and challenges the framework’s four dimensions (anticipation, reflexivity, inclusion, and responsiveness) help to articulate. We identified the elements that are important in aligning the design of the school with the education system and its users.

For more details on search methods, please refer to the Appendix.

Operational definitions of terms

In this analysis, we focused on stakeholder perspectives on the design and use of new-build innovative learning environments in schools.

Stakeholders

We defined our school stakeholders as anyone involved in the design, build or use of new schools. This included architects, designers, educational planners, policymakers and educational authorities, school principals, teachers and other school staff, students, parents, and school communities.

New-build

We defined new-build schools as learning spaces that were either newly constructed or which had undergone substantial, whole school renovations.

Innovative learning environments

We included any research which used the terms ‘innovative’, ‘flexible’, ‘modern’, ‘new design’, ‘21st century’ or cognates, in its description of school environments.

Schools

We included schools in both primary and secondary sectors, encompassing all system governance types. In order to preserve coherency and translatability of findings across contexts, we excluded preschool learning environments, as well as learning centres established outside of mainstream schooling, such as Forest Schools.
THE CHALLENGES OF RESPONSIBLE INNOVATION IN SCHOOL DESIGN

In the context of innovation in the design, build, and use of new schools we identified a number of elements that were organised around the adapted dimensions of Anticipation, Inclusion, Reflexivity and Responsiveness of the Responsible Innovation framework. (22) These dimensions are connected and should be considered as part of an integrated framework. It is worth noting that across all four dimensions, there is a dearth of empirical research examining the involvement of students, families, and members of the wider community in decision-making processes.

Anticipation – The challenge of clearly understanding the potential impact of the school design innovation

The dimension of anticipation plays a critical role in designing and building innovative learning environments that are fit for school needs. Here, the research literature can help highlight the junctures in the design, build, and occupancy process at which resource investment is crucial for success. This involves identifying common challenges in innovative learning environments, envisioning how these might play out in local school contexts, and addressing these challenges before they present as major barriers.

Anticipation must also include consideration of the broader socio-political and environmental contexts in which schools will be embedded over the building lifetime. This goes beyond 21st century learning and planning for technology-rich environments to consider trends like population growth and displacement, and environmental trends such as increasing temperature, drought and extreme weather.

Across our analysis, professional learning was consistently identified as a crucial anticipatory support for teaching staff. Though less often a focus of empirical research, there is compelling evidence that specialised professional learning support for other key stakeholders – architects and designers, educational planners, and school leaders – is necessary.

Teacher-focused professional learning is highly effective in supporting the transition into new innovative learning environments, but staff must be provided with professional learning opportunities that are sustained and authentic, and offer opportunities to shape school design processes as they reshape teaching practices. (23,30,32,36) To date, teachers’ professional practices have largely been shaped within walled classrooms and have employed teacher-centric spatial arrangements. Transitioning to more open, flexible learning environments involves building trust and skills to facilitate co-teaching processes and new forms of student behaviour management. (29,33,34)

Professional learning must involve both discussion and visioning processes that establish shared values and emotional buy-in to the process, and include experiential components such as field trips and pilot experiments. Discussions of shared values must be ongoing and authentic. Teacher feedback, concerns, and overall professional expertise must inform design processes. (7,11) Experiential learning as an anticipatory professional learning process requires built-in budgetary investments for staff field trips to successful innovative learning environments, and/or the ability to experiment with design mock-ups or pilot experimental spaces within older school buildings. This requires additional staff capacity through supply teachers, as well as support for school leaders to oversee this process. Effective professional learning also addresses the development of socio-emotional skills that facilitate adaptation to new circumstances. These include communication and conflict mediation, problem solving, and negotiation. (30,32,33,34)

Evidence points strongly to the critical role that school leaders play in supporting transition to new school buildings. (7,11,30,38) When school leaders are able to follow through on the design, build, and transition processes, they can serve as important communication bridges between stakeholder groups, anticipating and mitigating challenges through all aspects of the process. (7,11) However, we found no evidence of professional learning support offered to school leaders to help them navigate these tasks, nor indications on what forms of preparation differentiate those leaders who were able to secure successful transitions from those that were not.
Anticipatory professional learning is not limited to school staff; it can also involve planners, designers, and other stakeholders involved in the design and build processes. Experimental co-learning, through the development, trial, and feedback processes of model or mock-up innovative learning environments, supports the detection and mitigation of mistakes before they are built into new school spaces. This co-learning process also builds up affective ties and increases emotional investment in project success across stakeholder groups. (11,32)

**Reflexivity – The challenge of aligning design, system and values with social and educational practices**

The Reflexivity dimension is linked to questions about the purpose of education and about how school architecture supports that purpose. Reflexivity is applied across all levels of education, from system level authorities and educational planners to architects and designers, school principals, teachers, and students. Studies connected with reflexivity were primarily concerned with mechanisms for aligning design thinking and system agendas with social and educational practices and values in varying contexts.

The research to date highlights the importance of involving different groups of stakeholders, as their varied experiences bring different expertise and understandings to a design process. (32) Stakeholder involvement will also change throughout the design process, with stakeholders having different roles in different phases of the process. (11,32,36)

Educational planners, designers and architects first need to assess and reflect on how the design of the new learning environments will impact modes of teaching and learning across a variety of school spaces. (39) Different spaces enable different forms of learning, such as large group teaching, small group collaboration, and individual reflective practices.

Within schools, reflection and reflective practice have long been a feature of quality teaching and are considered essential for improving practice. (40,41) School leaders state that their experience of innovative spaces prompts reflexivity and creates learning opportunities for changing practices, which in turn prompts the changing of spaces. (5,12,42)

These findings are further extended by an extensive body of work in the UK on the relationship of the physical environments to the experiences of teachers, students and parents in new schools. (11,30,43,44,45,46) There is a strong case that school design should be analysed as a social practice that is driven by multiple motives, acknowledging the contradictions within the process. (30) Using values-based decision frameworks helps to articulate the design intentions and develop shared understandings, which can then contribute to solutions for subsequent projects. Stakeholders have different expertise, agendas, accountability frames and motivations for the decisions that they make, and a values-based framework can address and make visible stakeholder differences throughout the design and occupation processes. (30) Continued evaluation of innovations in school designs are needed over time and to assess the social impact and the alignment of the design with future conditions and the future educational and cost benefits and challenges. (11,30,36,37)

Reflexive issues that arose across several studies make it clear that aligning the value systems and social practices of schools is a necessary, albeit challenging task. This process is likely to strengthen reflexivity and empower participants to adapt and further innovate over time in response to their specific needs and their specific context. Although students and parent voices are largely absent in the research to date, it is apparent that including their reflections would bring unique contributions to the design processes.
Reflexivity and inclusion are highly interconnected concepts, particularly in the context of educational systems where inclusive access to schooling has been a persistent concern. It is clear that incorporating diverse perspectives into decision-making processes supports innovation and helps avoid mistakes. (47) However, when diversity is enacted through an accommodation model, where diverse components or stakeholders are introduced without intention toward system change, diversity becomes little more than a celebration of difference. Bringing diverse viewpoints, with associated histories of exclusion related to ability, race, gender, class, sexuality, into collaborative contexts requires recognition of differential powers and privileges, both individually and institutionally wielded. (48,49) Contextualising diversity is a critical ethical practice. For example, what does diversity mean in a colonial territory? What is its relation to Indigenous knowledge? And what does Responsible Innovation mean in this context?

In the studies we reviewed, aspects of inclusion are mainly addressed through analysis of participatory design processes and of student autonomy during occupancy of new school spaces. The evidence highlights that emotional capital is built through participatory design processes and that these affective investments in project outcomes are critical to the design of successful school innovative learning environments. (11,30,32,36) Participatory design should be synergistic, combining perspectives and knowledge of different groups throughout the process. (36)

van Merriënboer and colleagues present a participatory design model supporting equal participation of educators and designers. In order to ensure that teaching and learning drove the design, educators led the initial design stage, while designers and builders took the reins in the final design stage of construction. The middle phase required extensive cooperation and co-learning amongst all stakeholder groups, in order to align the proposed spatial design of the school with the vision of teaching and learning. (36)

Communication across stakeholder groups is especially critical at key juncture points in the design process when new stakeholders are introduced and understandings of design processes and principles may be re-configured. For example, in the case of the Building Schools for the Future programme in the UK, the initial architectural firm that created school design was not successful during the construction build process; instead, a company that had not been involved in design processes won the bid. This eventually resulted in frustrations in consulting redundancies, communication breakdowns, and cost-cutting measures that rendered the final buildings not fit for use according to school staff. (11)

It is important to note significant gaps in empirical evidence for participatory design. Although there is growing understanding of the benefits of including students in design processes (32,36,37), we found only one study that examines how students were effectively engaged in a school design process. (37) We also note an absence of research focused on including community perspectives in school design. There is increasing recognition that schools are multi-use spaces, with the ability to support community activities. (50,51) Inclusion of community members as key stakeholders in the design process helps ensure that schools can more effectively serve the needs of students, families, and diverse surrounding communities.

While student perspectives are largely absent from school design processes, there is more evidence of student learning experiences within new school buildings. Overall, students indicate that they prefer new school spaces to traditional school plans. (30,36,52) Students report that innovative learning environments foster a greater sense of community and belonging, particularly through the inclusion of informal social space. However, this sense of belonging is mediated by the underpinning values of the school. In schools that actively foster community values, students experience school openness as inviting social space. (7,30,36,52) In contrast, in schools that focus on behavior management, surveillance, and vandalism prevention, students experience open spaces as sites of surveillance and they avoid these spaces. (30,53)

Across diverse contexts innovative learning environments support increased student autonomy. (8,36,37,52,54) Flexibility and openness of work spaces permit students to move around in response to their learning needs: they can choose to escape peer distractions by moving to quieter spaces or, conversely seek out peers for help with challenging work.
I actually find it a lot easier to work, because the environment changes your emotion. It sounds kind of cheesy, but it changes the way that you look at the work... [it is] easier to concentrate on the work, but it is also your decision [as a student] ... I need to get this work done, I need to move away from the distractions. (52, p. 588)

In addition to open learning spaces, students and teachers describe the need for quiet retreat spaces as a critical component of student autonomy and overall learning. (37,52,55)

**Responsiveness – The challenge of adjusting and adapting school design innovation**

Responsiveness has been primarily concerned with adapting practices to align with flexible and open spaces in new schools. (31,57) Adaptation is often driven by testing and experimenting with various teaching and learning arrangements that include critical reflection and then action. (7,58) These changes can disrupt traditional ways of working and create tensions for teachers. (31,57)

A key finding that emerges from this study is the important role school leadership plays in supporting change within the school environment. (9,31,38) Rather than innovative learning environments determining school practices, our analysis indicates that ‘savvy’ school leaders – principals and head teachers – recognise that new learning spaces represent invitations or provocations to do things differently. (7,52)

Leadership requires both vision and coaching skills, as articulated by one architect in the case of a school struggling to adapt to their newly-built school: ‘You can have a visionary Head but you’ve got to take your staff along with you as well, there was no prior preparation or involvement for staff and students at the school’. (11, p. 779)

Indeed, opportunities for teachers to experiment, adapt spaces and change practices are enabled by the organisational conditions shaped by leaders in schools. (9,52,56) Flexibility fosters responsive cultures and teacher and learner autonomy. These conditions support the alignment of the various elements of the learning environment and enable users to drive change. (7,9,31,56,59)

Structure and constrained flexibility also play a role in supporting transitions to new school spaces. In one case study, a school principal coined the term ‘enabling constraints’, to describe the physical features of the school and how design and organizational features can serve to constrain one behavioural choice and encourage another (9), thus supporting sustainable behaviour change. Removing teacher desks and extending the school timetable are examples of enabling structural constraints. However, in order for these structural nudges to function effectively, it is important for school leaders to foster a mindset of risk-taking, and a culture of trust. (9)

Collaborative teaching practices figure prominently within new school spaces, though these practices have not been universally adopted. (29,30,34,57,60) Evaluations of the transition to innovative learning spaces reveal that team teaching practices are sustained amongst primary teachers but not secondary teachers, who revert to more traditional single-subject teaching. (55) What characterises the successful transition to effective team teaching is a culture of trust within the school. (9,38,56) But these collaborative relationships must be developed over time. (9,35) The experiences
of student teachers in innovative learning demonstrate that teacher education presents an opportunity to prepare new teachers for these conditions. (35)

The potential of new-build school environments to enable student collaboration is a key finding of this research. (36,52,54) Innovative learning environments can both structure collaboration into the design of physical spaces and support ad-hoc peer learning. (36,54) When spaces are designed for dynamic and fluid occupation, more opportunities for collaborative student learning emerge; more rigidly structured space encourages more teacher-centric and individual learning approaches. (54)

If the designed spaces in schools can be adapted for different contexts and future conditions, they are more likely to be sustainable over time. In Victoria, some schools in growth corridors have had to deal with enrolment numbers well in excess of their intended capacity. The urgent need to accommodate increased numbers of students has resulted in additional portable classrooms being located on school grounds. In some cases, the numbers of added portables exceed the number of built classrooms, undermining the design intentions of the newly built school. (61)

Barriers limiting user responsiveness are a consistent source of misalignment in innovative learning environments. These barriers include both material limitations such as inflexible designs, lack of social space, and absence of quiet/withdrawal spaces, as well as socio-political limitations such as communication barriers and contractual obligations that prevent users from changing designs that are not working for them. (11,30,53,62) One study that applies a participatory approach to post-occupancy evaluation has documented the design challenges within three case study schools, including inadequate social space and poor acoustics, ventilation and temperature control. (53) Compounding the physical challenges are overly bureaucratic response procedures, with school managers citing prolonged administrative processes for requesting simple maintenance tasks and the imposition of excessive penalty costs.

Table 1 provides a summary of Responsible Innovation elements arising from our analysis and synthesis of empirical research focused on newly designed and built schools. Many of these elements are supported by knowledge that is well-established in education literature. While the identified elements are not meant to be prescriptive, they provide a guide for further development and research.
Table 1: Responsible Innovation elements arising from the synthesis of research on designing schools

**ANTICIPATION**

The challenge of clearly understanding the potential impact of school design

- Ongoing stages of resource investment in the design, build and occupancy process, with emphasis on social, cultural and environmental context as well as economic aspects
- Professional learning as anticipatory support for architects and designers, school leaders and teachers; professional learning and engagement strategies to address transition and adaptation to evolving challenges of occupation
- Flexibility prioritised in the design of schools so that physical spaces can be easily and sustainably shaped and reshaped for multiple purposes, users and conditions
- Evidence arising from innovative schools modelled with demonstration classrooms to support professional understanding and future design

**REFLEXIVITY**

The challenge of aligning design and system values with social and educational practices

- Transparent, values-based decision frameworks that engage multiple stakeholders, develop shared understandings, and incorporate learning into solutions for next project
- Evaluation of social and educational aspects of school designs over time to determine effectiveness and potential future educational and cost benefits and challenges
- Assessment of experiences of users in the various environments of the school, and the flexibility of the physical spaces
- Assessment of school level organisational structures to support flexibility and agency, with emphasis on collaborative and evidence-informed decision-making

**INCLUSION**

The challenge of including multiple stakeholders in the school design processes

- Incentives to promote the staged and selective engagement of a diversity of stakeholders for different purposes and at different times
- Engagement of diverse stakeholders that is sensitive to power imbalances and accountability frames throughout processes
- Appointment of designated person(s) with authority to resolve. Conflicting agendas among stakeholders and tensions between legitimate user challenges and resistance to changes produced by innovation

**RESPONSIVENESS**

The challenge of adjusting and adapting school design innovation

- Engagement of school leaders in all stages of school design processes
- Leadership guidelines to support capacity building and alignment with varying contextual conditions
- Innovation hubs inside schools as experimental spaces for gathering evidence on effects on student agency, well-being and learning and for further developing practices
- Promotion of user autonomy to adapt environments in response to contextual conditions and practices over time
DISCUSSION

Despite widespread agreement that innovative learning environments can support better learning outcomes and increased well-being for staff and students, newly designed schools do not always realise these desired outcomes. A key reason for this is the poor alignment between the intentions of the school design and the needs, values and practices of users in diverse contexts. If schools are not fit for purpose, then retrofits and adaptations, that can involve considerable financial and social resources, still might not achieve the intended aims of innovation. (30,53,62) Despite challenges, recent research confirms the overall benefits of well-designed schools that are well used. For students, these benefits include increased autonomy and self-regulation, and flexible and collaborative learning. (7,9,30) For teachers, benefits include increased agency and creative, high-trust collaborative teaching environments. (9,38) In addition, there is an increased sense of belonging across all school community members. (7,9,30,38,42)

This paper has provided a synthesis of elements and strategies in a Responsible Innovation framework adapted for the context of education. We have identified the critical roles of participatory design and professional learning as both anticipatory and ongoing elements in the Responsible Innovation framework. These two elements align closely with existing education participatory research approaches that have long emphasised the importance of context and local knowledge in informing development and shaping innovation.

Our analysis shows that despite higher upfront costs, investments in participatory design and associated professional co-learning opportunities can support successful transition and occupancy of innovative environments in schools. These processes can help to align design processes with the needs of the users and avoid costly mistakes. When co-learning takes place across a range of stakeholder groups such as designers, builders, and educators, it builds social and emotional capital amongst participants. This encourages relations of care and investment from all in making a successful transition to innovative learning spaces.

It is important to note that participatory processes do not require that all stakeholders participate equally at all stages. Initial design processes which include discussion of underpinning values are critical for broad participation, involving not only designers, builders, and educators, but also students, families, and community members. There is compelling evidence that consistent oversight of the design and build process by a designated school leader can support new school builds that are fit for purpose. (11,30)

Teacher professional learning is important across all stages of transition to new build schools and should include the following basic elements:

- Develop clarity around the purpose and use of the particular design and its underlying values
- Anticipatory experimentation and observation in pilot schools and demonstration classrooms to support understanding
- Professional networking and conferencing opportunities, both face-to-face and via social media, to troubleshoot transition and occupation challenges

Teachers continue to be the primary focus for adapting practices and improving student learning and agency in schools, but our review also highlights the critical role of school leadership. This finding is not surprising in light of research on effective school leadership. Decades of research has demonstrated that school leaders are pivotal to improving the learning environment and enabling teachers’ efforts, which in turn impact student learning and the effectiveness of the school. (63) The leadership dimensions of particular importance in creating effective learning environments are:

- Establishing school wide commitment to the identified practices
- Building professional capacity and communities of practice
- Promoting the use of student data as a mechanism for improving teaching and learning and well-being
- Creating a culture that includes collaborative decision-making and the on-going development of positive relationships with members of the school community (63)

Leaders who are committed to creating effective and equitable school environments must continually refine and improve practices, which necessarily includes building professional capacity and improving their own effectiveness. (64) What is clear from the research is that the effectiveness of innovative learning environments, regardless of the specific context or challenges, depends on effective leadership practices.
A RESEARCH AGENDA FOR RESPONSIBLE INNOVATION IN SCHOOL DESIGN

This paper has drawn on peer-reviewed empirical literature evaluating stakeholders’ experiences in the design, build, and use of innovative learning environments and new build schools. A proliferation of research in the last five years has provided evidence to support the critical role of participatory design, professional learning, and effective school leadership. However, there remain significant gaps in our understanding of how to support Responsible Innovation within the school building sector. Here, we propose an agenda for future research focused on cross-disciplinary, interdisciplinary, and transdisciplinary research, and underpinned by collaborative multi-sectoral engagement.

Cross-disciplinary, interdisciplinary, and transdisciplinary research

Governments in Australia, as well as internationally, are investing billions of dollars in new-build schools, all while facing rapidly-changing future conditions. It is critical that new school investments are future-resilient, able to adapt to uncertainty and variance. Here, the anticipatory element of Responsible Innovation is especially important, as is research that crosses traditional disciplinary boundaries. We argue that educational researchers need to work alongside sustainability scientists, futures analysts, economists, and others to create research programmes that inform the design of future-resilient schools.

Both forecasting and foresight (the use of quantitative and qualitative data, respectively), need to play prominent roles in designing new school buildings. In the case of forecasting, this involves using recent data on climate predictions and population growth patterns including rural-urban, inter-state and international migration. Foresight requires synthesising expert judgment across a range of educational, architectural, and scientific disciplines, as well as using deliberative democracy, community asset-mapping, and other participatory methods to elicit ideas and concerns from the school and the broader community.

For example, in Australia future planning might consider the role of school buildings in adapting to bushfires. We might ask: What are some of the plausible scenarios for bushfires within the next 10 to 20 years? How will we deal with school-aged populations, and their families, who may be temporarily displaced but still have a need and a right to education? Combining the anticipatory dimension with reflexivity, what values will underpin our decisions?

Collaborative multi-sectoral research

This leads into our second, related research recommendation: a focus on collaborative, multi-sectoral research. This is critical in both the design process and in the post-occupancy evaluation. Decisions about new-build schools must be evidence-informed and involve authentic, multi-sectoral engagement. There is a dearth of empirical evidence to support decisions about how and when to include students, families, and communities in the design of new schools. This should be a focus of future research.

As governments increase investment in innovative learning environments, there needs to be regular evaluations of how these school spaces are experienced by stakeholders, both immediately following the transition period and over time. While ongoing evaluation is important in addressing challenges as they emerge, it is critical that it is conducted through systematic and comparative methods, and in conversation with international research findings. With an applied research focus, we can develop a robust body of evidence to support good practice in the design and use of innovative learning spaces.
MOVING FORWARD IN INNOVATIVE SCHOOL DESIGN

The application of the Responsible Innovation elements provides a conceptual frame to review recent research in school design and offers an opportunity to think about the design and use of new schools.

This report draws attention to the challenges that responsible school design faces and points to the strategic elements that can be used in the future to address these challenges. We believe that applying the Responsible Innovation concepts of anticipation, reflexivity, inclusion, and responsiveness can bring to light potential limitations in school design processes and thus provide opportunities for further development of what is important across diverse groups.

While the Responsible Innovation framework has supported our analysis and interpretation of empirical findings in school design, it is not without limitations. Our study was restricted to new schools and did not include research on schools with combinations of traditional and newly renovated spaces or partially renovated environments. Therefore, this synthesis ignores findings regarding the potential impacts on teachers and learners who experience both kinds of environments. We also chose to frame our data collection and research findings around stakeholders’ experiences in the design and use of innovative learning environments, rather than on quantitative impacts or outcomes. Quantitative studies undertaken on the impacts of innovative learning environments on student learning outcomes suggest that innovative learning environments improve student achievement. (54)

Our review emphasises the need for further research that goes well beyond evaluation of the physical attributes of school design to evaluate the educational and social relational experiences of teachers, students and other members of the community who use these environments. The benefits of further developing our understanding of the physical space in schools through participatory research and evidence-informed collaboration are a better alignment of policy with design and use, and continued transformation of innovation in school design and educational practices. These findings have implications for policy-makers because they enable us to think about the experiences of planners, designers, school leaders and teachers and how prepared they are for creating effective 21st century learning environments.
FIVE KEY RECOMMENDATIONS FOR POLICY

1. Develop understanding
   A clear articulation of the intended uses of an innovative space and the values that underpin the design is a prerequisite to building understanding among stakeholders.

2. Ensure school designs are flexible and adaptable
   To be future-resilient, the physical spaces need to be easily reconfigured for multiple teaching and learning purposes, diverse user contexts and changing conditions.

3. Engage multiple stakeholders
   Sustained engagement of diverse stakeholders in the design and occupation processes is critical to align policy with design and use. Professional learning and participatory practices should be employed to engage students, families and other members of the wider school community in these processes.

4. Prioritise school leadership
   School principals with the autonomy to provide oversight and make changes are necessary to build capacity and create flexible organisational structures that will be able to respond effectively and sustainability.

5. Embed assessment and evaluation
   Evaluation of individual schools is essential for determining potential educational, social and cost benefits, and for informing future development and innovation in design.

These policy recommendations are not intended to invalidate expert knowledge or shift control of the design processes to users. Nor do we intend that decision-making should involve constant negotiation over diverse needs and concerns. Rather we offer these recommendations to help guide future innovations in school design by supporting governments, educational system planners, architects and school leaders to consider the suitability of school design in terms of its alignment with its users. It is hoped that engaging in Responsible Innovation will result in school learning environments that are well-designed and well used and sustainable.
APPENDIX: SEARCH METHODS

We systematically identified empirical papers focusing on the experiences and perspectives of participants involved in the design and occupancy of new-build schools. We limited our review to recent peer-review research published in the last five years, from 2015 to 2019, including online publication in advance of print date. We developed a set of search terms focused on participant experiences in school learning environments (Table 2). These search terms were tested against a set of previously-collected articles to ensure that all relevant literature would be captured. We conducted searches using the terms outlined in Table 1 in the full suite of databases included in ProQuest and Scopus platforms.

Table 2. Search terms used in comprehensive database searches. Including an asterisk character (*) permits multiple endings for search terms (e.g. family and families)

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Search terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning environments</td>
<td>“learning environment” OR “classroom environment” OR “school environment” OR</td>
</tr>
<tr>
<td></td>
<td>“physical environment” OR “physical space” OR “learning space” OR “educational space” OR “school space”</td>
</tr>
<tr>
<td>Participant experiences</td>
<td>interview* OR focus group* OR “case stud*” OR qualitative OR ethnograph* OR photo OR “action research” OR participatory OR “post occupancy” OR (any combination of)</td>
</tr>
<tr>
<td></td>
<td>Student*/teacher*/educator* + voice/perspective/perception/experience/engagement OR Communit* OR parent* OR famil*</td>
</tr>
</tbody>
</table>

We imported an initial set of 8,096 articles into the Rayyan systematic review platform (65) for review by two analysts. We read all article abstracts and excluded articles in a step-wise method, as documented in Figure 1. We first excluded all articles that did not meet basic format requirements, for example, editorials or review papers. We then excluded all articles that did not deal with primary or secondary schools, followed by all articles that did not include some consideration of the physical or material school environment. Finally, we excluded all articles that did not include participant perspectives or experiences. Throughout this process, we also manually identified a total of 144 duplicate articles. (Rayyan enables auto-identification of duplicates; an initial 560 duplicates were reviewed and removed through this process; these articles are not included in the initial total of 8,096.)

We completed a blinded review of a subset of 300 article abstracts to determine inter-analyst reliability in inclusion/exclusion decisions, with agreement on 299 articles (agreement >99.6%). We therefore had high confidence in decisions of articles assigned to the final set. We undertook full-text review of 193 articles, narrowing to a final set of articles that satisfied all criteria in Figure 1. We then narrowed this dataset to a subset of articles that focused on newly-built schools, including schools that had undergone substantial, whole-school renovations.

We searched the reference lists of these articles for relevant literature, which contributed three additional papers to our final set. Finally, we searched for all citing literature within Google Scholar, which yielded an additional five papers. All relevant articles were assessed for quality using a systematic quality appraisal tool for qualitative research (66). We excluded a single article at this stage, due to mis-alignment between research objectives and findings.
This analysis included a final set of 29 articles.

1. Meets basic format requirements?  564 excluded
2. Focuses on primary & secondary school contexts?  3792 excluded
3. Includes consideration of the built/material environment?  3160 excluded
4. Includes empirical investigation of participant experiences?  254 excluded

A) Limited set to new build schools through full-text review (-182)
B) Citation searching (+8)

Final set: 29

Figure 1. Stepwise determination of set of articles to include in analysis. Steps 1-4 excluded a total of 7770 articles. The remainder of the 8096 articles were excluded through identification of duplicates (144 articles), and full text review (182 articles).
REFERENCES


FURTHER REFERENCES


