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CASE REPORT

Implementation as more than installation: a case study of the challenges in implementing green infrastructure projects in two Australian primary schools

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ABSTRACT

Green infrastructure delivers a range of benefits for urban water management, amenity, human well-being, and ecosystem health. However, the implementation of green urban infrastructure can be challenging, whether in private or public spaces. In Australia and elsewhere, there is increasing investment in green infrastructure projects in schools. To date, the implementation issues experienced in schools have not been investigated. This article reports on a case study of the range of factors influencing implementation of green infrastructure projects in two primary schools in Melbourne, Australia. Interviews with diverse stakeholders in these projects revealed four key areas of concern for implementation: 1) professional roles and relationships; 2) planning and design; 3) value to the school community; and 4) engagement of the broader community. We conclude that successful implementation is not simply the installation of well-functioning green infrastructure; rather, it is an ongoing achievement that is as social as it is technical.

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Introduction

Urban areas worldwide face a range of social and environmental challenges associated with increasing urbanization and a changing climate, such as the urban heat island effect, increased stormwater run-off, and loss of green space. In light of such concerns, there is considerable interest in green infrastructure as a means of integrating ecology and water management with practices of urban design and urban resilience. Green infrastructure in the urban context includes vegetation, soils and built structures designed to restore or emulate natural forms and processes (Fletcher et al. 2015).

In this paper, we present a case study that highlights the range of challenges experienced in implementing green urban infrastructure in schools, and strategies for addressing these. The school, whilst becoming an increasingly common site for such projects, is a context in which implementation issues have not yet been investigated.

Green urban infrastructure offers a range of localised and distributed benefits for urban amenity, human well-being and ecosystem health. Firstly, water sensitive urban design offers alternative strategies for dealing with issues of urban water management (e.g. urban flooding and water quality) which conventional stormwater drainage systems may have exacerbated or struggled to manage (Vietz et al. 2016). Secondly, green infrastructure contributes to climate change mitigation and adaptation in cities, whether by providing carbon storage, street shading, and evaporative cooling (Demuzere et al. 2014; Norton et al. 2015), or decentralised, fit-for-purpose water supply (Mitchell 2006). Thirdly, green spaces provide well-documented positive effects on human well-being and the liveability of urban environments, such as improving air quality, promoting physical activity, improving workplace concentration, and providing restorative experiences (Coombes, Jones, and Hillsdon 2010; Lee et al. 2015). Fourthly, innovative urban forms such as living roofs and roadside raingardens create more spaces for nature within densely occupied urban environments, with benefits for urban biodiversity and ecosystem health (Tzoulas et al. 2007).

Further to these general benefits, green infrastructure has additional significance in the school environment. Natural landscape elements in school grounds support more imaginative and inclusive play (Jansson et al. 2014; Mårtensson et al. 2013), improve academic performance (Hodson and Sander 2017), and reduce symptoms of attention deficit/hyperactivity disorders in children (Faber Taylor and Kuo 2011). Green infrastructure provides an experiential learning resource in educating for sustainability, not just for children (McFadyen 2012), but also the school's community more broadly (Henderson and Tilbury 2004; Townsend et al. 2014). As these studies suggest, schools (in Australia and the United States at least) are increasingly a site of interest for green infrastructure projects.

Despite the promise of green infrastructure in offering a range of socio-ecological benefits, these technologies are not yet employed as normal practice in urban water management or urban design (Morison and Brown 2011; O'Donnell, Lamond, and Thorne 2017). Numerous studies have identified a range of social, institutional, regulatory, biophysical and technical factors that impede the successful implementation of green infrastructure in the urban environment, impacting on the socio-technical transition to sustainable urban water management (Brown and Farrelly 2009). This has included broad scale investigations, whether of the range of impediments identified by diverse stakeholders and practitioners operating across different contexts and professions (O'Donnell, Lamond, and Thorne 2017; Sharma et al. 2016), or of

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the interactions and feedback mechanisms amongst barriers within a system (Thorne et al. 2015; Winz, Trowsdale, and Brierly 2014). Other studies have addressed specific domains of concern or sites of practice, including perceptions of technological capability and performance (Madsen et al. 2017), building construction practices (Parsons et al. 2010), planning processes (Faehnle et al. 2014; White and Howe 2005), governance and institutional capacity (Brown and Farrelly 2009; Lane et al. 2017), household practices (Baptiste, Foley, and Smardon 2015; Brown et al. 2014), and community engagement (Morison and Brown 2011). These analyses indicate that the implementation of green infrastructure can be challenging across a range of public and private developments.

Despite this large body of work, there has been no study to date of the range of factors influencing the implementation of green infrastructure within schools. This is worthy of specific investigation given the distinct nature of the school environment, and the challenges that may be particular to that context. This paper addresses this knowledge gap, and in doing so provides insights for the future implementation of green infrastructure in these important components of the urban landscape and community.

Case study description

Melbourne, in south-eastern Australia, is home to almost 5 million people (Infrastructure Australia 2018). Rapid population growth, the impacts of climate change on an already drought-prone region, and the pressures of urbanisation on natural assets are amongst the key challenges that the city is addressing (City of Melbourne 2009). Recently, there has been considerable support for green infrastructure in Melbourne, from State Government and local government, water authorities and retailers, researchers and the not-for-profit sector, and this is often articulated through the vision for Melbourne as a water-sensitive city (Madsen et al. 2017). This support has included grants and financial incentives, planning processes, decision-making and design tools, education programs and teaching resources.

Primary schools have been amongst the recipients of this support through several initiatives. Sustainability Victoria's ResourceSmart Schools program provides staff support in developing and monitoring sustainability initiatives, awards schools for best practice, and develops educational resources for modules on water and biodiversity. The water industry sponsored Schools Water Efficiency Program (SWEP) provides water use monitoring systems and associated curriculum resources. The Teacher Environment Networks (TEN), facilitated by local councils, provide forums for professional development, sharing of best practice, and communicating opportunities to schools.

The two Melbourne primary schools investigated in this study have both engaged to some degree with these programs in committing to green infrastructure projects in recent years. School A received funding from a philanthropic trust, a water retailer, and several State Government agencies, while School B received a State Government grant. The schools had similar objectives for their projects: improving water use efficiency in the school, integrating aspects of the design into sustainability education, creating a natural play landscape, and supporting the wellbeing of students. At the time of this study, however, the schools differed markedly in their delivery of these projects.

After three years, School A had plumbed their existing rainwater tank into the toilets and reconstructed a sports oval to improve drainage, but the proposed urban forest, artificial wetland, swales, permeable pavement, and bioretention pits had not been installed. In contrast, after two years School B had constructed most of their proposed assets, including a stormwater-irrigated productive garden, a raingarden, an artificial wetland, shading trees, a reflective garden and a revitalised native garden. With differing networks of support, elements of water-sensitive design, and progress towards completion, the selection of these two schools supported the objective of this study in identifying the range of factors that impact on the implementation of green infrastructure projects in the school environment.

Methods

A case study design was employed alongside a multi-methods approach (Bryman 2016), including a resource assessment, semi-structured interviews with project stakeholders, and site observations. In this paper, we primarily draw on the interviews in reporting on challenges and strategies in implementing green infrastructure projects in schools.

As stated above, the two case study schools were selected on the basis of their differing experiences of green infrastructure projects. The purpose of including two schools was not for direct comparison between them in order to explain different outcomes, but rather to assist in identifying a broader range of implementation issues that may be experienced by schools. To this end, the schools were also selected as having progressed to some degree beyond the installation phase, so that participants could identify issues across the lifecycle of those projects, from initiation and planning phases, through design and installation, to maintenance and evaluation.

At each school, semi-structured interviews (n = 8) were conducted with members of staff and the school community that had been involved in the school's green infrastructure project. A purposive sampling strategy (Bryman 2016) was used to selectively target for interview stakeholders with different types of engagement with these projects, from governance and coordination to installation and maintenance. Participants in this study thus ranged across the following, sometimes overlapping, roles: principal, project manager, project champion, science/sustainability teacher, school council member, parent, plumber, and contractor.

Interviews were conducted face to face in late 2016, and lasted between 30 and 60 minutes. A semi-structured interview guide covered open-ended questions related to the school's approach to sustainability education and operations, the participant's role in and experience of the project, and issues for green infrastructure projects in schools more generally. Interviews were audio-recorded and transcribed, with participants and schools being anonymised in the transcripts. An inductive and iterative analysis (Bryman 2016) was conducted, generating categories directly from the data for coding the transcripts. This thematic analysis was directed

towards identifying the range of implementation issues experienced by these schools, rather than calculating the distribution or frequency of these issues, or quantifying the technical attributes or outcomes of these projects.

Results

Participants' reflections on the challenges of project implementation, and associated strategies for managing these, clustered around four key themes: 1) professional roles and relationships; 2) planning and design; 3) value to the school community; and 4) engagement of the broader community (Table 1).

Professional roles and relationships

For participants across both schools, the quality of professional roles and relationships were perceived as key to the project's outcomes. The success of School B's project was frequently attributed to the principal's championing of the project within the school community, inspiring others to contribute and legitimising this commitment of their time:

> '[The principal] knew their school needed it and they had enough passion and enthusiasm to give the project what it needed… it kind of reverberates through everyone else, so that made my job a lot easier' (School B contractor).

Several respondents from both schools distinguished between the work of championing the project and managing the project, another essential role. 'If there wasn't someone to coordinate all the parties, that would be a challenge,' admitted School B's principal. At School A, the project champion voluntarily took on the role of project management in their 'spare time', whereas School B was fortunate in having funds to contract an external consultant as project manager. In addition to the heavy workload required to carry both roles, a contractor from School B argued for the separation of these roles to maintain some distance between emotional attachment to the project and project decision-making.

Specialist knowledge (or lack thereof) of engineering contractors was a key issue identified by several respondents.

> '[The contractors] would start to err [towards] the normal process. I said, "No, how much permeable area is there now? How many shade trees will there be? What is the likely impact of that on water and climate?" and stuff like that… None of the contractors came forward with that knowledge.' (School A project manager)

To ensure the quality of installation and maintenance School B's contractor likewise insisted that the use of trained specialists 'should be factored into the approval of the project… It shouldn't be any Joe Blow going into schools and putting in these things.' School A's plumber further suggested that many school projects encounter problems due to sub-contracting: 'When [the government] handballs it to the contractor and then he handballs it to another contractor, it won't work. I call it pyramid contracting… The schools just don't get their money's worth.'

According to most respondents, good working relationships between the school, contractors, local council, government agencies, and other stakeholders are essential to the smooth running of the project. Several participants remarked that these relationships tended to be facilitated through shared sustainability values. In situations where not all those working on the project were driven by strong environmental values, then relationships between project managers, internal staff and contractors became more challenging.

Planning and design

Investment in site-specific knowledge in the planning and design stages was identified as a crucial element for green infrastructure projects. Both schools reported issues where

Table 1. Strategies for successful implementation of green infrastructure projects in schools.

Professional roles and relationships	• Leadership through project champion • Investment in dedicated project manager • Contractors with specialist knowledge • More direct contracting • Good working relationships, through shared sustainability values
Planning and design	• Site-specific planning and design • Consideration of school's technical expertise • Planning for succession in school community • Investment in quality installations and long-term maintenance • Record keeping of school assets
Value to the school community	• Shared knowledge of benefits of green infrastructure for student well-being and performance • Relation of project to core concerns of the school • Identification of learning opportunities through all project stages • Promotion as teaching resource beyond sustainability
Engagement of broader community	• Diverse steering group membership • Identification of recreational and learning opportunities for community groups • Demonstration site for sustainable practices and future projects • Site protection through community ownership

government-funded schemes did not provide scope for the local customisation of infrastructure design, and integration with other commitments:

> 'The grants that are out there are not really holistic in their design. They're more specific and restricting. That's the best way to put it! It favours the contractor and not really the school.' (School B contractor).

Similarly, project engineers did not always sufficiently account for the specific site, nor the impact on technical feasibility and maintenance:

> 'Spend a bit of money to get someone in to investigate the area properly, which could take two, three days to familiarize themselves with where things are, where things turn on, where accessibility is. The biggest thing is thinking if they were to do it themselves, how would they do it? Can I get up there, physically?' (School A plumber)

Participants from both schools criticised previous infrastructure projects for having designed and installed water tanks without consideration for the school staff's technical capacity for the operation and maintenance of such assets.

Biophysical characterisation of the site was recommended in the scoping stage of the project. School A's proposal included a large wetland to capture water from the asphalt play areas. Installation was abandoned when soil contamination and an extensive network of underground piping were discovered on the site, adding 'prohibitive costs to the design' (School A project manager). This relates to a broader issue reported, that of the failure to retain records of previous works and assets: 'There's not a lot of knowing what's there' (School A plumber). This was highlighted as a particular issue given the inevitable changes in school staff over time, and an associated loss of knowledge of local infrastructure.

Long-term planning was identified as a strategy for dealing with the potential for 'burn-out' amongst project participants (School A project manager), as well as the inevitable turnover of teachers, staff and parents. Succession proved an issue at School A, when the school community changed mid-way through the project: 'A set of families is there for five to ten years, then a new set comes along and they've got new priorities. There's constant reinventing of the wheel.' (School A council member).

Several participants observed that government grant schemes tended to have a short-term focus, resulting in rushed projects that left infrastructure disconnected or functioning very minimally.

> 'The number of schools that you hear from that got solar panels in previous grants that were never installed correctly, were never turned on, connected, just been sitting on a roof gathering dust.' (School B project manager)

Further to this, the focus of government schemes and schools on installation, with relatively little investment in the long-term operational or maintenance implications of infrastructure, may put the future functioning of these assets at risk: 'Not enough attention is paid to active maintenance of the facilities' (School A council member).

Value to the school community

The lack of awareness within the school community of the benefit of green infrastructure to student well-being and academic performance was identified as an impediment for such projects:

> 'Their core concern was child education, child welfare. You can see that facilities and grounds become a very clear third or below. We know it helps with those things, but the principals don't.' (School A project manager)

A narrow understanding of green infrastructure as landscaping for amenity and aesthetics was attributed to other school staff as well as to the State Government's Department of Education. This resulted in a perception amongst some staff that green infrastructure projects distract from or are peripheral to the core business of schools, rather than being integral to improving students' learning, well-being and play.

The integration of green features into teaching and learning was a priority for both schools, with varying success. At School B, students were involved in the project from the outset, rather than simply being presented with the finished product, increasing the quality of their engagement:

> 'First off we had the kids do the designs themselves. They drew up their own plans… They had a chance to say what they would like and they were given over to the people involved.' (School B sustainability teacher)

The modified scope of School A's project compromised plans to engage with sustainable water management in the curriculum.

Project managers at both schools struggled to some degree to engage teachers perceived as 'non-environmental'. This lack of engagement was attributed in part to teachers being 'just crazy busy' (School A project manager). At School B, the sustainability teacher and principal advocated for more regular classes to be held in the outdoor classroom space, to realise the project's value as more than a sustainability teaching resource.

Engagement with the broader community

Both projects benefited from support from outside organisations, through funding, resources and expertise. At School A, the steering committee included members of the local council's environment and urban design teams, an environmental not-for-profit organisation, and a water research centre, while the project received funding from 'City West Water, Melbourne Water, the Department of Health, because of the shading, the greening link to health, and even VicRoads [the local road and traffic authority]' (School A project manager). Interestingly, due to the multi-faceted intentions of both projects, many supporting organisations were not environmentally related.

These partnerships were often motivated by the projects' value to the wider community, whether in creating opportunities for use of the school's facilities, encouraging sustainability outcomes more broadly, or as a model for future developments elsewhere.

> 'Agencies that are trying to get these sustainable city outcomes know that schools are a great way to do that, because you're not only educating students you're educating parents and schools are such a community hub.' (School A project manager)

School A negotiated a public space agreement with the local council for public access to the gardens for recreation on weekends. School B's productive garden and school kitchen became a resource for teaching English to parents at the school and as a community hub for the local migrant population. As School B's principal explained, 'Parents can feel more comfortable coming into the school and seeing it as a place for them as well, where they're welcome.' The importance of fostering this sense of community ownership and engagement was also linked to preventing site vandalism.

Discussion

The range of barriers and strategies identified by participants in this study offers original insights into the challenges of implementing green infrastructure projects in schools. As observed in previous studies of green infrastructure initiatives in other contexts (e.g. Brown and Farrelly 2009; O'Donnell, Lamond, and Thorne 2017; Sharma et al. 2016; Thorne et al. 2015; Winz, Trowsdale, and Brierly 2014), implementation is influenced by a broad range of social, institutional, managerial, biophysical, technical and governance factors.

That said, the concerns for implementation shared by the study's participants focussed more on social relations and institutional practices than on technical performance and biophysical properties of the infrastructure and the site. This focus on socio-institutional barriers has likewise been remarked in several broad-scale investigations across different implementation contexts (Brown and Farrelly 2009; O'Donnell, Lamond, and Thorne 2017; Thorne et al. 2015). Whilst for some participants the relative attention given to socio-institutional factors may be due to an expert confidence in available technology, as observed elsewhere (O'Donnell, Lamond, and Thorne 2017; Thorne et al. 2015), for others this may be due to having less familiarity with the technical aspects of these green infrastructure projects, and more involvement with the governance, institutional or pedagogical dimensions. It may also reflect the strong commitment amongst these stakeholders to understanding success of such projects not just in terms of the installation of well-functioning assets to improve the environmental performance of the school, but also the ongoing achievement of pedagogical and well-being benefits to the school and broader community.

Whilst the broad categories of barriers that are identified in this study are to some degree familiar from previous studies, most of these barriers manifested in unique forms within the context of schools. The study suggests that three characteristics of the school environment were particularly influential in shaping these barriers and the strategies proposed for addressing them: 1) the transient nature of the school community; 2) the pedagogic focus of schools; and 3) the school as a public institution.

In identifying barriers to implementation, numerous participants emphasised the transient nature of the school community, from the regular turnover of children attending the school and parents involved in the school's governance and operations, to changes in teaching and support staff. Whilst institutional expertise and capacity, commitment to long-term vision, and achieving ownership and buy-in have been identified as challenges in other studies of the implementation of green infrastructure projects (Brown and Farrelly 2009; O'Donnell, Lamond, and Thorne 2017; Thorne et al. 2015), in the context of schools these barriers are shaped and exacerbated by the constant turnover of key stakeholders in these projects. Unsurprisingly, participants in this study identified several strategies that address such issues related to the transient school community, most notably planning for succession, sustaining leadership through project champions, and improving records of school assets.

A second characteristic of the school environment that recurred in the discussion of barriers to implementation was the school's pedagogic focus. As Morison and Brown (2011) remark in the context of municipal projects, stakeholder support relies in part on the ability of proponents to articulate the value of green infrastructure in terms of specific stakeholder concerns and commitments (for example, water retention to keep community sporting fields green during times of drought). Similarly, in this study, some participants highlighted the challenge of gaining support from 'non-environmental' teaching staff who either narrowly interpreted the value of green infrastructure as improved landscaping and sustainable operations, or restricted the pedagogic value to sustainability teaching. Thus these teachers may have felt little meaningful connection to their own teaching commitments or the core business of the school as education. Strategies identified by participants for responding to this situation included more effectively promoting green infrastructure as teaching spaces, as resources for learning other competencies (such as citizenship), and as natural settings that improve student welfare and academic performance. This suggests that despite the well-established range of well-being and academic benefits identified in previous studies of green infrastructure in schools (e.g. Jansson et al. 2014; Mårtensson et al. 2013; Hodson and Sander 2017; Faber Taylor and Kuo 2011), a key concern is extending the awareness of teachers and the school community of the value to students and teachers beyond sustainability curriculum and operations.

In identifying community engagement as another key area of concern for implementation, the pedagogic focus of schools intersected a third characteristic of these schools, that of being public institutions. An understanding of the school's green infrastructure as a community asset, rather than merely school property, manifested through commitments to providing access to green infrastructure as teaching and learning resources for community groups, and in presenting the site as a demonstration of sustainable practice within their neighbourhood. Being an experiential learning resource in community education for sustainability (Henderson and Tilbury 2004; Townsend et al. 2014) was for both schools an essential element of the success of such green infrastructure projects.

Whilst this case study and the qualitative methods employed provide preliminary yet robust evidence of the range and nature of the challenges faced by schools in implementing green infrastructure projects, it is limited on several

fronts and indicates the value of further research on this topic. Firstly, a more comprehensive inventory of the range of barriers to implementation would be obtained from a larger qualitative study with a sampling strategy that included a broader array of stakeholders within and beyond the school (for example, funders, engineers, contractors, government agencies, and members of the local community), as well as different kinds of schools and green infrastructure projects. Secondly, a broad-scale quantitative investigation that surveyed a representative sample of schools could inform an analysis of the distribution and relative importance of these factors for schools in general. Given the unique characteristics of schools described above, generalising findings from other well-studied contexts (such as households and municipal works) into schools does not offer a valid approach to understanding and addressing the challenges faced by schools.

Conclusion

Whilst in Australia and elsewhere there is increasing investment in green infrastructure in schools, the barriers to implementation within this domain of practice have been hitherto unexamined. This exploratory case study has highlighted a range of barriers to implementation and proposed strategies related to: 1) professional roles and relationships; 2) planning and design; 3) value to the school community; and 4) engagement of the broader community. Key elements of the school environment that influence the shaping, prioritisation and response to these challenges include the transient nature of the school community, the pedagogic focus of schools, and the school as a public institution. These specific features of schools, and their increasing significance as sites of investment for green infrastructure, warrants further investigation into the implementation issues that schools may experience and strategies for supporting successful outcomes.

Finally, the range of issues identified by these stakeholders is a useful reminder to pay attention to what is meant by implementation, and indeed by success, in assessing green infrastructure projects. As previously stated, these green infrastructure projects were proposed in both schools not simply as a technical intervention to improve the school's environmental performance, but also as a pedagogic resource in teaching sustainability and other competencies, as support for student well-being and play, and as community resource. In this context, as no doubt in others, implementation does not equate solely with installation of green infrastructure, nor does success equate solely with the moment of technical achievement. Instead, successful implementation is understood as an ongoing process, one that is a social achievement as much as it is a technical one.

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