The role of education in the circular built environment: Analysis of Australian educational programs impact on construction and demolition waste management

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Abstract: Resource circularity has become a necessity in the built environment sector. A significant amount of construction and demolition (C&D) waste is generated worldwide. This waste results from poor resource efficiency in the sector. Australia is among the lowest-ranked countries in the Organisation for Economic Co-operation and Development (OECD) regarding the sector's resource efficiency. A circular economy and resource efficiency can be achieved primarily through education, enforcement, and encouragement in the sector. Of these three elements, education is the focus of this paper. Education can generate attitudinal and behavioural change among stakeholders to move towards effective waste management (WM). This study aims to determine whether current Australian educational programs have successfully achieved circular economy objectives and improved resource efficiency. This paper provides an insightful overview of the programs and proposes a framework to evaluate the effectiveness of educational programs in a circular built environment. Lastly, it recommends a few practical suggestions to improve their effectiveness in the built environment sector.

Keywords: Construction and demolition waste, circular economy, behavioural change, Australia, training.

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1. Introduction

In the built environment (BE) industry, environmental and ecological problems linked with building operations have become a growing issue. The substantial quantity of waste created on construction sites is seen as a significant obstacle to the global expansion of the BE industry (Aslam *et al.*, 2020; Bao and Lu, 2020; Shooshtarian *et al.*, 2021b). Currently, the BE industry generates 35 percent of all garbage transported to landfills globally (Zheng *et al.*, 2017). In 2014, the United Kingdom created 49 million tonnes of construction and demolition (C&D) waste, of which more than half was landfilled (Menegaki and Damigos, 2018). China generates 2.36 billion tonnes of C&D garbage annually (Zheng *et al.*, 2017), whereas the United States generated 516 million tonnes in 2017 (US EPA, 2019). In Australia, housing, buildings, and transportation infrastructure development projects are being completed at an unprecedented pace. In this industry, the average annual growth rate between 2009 and 2019 was 3.33% (Kelly, 2021). According to the most recent statistics, Australians produced 27 metric tonnes of C&D waste, of which only 67 percent was recovered (National Waste Report, 2020). In response to this problem, three broad clusters of mitigation strategies, including enforcement, education, and encouragement, are offered. Education may play a crucial part in the 3R approach to waste management, which includes waste reduction, reuse, and recycling. Education has a significant impact on four primary domains in favor of waste management: increasing the awareness of industry stakeholders, improving organizational culture and changes in their attitudes and behaviors. Furthermore, recent efforts to implement circular economy (CE) concept in the BE industry place stress on education.

In Australia, the National Waste Policy (National Waste Policy, 2018) Strategy 3 (knowledge sharing, education and behaviour change), it is advised that coordinated knowledge sharing and education initiatives should be implemented to address the needs of governments, businesses and individuals, and to encourage the redesign, reuse, repair, resource recovery, recycling and reprocessing of products. Most Australian jurisdictions have formed teams dedicated to educating industry people and the wider community. Research and education are critical factors highlighted in all Australian waste strategy strategies and guideline documents. These documents have introduced initiatives to fund education programs to reduce waste disposal (Shooshtarian *et al.*, 2020a). A report by Senate Environment and Communications References Committee (2018) recommended that the Australian government should support state and local governments in providing effective recycling education initiatives. There is an ongoing debate about the individual role of education in promoting sustainable behaviour and attitudes in this context. For instance, Crocker and Lehmann (2013) highlight, that education alone has little or no effect when it comes to sustainable behaviour, concluding that improving knowledge and changing attitudes may not impact behaviour. Lingard *et al.* (2000) Lingard et al. (2000) suggested that if managers see a training program as successful and workers view it as irrelevant, it is unlikely that the training would have the intended impact. On the other hand, Chapman *et al.* (2013) observed that experiential learning results in new habits, and actively experiencing things is the most effective way to learn about environmental initiatives. Park and Tucker (2017) suggested that effective training can encourage the sharing of C&D waste responsibilities between contractors and professionals, and improve awareness and interest from would-be homeowners, clients and developers.

Several studies have highlighted the critical role of education in the Australian C&D waste context. Tam (2009) argued that inadequate private sector education on waste management technology investment is a crucial barrier to adopting C&D waste-related technologies in the Australian industry

relative to its Japanese equivalent. A survey by Li and Yang (2014) showed that lack of knowledge and training of waste minimisation is the second most important waste management factor for building retrofit projects. Udawatta *et al.* (2015) study involving interviews of the sector professionals highlighted the importance of training and education for all stakeholders to enhance C&D was management performance. Park and Tucker (2017) identified attitudes towards reuse practices and training, lack of interest and demand are the major barriers to reusing recycled C&D waste materials in Australia. Newaz *et al.* (2020) interviewed 19 practitioners in NSW and found that knowledge, experience, and training of site operatives were one of the key factors influencing C&D waste management. Results of a survey showed that 'culture, poor education (attitude and behavior) and acceptance' is among the top four factors hindering a successful C&D waste management system (Shooshtarian *et al.*, 2021a). According to a survey of stakeholders' awareness of CE it was found that while over 70% of professionals grasped the essence of the CE concept, only 12.9% had enough expertise to implement CE in their organisations, (Shooshtarian *et al.*, 2022). Zhao et al. (2021) stated that to achieve state compliance standards, stakeholders must teach employers to change their attitude and awareness of WM. This will lead to effective WM behaviour from stakeholders over a project's life cycle. No studies have evaluated the impact of education on the C&D waste management system in Australia to yet. Consequently, the purpose of this study was to identify educational opportunities that would enhance the industry's capacity to alter the present C&D waste management status quo. This is the first effort to document such training initiatives in Australia, and it is part of a larger research project that seeks to discover the strategies to enhance the use of recycled C&D waste materials in Australian building projects. To achieve this aim, two objectives were set out: (1) to identify the main opportunities for educating the industry stakeholders on effective C&D waste management in Australia and (2) to provide suggestions for maximining the impact of education on C&D waste management.

2. Methodology

2.1. Research design

This study attempted to achieve research objectives by reviewing relevant literature. The literature used for this study included journal articles, conference papers, industry reports and other grey literature. Notably to achieve the first objective the primary educational providers and associated stakeholders were reviewed. The keywords used for extracting relevant literature included *'Australia', 'education', 'training',* '*construction and demolition waste', and 'circular economy.*

2.2. Study context

Australia's Commonwealth consists of six states and two self-governing territories. The Australian government, often known as the federal government, is the national government. The states and territories have a significant degree of autonomy; unless two conditions are met, the Australian government lacks the legal authority to influence many of state and territory governments' decisions, including waste regulations: (1) the regulations set by these governments conflict with international treaties that Australia is a party to (e.g., Agenda 21, Basel Conventions, and Stockholm Conventions) or (2) they impose threats to the environment that are of national concern. Furthermore, local governments and municipalities provide waste collection and recycling services, manage and operate or administrate landfill sites, deliver education and awareness programs, and provide and maintain recycling infrastructure (National Waste Policy, 2018). Therefore, the majority of legislation occurs at state and

territorial government levels. The C&D waste stream is the largest source of waste in Australia. The waste management and resource recovery sector contributes 0.3% of Australia's GDP. Australian Bureau of Statistics for 2022 shows that over 1 million people work in the construction business and 656,000 in waste collection, treatment, and disposal (ABS, 2022). This organisation reported that the construction industry had spent $2 billion on waste collection, treatment, and disposal services among various sectors. These expenditures are calculated through the indicator of waste intensity, which quantifies the amount of waste generated per million dollars of value-added to the economy. This indicator for the construction industry is 87 tonnes per million dollars (ABS, 2020). These numbers simply imply the potential economic benefits obtained from educating employees in the construction and waste recovery industries.

3. Results and discussion

3.1. Educational opportunities

this section explores the extant educational opportunities for stakeholders involved [will be involved] in C&D waste supply chains. As illustrated in Figure 1, six common educational opportunities are provided by both the public and private sectors.

Figure 97. The most common educational opportunities in Australia

LinkedIn Learning- in recent years many universities and educational institutes across Australia are subscribed to this platform to unlock countless learning opportunities for their students and staff. LinkedIn Learning (LL), as a subsidiary of LinkedIn, is an online learning provider that offers video courses taught by industry experts in software, creative, and business skills. All the courses on LinkedIn fall into four categories: Business, Creative, Technology and Certifications and are designed for three levels: beginner, intermediate, and advanced. At the time of writing this article, the thirty-one courses on this platform are directly or indirectly linked to C&D waste management.

Tertiary education- The formal tertiary education system in Australia involves two primary levels: higher education (HE) and vocational education and training (VET, also known as TAFE: Technical and Further Education). HE focuses primarily on knowledge, theory, and critical thinking, and VET emphasises job-specific practical skills. The HE offers bachelor's degrees, graduate certificates, graduate diplomas, master's degrees, and doctoral degrees, and VET provides four levels of Certificates, diplomas and

advanced diploma. Currently, the Australian tertiary education system advances the industry's understanding of effective C&D waste management in three ways: (1) providing waste management-specific courses in VET, (2) providing core or elective courses on sustainable construction management, technologies, practices and planning in HE and (3) providing opportunities for research activities focusing on C&D waste management in HE. NCVER (2022) reported that in 2021, 60.6% of VET qualification completers had an improvement employment outcome after training. Table 1 shows the current VET courses specific to waste management and their description.

Table 49. VET courses on waste management

Course title	Duration	Course syllabus/description
Certificate II in Waste Management	1 year	Students learn how to stay safe at work and then correctly sort waste and recyclables according to environmental protection laws. Students can choose electives that will enable you to drive forklifts and waste collection vehicles
Certificate III in Waste Management	1 year	The course includes identifying and segregating waste, conducting waste resource recovery, identifying hazards and responding to waste management emergencies, following WHS and site procedures, operating waste processing plant, carrying out waste assessments, operating waste collection vehicles, administration and leadership skills
Certificate IV in Waste Management	1 year	It teaches essential aspects of operations and safety management at waste processing facilities. Students will learn how to build relationships with staff and clients while implementing waste management plans—in accordance with environmental protection laws

With increased awareness of construction environmental impacts, Australian universities started to incorporate topics related to waste management, planning and practices in their course contents. The waste content is primarily included in courses that deal with construction sustainability. Also, few courses are offered that are specific to waste management, including 'Sustainable Waste Management' that covers C&D waste management. Some of these courses are also provided individually through Open Universities Australia (Crock *et al.*, 2013). Research activities provided via research programs or courses at three levels (i.e., undergraduate, master's and PhD programs) represent a further potential for the education of people about the C&D waste stream within HE. Students engaged in research-related courses at the undergraduate level may choose C&D waste management as their research topic, leading to Honours recognition from their host educational institutions. Students pursuing a Master's degree may undertake research on C&D waste management challenges via either the Masters by Research or Masters by Coursework programs. As the last point, there is a rising number of PhD candidates seeking to research C&D waste management for their doctoral theses. As shown in Figure 2, the number of thesis projects completed recently has seen a spike. According to Shooshtarian *et al.* (2021b), this might be due to increasing government funding possibilities for investigating C&D waste management challenges.

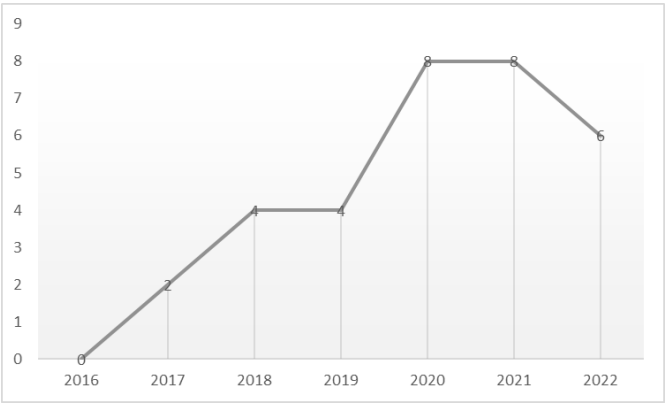

Figure 98. Number of research theses related to C&D waste recently completed in Australia. Source: Trove, National Library of Australia (2022)

Industry associations: Industry associations play an important role in providing a collective voice for individual businesses within an industry. Additionally, they attempt to educate their members on current industry-specific issues and solutions. In Australia, there are several associations that provide educational opportunities for stakeholders involved in C&D waste supply chains. Notably, the most active ones include Institute of Engineers Australia (IEA), Waste Management and Resource Recovery Association of Australia (WMRR), and Australian Council of Recycling (ACOR). These associations frequently arrange waste conferences and exhibits to offer networking and educational opportunities for industry stakeholders. WMRR has facilitated state-based waste education working groups to strategise waste education initiatives at the state and national level. These working groups consist of industry professionals, government representatives, and academics. ACOR designed a community-driven national recycling education program Recycle Mate, to increase public awareness of recycling issues and support recycling initiatives. Lastly, the Green Building Institute (GBI) provides some training course to minimise waste in the BE sector.

Sustainability rating organisations: these organisations primarily aim to improve sustainability in the Australian BE sector through their rating systems which recognize sustainability efforts in building and infrastructure sectors (Shooshtarian *et al.*, 2019). The main two organisations are Green Building Council of Australia (GBCA) and the Infrastructure Sustainability Council (ISC). In addition, they organise periodic professional development training to promote the awareness of sustainable construction among their members and other industry professionals. C&D waste management is one of the primary topics explored

in these courses and activities. In a survey conducted by GBCA (GBCA, 2022), it was found that 91% of its members considered CE as 'extremely important' and 'very important key are of focus for education.

Industry organisations: various organisations operating in waste recovery sector have launched educational programs that focus on behavioral change in the industry. Examples include Getting Wise About Waste and Greenius offered by Veolia and Cleanaway, respectively that are two major waste service providers in Australia. The former initiative is a fully interactive online learning portal for waste and recycling education– titled the EduPortal. The EduPortal provides clients with tailored information to help staff on-site across various positions, understand how to identify different waste streams and locate the correct receptacle within which to dispose of these materials. Lastly, Clean Site® is an industry education program created and executed by KESAB environmental solutions in collaboration with state and local governments and other industry associations delivers education and training embracing best practice on construction sites through onsite demonstration and information resource materials(KESAB, 2022).

Government educational programs: National and state governments have a pivotal role in providing and supporting educational programs for the BE sector. In most state waste strategy documents the role of education is highlighted (Shooshtarian *et al.*, 2020b). Some examples of these programs include ecologiQ that is a Victorian Government program that was designed in 2019 to help Victorians incorporate construction materials into transport projects. The ecologiQ offers educational opportunities for industry stakeholders in order to maximise the usage of recycled materials in infrastructure projects. In addition, the federal government, through Skilling Educators for Sustainability Australia (SESA), offered an opportunity for trainers in the waste sector to increase their skills and capabilities in order to better help their colleagues in responding to waste concerns. South Australian Green Industries has launched Circular360 (Global Centre of Excellence in Circular Economy) that will deliver training on the role of the CE in reducing Australia's global carbon footprint through the smarter recovery, recycling and reuse of materials, with a focus on the benefits to business in becoming more circular (Waste Management Review, 2021). Lastly, each state's Environmental Protection Agency (EPA) offers professional educational opportunities. These opportunities that might be obligatory aim to enhance industry understanding of dealing with waste challenges.

3.2. Education's influence on C&D waste management: Analysis of evidence and way forward

In this section, the study analyses the impact of education on C&D waste educational programs. There is little evidence showing how the educational programs have led to increased sustainability in C&D waste management. However, it is documented that the quality of an educational programme may have a substantial influence on the attitudes and behaviours of industry professionals. For instance, a survey conducted by an Australian organisation (Alchemy Living & Learning, 2014) showed that waste educational programs would be more effective if there were primarily face-to-face, through networking and conferences and include onsite field studies. The research also attributed the success of waste education to providing accreditation or pathways into larger qualifications. The two main barriers to successful waste education included time and cost followed by the not knowing a course is running and lack of perceived value and relevance of an education program. Waste educational programs aim to influence attitudes and behaviours in the BE sector and waste recovery industry. To do this, educational programmes must be revamped and authorities must concentrate on maximising effect. This section

offers strategies for achieving education providers' goals. These solutions rely on a framework by Michaela Zint of University of Michigan (Meera, 2022), as shown in Figure 3.

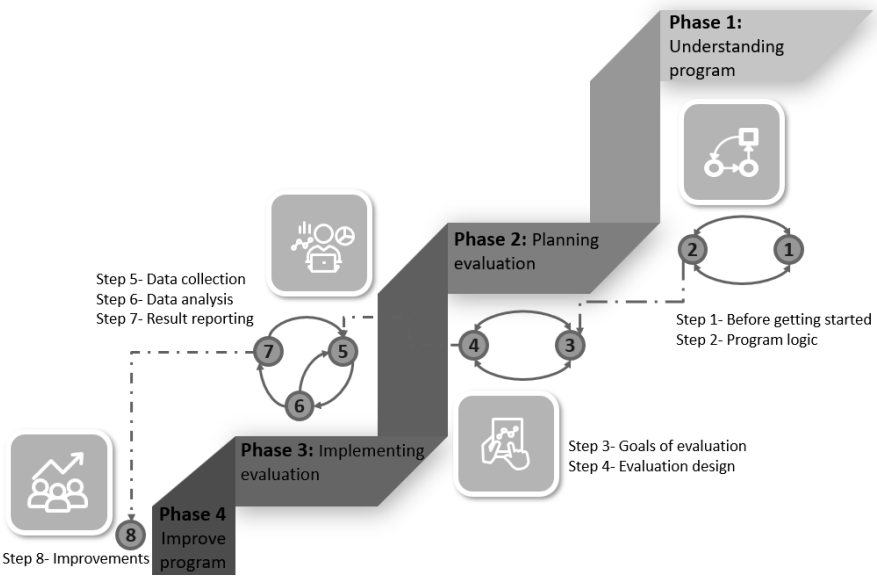

Figure 99. A framework to evaluate an educational program effectiveness.
Source: Adopted from Meera (2022)

This framework guides improvements in educational programs in four phases (understanding program, planning evaluation, implementing evaluation and improve program) and through eight steps. These eight steps are described in Table 2.

Table 50. Summary of strategies for successful design and implementation of waste educational programs

Step	Description of strategies	
1	• Engage external evaluator to conduct assessment activities • Create a forum to generate discussion and promote interaction among stakeholders	• Build organisational capacity and stakeholders' support to collaborate to evaluate program success measures
2	• Create a logic model to assist stakeholders understand the program's objectives and how it is accomplishing them	• Develop a logic model that shows your program's logic and the links between inputs (resources used), outputs (activities and audience), and benefits (outcomes and impacts in short, intermediate and long-term)
3	• Identify why evaluation is planned and who will use the evaluation's results which determine the method of evaluation • Develop indicators that help demonstrate whether program goals have been achieved	• Set evaluation questions based on the logic model components (created in Step 2), which also consider the concerns of multiple stakeholders
4	• Identify what type of data to collect and how to collect those data by reviewing the most effective methods	

5	• Devising a work plan with deadlines for all key aspects of the evaluation to keep the process manageable	• Identify expectations for staff and evaluation team members • Pilot-test instruments to ensure that directions are clear and that measures are appropriate for the target audience
6	• Ensure to analyse data at the appropriate level (e.g., intermediate or advanced)	
7	• To determine how results are shared based on target audience and program goals	
8	• Communicate the program's successful results to demonstrate the impact it has on your target audience or the community. • Address organization and planning problems to make the implementation of program more successful and increase participant satisfaction • Change content based on participants' feedback or other evaluation results	• Use what is learned from the evaluation to identify ways to increase awareness of your program's offerings • Consider investing in certain components of the program if some components provide less than ideal results than others • Learn from the mistakes and limitations of past evaluations to avoid these pitfalls in the future

In addition to evaluation, there are other strategies that may help program educational program achieve their goals. These strategies are provided below:

- Provide accreditation or pathways into larger qualifications
- Devise mandatory education for individuals engaged in C&D waste generation and handling
- Alignment between various waste educational initiatives
- Financial assistance from the government for participation in educational programmes
- Building capacity in organisations to enable individuals' participation in waste education

4. Conclusions

Education, enforcement, and encouragement are the three driving forces that enable the design and implementation of a successful C&D waste management system. In the Australian context, the role of education in advancing C&D waste is ill-studied. This study is the first attempt to capture the educational opportunities that will facilitate behavioural and attitudinal changes towards better waste management in the BE sector. The results showed that in the Australian context, there are six major channels for waste education. However, there is little evidence showing how these programs have been reflected in attitudinal and behavioral change in the BE sector. The present research contributes to the theory and practice of waste education in the Australian BE sector through providing suggestions that enable educational programs archive their intended goals. This review sets the springboard for the larger research project roadmap to evaluate how educational programs will lead to attitudinal and behavioral change resulting in minimization of C&D waste landfilling in the Australian BE sector.

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