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ARTICLE

How Well Does the F-10 Australian Curriculum Prepare Students to be Water Literate Citizens?

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Abstract

Global water availability and management are persistent challenges to sustainable futures, yet people may have limited understandings of water systems and may hold negative attitudes towards sustainable solutions. With education a mechanism for realising a water literate citizenry, this study asks: *How well does the Australian curriculum prepare students to be water literate citizens?* McCarroll and Hamann's (2020) *Dimensions of Water Literacy* guided a document analysis of Version 9.0 of the F-10 Australian *Science* and *Humanities and Social Sciences* (HASS) curricula. Findings revealed that concepts related to water literacy were largely confined to the Year 4 Science and Year 7 Geography curricula. In Science, the dimensions of *Science and Systems Knowledge* and *Local Knowledge* were through concepts related to the natural and urban water cycle. In HASS, the *Hydrosocial Knowledge* dimension was privileged, owing to people's interactions with water. While there were occurrences of *Functional Knowledge* in both curricula, the organisation of the curriculum according to knowledge and skills does not explicitly focus on the development of students' positive attitudes and values towards water conservation, nor engage them in individual or collective decision-making and action. Implications for the Australian curriculum and what it means to be a water literate citizen are discussed.

Keywords: Humanities & Social Sciences curriculum; science curriculum; water education; water literacy

Introduction

Water is a critical natural resource affecting all life on Earth. In Australia, where the current study is situated, water is the lifeblood of the nation's landscape. Australia is the driest inhabited continent on Earth, with highly variable rainfall and extreme climate events such as droughts and floods. In the five years from 2017 to 2021, the quality of Australia's oceans and inland water have deteriorated (Green & Moggridge, 2021). Very-much-below-average rainfall has seen the driest 24-month period on record in 2018–2020, resulting in lowest-on-record stream flows that has adversely affected the health of rivers and streams, natural lakes, and wetlands (Green & Moggridge, 2021). Dams and reservoirs were affected too, with accessible storage volume across Australia falling in 2020 to the lowest level in more than 10 years (Green & Moggridge, 2021). At the same time, there were localised flood disasters, such as the 2021–22 Southern Queensland floods, estimated to have cost $7.7 billion in social, financial and economic losses (Deloitte Access Economics, 2022). Against this backdrop of variability in relation to water resources, which extends to many other global contexts (see UNESCO, 2024) it is more important than ever to ensure a water literate citizenry. Water literacy is critical for understanding and addressing the degradation of Australia's marine and freshwater systems, and for disaster preparedness and resilience in the context of more frequent and extreme climate events.

Water literacy, like many other 'ecoliteracies' (e.g., science literacy, climate literacy, ocean literacy), envisions sustainable human communities and societies (McBride et al., 2013). McCarroll and Hamann (2020) recently defined water literacy as a person's holistic understanding of water and our (humans') relationship with water, or in other words "the culmination of [one's] water-related knowledge, attitudes, and behaviours" (p. 1) — a concept we unpack in the next section of this paper. These authors describe the dual goals of water literacy as "sustainable water management" and "social water equity" (p. 1). The former refers to the function and resilience of water systems under changing climate and social conditions, while the latter refers to water systems supporting the health and welfare of all individuals by way of safe drinking water and food security, among others. The realisation of a water literate global citizenry, however, may be impacted by people's limited water-related knowledge, poor attitudes, and limited actions towards sustainable water security solutions (e.g., Dean, Fielding & Newton 2016; Johnson & Courter, 2020; Moglia, Cook & Tapsuwan 2018).

In Australia, one of very few national surveys conducted by the Cooperative Research Centre for Water Sensitive Cities in 2015 revealed more than half of respondents had not seen or heard any information about water in the six months prior to completing the survey. Respondents also had limited knowledge of where their drinking water comes and of water treatment processes. The survey revealed concerns around people's attitudes and values towards water, evidenced by an unwillingness to support sustainable water security solutions such as desalination and purified recycled water. Another study on community knowledge about water management by Dean et al. (2016) concurred, demonstrating a low level of overall water knowledge among a sample of Australian adults. The authors identified that the least understood areas were related to the 'urban water cycle', namely water supply and treatment systems that they labelled as "invisible" to many people (Dean et al., 2016, p. 11). More recently, an independent organisation, *The Water Conservatory*, revealed that Australians held more positive knowledge and attitudes towards water, but less than one in five (18%) were aware of how they use water in their home (Palmer & Philpot, 2021). This finding, in particular, brings people's individual (in)actions in relation to water use and conservation to the fore (see also Moglia et al., 2018).

International research findings also paint a bleak picture, particularly around urban water processes. Research from the United States conducted by Johnson and Courter (2020) revealed college students from Ohio had limited knowledge about water treatment. More than half of the 224 survey respondents did not know the difference between treated and untreated water (60%), with only 4% rating their knowledge of drinking water treatment in their hometown as 'high' (see also Mahler, 2019; Sadler et al., 2016). Concerns around water literacy, particularly the sustainable management and use of water, are also documented in the research literature for parts of the United Kingdom (Robins et al., 2017), South-East Asia (Maniam et al., 2021), and South Africa (McCarroll, 2023). Finally, Abbott et al. (2019) conducted an analysis of 380 water cycle diagrams from 12 countries across the globe, with 85% of representations showing no interaction between humans and the water cycle. The amalgam of this longstanding research from Australia and internationally suggests the need for strategies to enhance people's water literacy through education.

Academic literature about water literacy, and indeed water education more generally, appear to be scarce. Some studies outline school students' cognitions about water-related concepts; for example, (mis)conceptions and learning progressions related to the water cycle (Barrutia et al., 2021; Gunckel et al., 2012, 2018). Other studies focus on known pedagogical approaches for improving conceptual understanding such as reasoning and argumentation (e.g., Dawson, 2024) as well as experiential and place-based learning (e.g., McClain et al., 2022). A study by Amahmid et al. (2018) explored water education in Morocco, finding that although there was good coverage of water-related topics in the curriculum, this did not translate to students' positive attitudes, values and behaviours towards water usage. Similar findings are reported by Martinez-Borreguero et al. (2020), who document a moderate coverage of water-related topics in the Spanish curriculum, but frequently in non-compulsory school subjects. Finally, a study conducted in Queensland, Australia, revealed only two instances of learning about water in the science curriculum, and none that emphasised human or societal relationships with water (Sammel et al., 2018). These latter studies suggest that education is a mechanism for enhancing water literacy, but there are nuances and challenges.

Inspired by this literature and the importance of water literacy for sustainable futures, we believe an examination of the scope and sequence of formal water education in Australia is warranted. In this study, we ask: *How well does the Australian Curriculum prepare students to be water literate citizens?* Having already provided a brief background and literature review, we outline the conceptual framework for the research, before providing an overview of the Foundation to Year 10 (F-10) Australian Curriculum, and the Science and HASS learning areas. Then, we outline the research methods, before presenting and discussing the research findings.

The dimensions of water literacy

We have used McCarroll and Hamann's (2020) work on water literacy to guide our curriculum analysis. Writing as Geography scholars from the United States, these authors argue that water sustainability relies upon knowledge and understandings of water resources and their relationships with humans and global systems. McCarroll and Hamann (2020) inform us that water literacy is a popular term used by scholars, government departments, and community organisations and non-profits to broadly refer to people's water-related knowledge, attitudes and behaviours. However, they explain that "there [is] no consensus on how to define, apply, and assess water literacy as a concept" (p. 2). To develop a common understanding, McCarroll and Hamann (2020) first conducted a systematic literature review to identify academic sources that used the term. Next, they identified each authors' definition of water literacy (26 definitions in total) and analysed them to generate eight themes showing how the term is being collectively defined and used. They named the eight themes "knowledge sets" (p.7; we have preferred the term 'dimensions'), which span cognitive, affective, and behavioural domains. These dimensions are: *General/Unspecific Knowledge*, *Science and Systems Knowledge*, *Hydrosocial Knowledge*, *Local Knowledge*, *Functional Knowledge*, *Attitudes and Values*, *Individual Action*, and *Collective Action*.

Beginning with the cognitive domain, McCarroll and Hamann (2020) identified five dimensions comprising one's water literacy. The first is General/Unspecific Knowledge (GK) (e.g., basic watershed concepts). This dimension is purposively broad, capturing any un-specified knowledge not defined in the subsequent dimensions. Next is Science and Systems Knowledge (SSK). This dimension is about "hydrologic and ecological science along with systems thinking" (p. 8). Examples of SSK include water's physical and chemical properties, and the hydrologic cycle. Hydrosocial Knowledge refers to "bi-directional and continuous interactions between society and water resources" (p. 8). Local Knowledge (LK) concerns knowing the origin of usable water, including an understanding of local water sources, water infrastructure, and water demands and uses. Finally, Functional Knowledge (FK) is about sustainable water usage — "the difference between how water is used currently, and how water should be used" (p. 9). Examples of FK include knowledge of how to use water sustainably and how to protect and/or restore watersheds.

Turning now to the affective and behavioural domains, the Attitudes and Values (AV) dimension is defined as an individual's thoughts or feelings about water, and the importance assigned to water resources. Individual action (IA) refers to "informed and responsible decisions about water resources" (p. 9) that can lessen individuals' impact on water resources, while collective action (CA) concerns informed societal decision-making that reduces humans' collective impact on water quality and quantity.

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As Education scholars, we noted the similarity to the pro-environmental behaviour literature in the tripartite dimensions of water literacy proposed by McCarroll and Hamann (2020) — knowledge, attitudes and values, and action — and acknowledge that while there may be dimensions unaccounted for, there is potentially no direct relationship between these dimensions. As recently described by Siegel et al. (2018), people's pro-environmental behaviour is influenced by an "intricately complex and interconnected web" (p. 197) of internal and external factors. We also noted that McCarroll and Hamann's (2020) conceptualisation does not recognise dimensions of 'environmental literacy' or 'ecoliteracy' already proposed by Environmental Education scholars such as relationality, connectedness, and context (e.g., Wooltorton, 2006), as well as problem solving skills, inquiry skills, and information analysis and evaluation skills (e.g., Simmons, 1995). Nevertheless, understanding the extent to which the three dimensions of water literacy are represented in the formal school curriculum is valuable. We elaborate on limitations around the framework in the Discussion section of this paper.

The F-10 Australian Curriculum for Science and HASS

In Australia, a national curriculum is provided by the Australian Curriculum, Assessment and Reporting Authority (ACARA). The F-10 curriculum identifies the knowledge, understanding and skills that children are required to learn from approximately 5 to 15 years of age (ACARA, 2022a). While the curriculum "sets high aspirations" for all students, irrespective of where they live and learn, implementation is guided by the education and curriculum authorities in each Australian state and territory (ACARA, 2022a, para. 1). With this noted, and acknowledging the water-focused curriculum programmes that exist in specific states and territories reviewed herein, we decided to focus our study on the analysis of the Australian Curriculum, as it represents the core curriculum that is implemented in Australian schools.

There are three dimensions of F-10 Australian Curriculum:

- Eight discipline-based ***learning areas*** that include *year or band level descriptions* (an overview of learning each year, or in 2-year bands), *achievement standards* (a description of the expected quality of learning that students should demonstrate); *content descriptions*[1] (the required knowledge, understanding and skills that guide teaching and learning); and *content elaborations* (illustrative examples of how content descriptions may be taught) (ACARA, 2022b).
- Seven ***general capabilities*** that are integrated in learning area content: *critical and creative thinking*; *digital literacy*; *ethical understanding*; *intercultural understanding*; *literacy*; *numeracy*; and *personal and social capability* (ACARA, 2022c).
- Three ***cross-curriculum priorities*** (CCPs) that are also addressed through learning area content, and reflect national, regional and global contexts: *Aboriginal and Torres Strait Islander Histories and Cultures*; *Asia and Australia's Engagement with Asia*; and *Sustainability* (ACARA, 2022d).

In the current study, Version 9.0 of the F-10 Australian Curriculum for the Science and HASS learning areas were analysed. This represents the 'Preparatory' (Foundation) year, the primary years of schooling (Years 1–6), and the junior secondary years (Years 7–10). These year levels were selected as the focus of the research because they represent the compulsory years of schooling before students make choices about subjects in senior schooling or employment. Science and HASS were chosen because of the natural alignment between these learning areas and concepts related to water literacy. For example, the Science learning area:

[1]Content descriptions each have a unique identifying number that indicate their location in the curriculum (e.g., AC9HS4K05).

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> "... enables students to develop an understanding of important science concepts and processes, the practices used to develop scientific knowledge, science's contribution to our culture and society, and its uses in our lives. It supports students to develop the scientific knowledge, understandings and skills needed to make informed decisions about local, national and global issues." (ACARA, 2022e, para. 3)

Science learning content is organised in three interrelated strands: *Science understanding*, *Science as a human endeavour* (SHE), and *Science inquiry* (SI). Each is comprised of several sub-strands. For example, Science understanding is comprised of four sub-strands: *Biological sciences; Earth and space sciences*; *Physical sciences*; and *Chemical sciences*.

The HASS learning area concerns peoples' "... behaviour and interaction in social, cultural, environmental, economic, business, legal and political contexts ... It plays an important role in assisting students to understand global issues, and building their capacity to be active and informed citizens who understand and participate in the world" (ACARA, 2022f, para. 3). The F-10 HASS curriculum introduces students to the disciplines of History, Geography, Civics and Citizenship, and Economics and Business. Learning content is organised in two interrelated strands and several sub-strands, depending on the discipline area: *Knowledge and understanding* (i.e., contexts through which concepts and skills are taught), and *Skills* (e.g., questioning and researching, and interpreting, analysing and evaluating).

Research methodology

In this qualitative study, document analysis (Bowen, 2009) was employed to systematically evaluate the F-10 Science and HASS curricula. According to Bowen (2009), document analysis may include elements of content analysis and thematic analysis. The former involves the categorisation of information related to the research question/s, while the latter involves the identification of salient themes through coding and category construction. The approach adopted herein involved content analysis: curriculum statements were carefully read, interpreted, and discussed by the authors through an iterative process, before categorising relevant statements using the dimensions of water literacy.

The curriculum statements that were analysed comprised of the achievement standards for each year level/juncture in the curriculum; the knowledge content descriptions drawn from the SU and SI strands of the Science curriculum, and the KU strand of the HASS curriculum; and the content elaborations. Curriculum statements were categorised according to the five *knowledge* dimensions of water literacy: GK, SSK, HK, LK and FK. The skills strands from each curriculum were excluded from analysis, given that the water literacy framework does not include a skills dimension.

Learning content within the Australian Curriculum identifies "essential knowledge, understandings and skills" (ACARA, 2022b, para. 2) that students should learn, and not attitudes, values, and actions, so the AV, IA and CA dimensions were not used in this study. It should be noted that while the curriculum refers to knowledge of action, it does not require that children *take action*. For example, in Year 4 Science, a SU elaboration suggests that students consider why people are encouraged to save water, and actions they can take to reduce water consumption and waste. This was coded FK, as it represents knowledge about action.

A Word version of each curriculum was downloaded from the ACARA website (https://v9.australiancurriculum.edu.au/) for analysis. A content search was first performed to identify direct matches with terms of interest. The following search terms were used: *water OR river OR lake OR catchment OR marine OR creek OR groundwater OR dam OR ocean OR reservoir OR weir OR stormwater OR wastewater OR flood OR drought OR runoff OR rainwater*. Curriculum statements that included direct matches were highlighted. Next, each curriculum document was

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read carefully in its entirety, including the year level descriptions and achievement standards, to understand the curriculum intent, the sequence of learning from P-10, and the possible relationship to the development of water literacy. Year levels that focus explicitly on the development of water knowledge, as per the year level descriptions and achievement standards, were identified.

All curriculum statements in these year levels were then reviewed by the authors and discussed for two purposes: (1) to identify other relevant statements that represent water knowledge, that were not captured in the initial term search; and (2) to exclude statements that were highlighted initially, but did not relate directly to water literacy (e.g., reference to water as a product of a chemical reaction). We also cross-checked against the Sustainability CCP priority to ensure that other relevant curriculum statements were not overlooked. As the curriculum statements were reviewed, it was noted that some relate explicitly to specific kinds of water knowledge, while others *could* develop water knowledge. We decided to differentiate between these statements by labelling them as "prescribed" opportunities versus "potential" opportunities to develop students' water literacy. "Prescribed" refers to relevant statements drawn from achievement standards and content descriptions; that is, elements of the prescribed curriculum. "Potential" refers to possible opportunities to develop water literacy that are dependent on teachers' instructional decisions; namely, content elaborations (which are not prescribed), and achievement standards or content descriptions that *could* be relevant if water is chosen as the context for learning (e.g., HASS, Year 4, students learn about the sustainable allocation and management of renewable and non-renewable resources). Curriculum statements that were included in the analysis were categorised according to the relevant knowledge dimensions of the water literacy framework. The categorisation was reviewed and discussed by the authors until agreement was reached.

Findings

We begin with a summary of the findings of the first phase of data analysis, the content search (i.e., direct matches for the term 'water' in each curriculum). A total of 140 instances were identified: 85 in the HASS curriculum and 55 in the Science curriculum. Seventy-one (51%) of these matches were located in the 7–10 Geography curriculum, whereas only six (4%) were found in the 7–10 Science curriculum.

Tables 1 and 2 summarise the findings to arise from the second phase of data analysis, wherein the direct matches with the term 'water' were refined to identify relevant matches, and specifically, instances of prescribed versus potential opportunities to develop students' water literacy by way of the knowledge dimensions of the water literacy framework. As shown in Table 1, a total of 48 relevant matches were identified: eight prescribed opportunities, and 40 potential opportunities. Noting that the overall number of prescribed opportunities was small, the most frequent types of knowledge presented were SSK (n = 3) and HK (n = 2). More potential opportunities were identified, namely by way of relevant content elaborations, particularly FK (n = 13) and HK (n = 13).

A more detailed presentation of these findings is shown in Table 2. Perhaps unsurprisingly, instances of SSK were most frequently identified in the F-10 Science curriculum (n = 6: 2 prescribed, 4 potential). Two prescribed instances were identified in the Year 4 Science curriculum. Students' understanding of water-related knowledge is assessed, as evidenced in the achievement standard. By the end of Year 4, students are required to " . . . *identify key processes in the water cycle and describe how water cycles through the environment*" (ACARA, 2022g). Specifically, a corresponding content description requires that students "***identify sources of water*** *and describe* ***key processes in the water cycle****, including* ***movement of water*** *through the sky, landscape and ocean; precipitation; evaporation; and condensation*" [AC9S4U02]. A single reference to SSK was found in the Year 7 Science curriculum by way of a content elaboration,

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Table 1. A summary of the prescribed and potential opportunities to develop each dimension of water-related knowledge in the water literacy framework

Knowledge dimension	Prescribed (n)	Potential (n)
General knowledge (GK)	1	1
Science and systems knowledge (SSK)	3	7
Hydrosocial knowledge (HK)	2	13
Local knowledge (LK)	1	7
Functional knowledge (FK)	1	13
Total	**8**	**40**

Table 2. A breakdown of instances of water literacy in the Australian Science and HASS curricula by year level and location

		Prescribed (n)		Potential (n)		
Curriculum	Year Level	Achievement Standards	Content descriptions	Achievement Standards	Content descriptions	Content elaborations
F-6 Science	Year 4	1 SSK	1 SSK	0	0	8: 3 SSK, 2 LK, 3 FK
7-10 Science	Year 7	0	0	0	0	1 SSK
F-6 HASS	Year 4	0	1 GK	1 FK	1 FK	3: 1 LK, 2 FK
	Year 5	0	0	1 FK	2: 1 FK, 1 GK	3: 2 FK, 1 HK
7-10 Geography	Year 7	1 HK	3 1 HS, 1 SSK, 1FK, 1 LK*	0	1 HK	16: 3 SSK, 7 HS 4 LK, 2 FK*
	Year 10	0	0	1 HK	1 HK	1 HK
Total		**2: 1 SSK, 1 HK**	**6: 2 SSK, 1 GK, 1 HK, 1 LK, 1 FK**	**3: 2 FK, 1HK**	**5: 2 FK, 1 GK, 2 HS**	**32: 7 SSK, 7 LK, 9 FK, 9 HK**

Note: Some content descriptions or elaborations were coded as including two types of knowledge.

which suggests the exploration and comparison of separation methods used in different situations, such as water purification. This elaboration was linked to a content description about the separation of mixtures.

Instances of FK, HK, LK, and GK were most frequently identified in the F-6 HASS and 7–10 Geography curricula (ACARA, 2002h, 2002i). A single content description in the F-6 HASS curriculum prescribes the develop of water-related knowledge in Year 4 (Geography sub-strand): "*The **importance** of environments, including natural vegetation and **water sources**, **to people and animals** in Australia and on another continent*" [AC9HS4K05] (GK). Broadly, the Year 4 HASS curriculum focuses on the importance of environments to people, and the sustainable allocation and management of renewable and non-renewable resources. As such, five potential opportunities to develop water-related knowledge were found, noting that these would rely on the teacher using water as an example of a resource for students to study (e.g., Year 4 Geography content description: "sustainable use and management of renewable and non-renewable resources" [AC9HS4K06]).

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In Year 7 Geography, there is an explicit focus on the development of water literacy, as a context as outlined in the year level description:

> *Water in the world – focuses on the many uses of water, the ways it is perceived and valued, and the hazards associated with environmental processes. Students examine the distribution of its different forms as a resource, its varying availability in time and across space, and its scarcity. They also explore the ways water connects and changes places as it moves through the environment, and the impact of water-related hazards on human–environment relationships* (ACARA, 2022i).

Here, four prescribed opportunities to develop water-related knowledge were identified, and 17 potential opportunities (Table 2). As identified in the achievement standard, by the end of Year 7, "*. . . students describe the importance of environments to people* [and] *the interconnections between people, places and environments, and describe how these interconnections change places or environments*" (HK). While water is not explicitly referenced, this was coded as prescribed knowledge, given the achievement standard relates to the context for learning, '*Water in the world*'. Three prescribed opportunities in content descriptions were identified; for example, "*the **economic, cultural, spiritual and aesthetic value of water for people**, including First Nations Australians*" [AC9HG7K03] (HK). One content description and one elaboration in Year 7 Geography (Geographical Knowledge and Understanding strand) were found to include two types of knowledge:

> Content description: "*the **location and distribution of water resources** in Australia, their **implications*** (LK), *and **strategies to manage the sustainability of water*** (FK)."
>
> Elaboration: "*describing the **distribution of Australia's water resources*** (LK), *and its **implications for people*** (HK)" [AC9HG7K02].

Potential opportunities to develop HK were identified in the Year 10 Geography curriculum, noting that the achievement standard, and a single content description and elaboration, broadly concern ". . . the effects of human activity on environments, and the effect of environments on human activity." Here, students could explore "human-induced changes that challenge the sustainability of places and environment," such as water pollution (ACARA, 2022i).

Discussion

The findings to emerge from our analysis of the F-10 Science, F-6 HASS, and 7–10 Geography curricula revealed few prescribed opportunities to develop water-related knowledge (n = 8, Table 2). There were significantly more potential opportunities, however, to develop students' water-related knowledge, by way of content elaborations. While content elaborations serve to illustrate how content descriptions may be taught and are not prescribed, other potential opportunities identified in achievement standards and content descriptions are dependent on teachers' instructional decisions, and whether water is used as the context for learning. In the Science curriculum, the development of prescribed water-related knowledge (particularly SSK) is chiefly limited to Year 4, wherein students are required to learn about the water cycle and movement of water through the environment. In the HASS and Geography curricula, water-related knowledge is confined to Year 7 Geography, where a prescribed context for learning, '*Water in the World*', sees students learning about the uses of water, distribution of water resources, the movement of water through places and environments, and the impact of

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water-related hazards on human-environment relationships. Overall, FK, HK, LK and GK appear to be privileged in the HASS and Geography curricula.

Recall that the water literacy framework is comprised of five knowledge dimensions, one attitudes and values dimension, and two action dimensions (individual and collective). Applying the framework to the F-10 Australian Curriculum proved challenging, given its poor alignment with the structure of the curriculum. Noting that the curriculum identifies the knowledge and skills that students are required to learn, we were unable to employ the values and attitudes, and action dimensions in our analysis. Conversely, the framework does not recognise skills that might be necessary to be water literate, so the SI and Skills sub-strands of the curricula were not analysed.

While the water literacy framework does not include skills, it was apparent in our reading of the curriculum that several content elaborations in the SI and Skills sub-strands appeared directly relevant to water literacy or would support the development of water knowledge, particularly given that the strands of the Australian Curriculum are interrelated (e.g., an elaboration in the SI sub-strand, Year 4: *Using maps to* ***locate water sources in the local area****, or constructing maps to* ***show sites of water wastage*** *in the school grounds*). In our reading of Skills and SI curriculum, we also found some evidence of reference to actions and attitudes, the remaining dimensions of the framework. For example, in the *Skills* strand, *Concluding & Decision-making* sub-strand of the HASS curriculum:

> **Year 4:** *Propose actions or responses to an issue or challenge that consider possible effects of actions* [AC9HS4S06] (elaboration: *reflection on personal behaviours and identify attitudes that may affect aspects of the environment at a local or global level*)

> **Year 5:** *Propose actions or responses to issues or challenges and use criteria to assess the possible effects* [AC9HS5S06]

While the Skills and SI strands of the curriculum were not analysed in this study, it is noted in these examples (where water may be used as a context for learning), the emphasis in on *proposing* (rather than *taking* informed) action.

Likewise, the SHE strand of the Science curriculum (a knowledge strand) was excluded from analysis because knowledge about the Nature of Science does not align well with the framework. Through the SHE sub-strand, '*Use and Influence of Science*', students "explore how scientific knowledge and applications affect individuals and communities, including informing their decisions and identifying responses to contemporary issues. They learn that in making decisions about science practices and applications, ethical, environmental and social implications must be taken into account" (ACARA, 2022e). In this way, the SHE sub-strand has the potential to develop students' water literacy, if issues such as water security are used as contexts for learning, as it engages with elements of HK, LK and FK.

Here we see how the Australian Curriculum 'exerts its influence' on the work that schools do and how they are organised by setting out authoritative mandates in relation to what content must be taught at different year levels. Importantly, is also outlines the social and education rationales that underpin the curriculum (Westbury et al., 2016). These rationales reflect specific educational imperatives or priorities, determine the goals and content of the curriculum (for example, what is valued, and what is excluded), and directly influence the kinds of learning opportunities that students are afforded (see Deng & Luke, 2008; Eisner, 1985). In examining the potential of the Australian Curriculum to develop students' water literacy, this study has raised questions about whether broader learning outcomes should be prioritised within the curriculum. Critical approaches to environmental education, for example, emphasise critical thinking, systemic thinking, futures-thinking, values clarification, collaborative decision-making and problem solving, and reflection. They also position students as agents of change, empowering them to assume active roles in envisioning and creating alternative futures; taking actions to transition to

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more sustainable economies and societies, and acting upon local and global sustainability challenges (Tilbury & Cooke, 2005; UNESCO, 2018; see also, Tomas, Mills, Rigano, & Sandhu, 2020). While there are clear synergies between these outcomes and the goals of water literacy, the narrow focus on knowledge and skills in the Australian Curriculum means that it is limited in its capacity to develop students' actions, attitudes and values in relation to water literacy. In the Year 4 example above, while not prescribed, the elaboration that suggests students reflect on their personal behaviours that may affect the environment aligns with a critical approach to environmental education.

Conclusion

In this study, we sought to examine the extent to which the F-10 Australian Curriculum has the potential to develop students' water literacy. In doing so, we have identified some limitations in McCarroll and Hamann's (2020) conceptualisation of water literacy (namely, the knowledge-centric nature of the framework), and propose that a broader set of skills and capabilities are needed to complement the knowledge, attitudes and values, and action dimensions. Our analysis also raised questions about the Australian Curriculum's capacity to develop water literate citizens. Notwithstanding the limited prescribed opportunities in the curriculum to develop students' water-related knowledge, its narrow focus on the development of knowledge and skills excludes broader learning outcomes, including the development of attitudes and values, that are integral to water literacy. Furthermore, the curriculum does not support students to take informed actions to reduce individual and collective human impacts on water resources.

Notably more *potential* opportunities to develop students' water literacy were identified in content elaborations (i.e., optional or suggested learnings), or achievement standards and content descriptions wherein water could be chosen as the context for learning. In this way, these potential opportunities are very much dependent on teachers' instructional decisions. This raises the question, how can teachers be supported to realise opportunities to develop students' water literacy when they enact the curriculum? One answer might be teacher reflexivity (i.e., the transformation of teachers' individual teaching practices through critical, informed and intentional internal conversations) (Feucht, Lunn Brownlee, & Schraw, 2017; Lunn Brownlee, Ferguson, & Ryan, 2017; Ryan & Bourke, 2013). In the context of a narrowed space in which teachers work to enact the curriculum, reflexivity can support teachers to view their professional decision-making as a form of individual agency through which they may come to realise broader curriculum goals, like the development of water literacy (see Tomas, Mills, & Gibson, 2022).

A second answer to the question of how to support teachers to develop students' water literacy calls for broader notions of a water literate citizen than what is offered by McCarroll and Hamann's (2020) framework. Drawing parallels to Leonie Rennie's (2005) seminal conceptualisation of a scientifically literate person as "using science in everyday life, not [necessarily] knowing a great deal about science as a body of knowledge" (p. 10), we would suggest that McCarroll and Hamann's depiction of water literacy neglects where people encounter water in everyday life. Being a water literate citizen requires spatial and systems thinking skills to understand the interconnectedness between natural and urban water systems; critical literacy skills to evaluate news, media, and weather information about water; data skills to understand water usage in the home by reading and interpreting a water meter or a water bill; and decision-making skills to weigh-up personal actions for saving water around the home. In view of this, it is important to consider the enactment of water literacy in context. For example, the water-related knowledge, attitudes and values, skills and capabilities, and actions required for protecting a local wetland are different to those required for natural disaster preparedness and resilience. Water literacy may also differ between geographical locations. We would suggest a revised conceptualisation of water literacy that encompasses these

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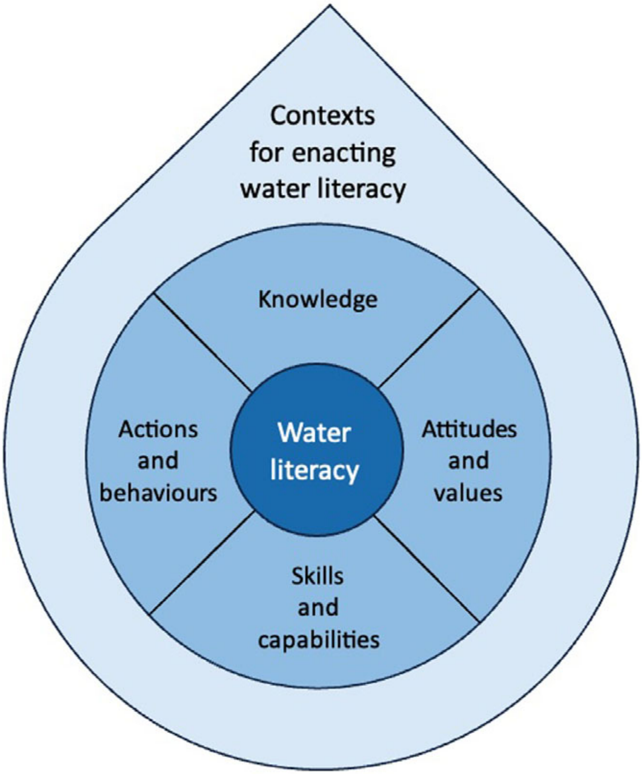

Figure 1. A revised conceptualisation of water literacy.

new dimensions—"Skills and capabilities" and "Contexts for enacting water literacy"—as shown in Figure 1.

Ongoing work to foster a water literate citizenry is important in view of water-related socio-ecological challenges such as marine and freshwater ecosystem conservation; water security; and drought, flood, storm, and cyclone preparedness and resilience, to name a few. We propose that there ought to be greater mandated attention to water education in the Australian Curriculum, especially in Science where there were only two prescribed instances in Year 4. We note that this instance of learning about the water cycle has not changed since an earlier analysis by Sammel et al. (2018), despite national curricula reforms occurring since the conduct of their study. One example of where this may occur is the Year 3 topic "Earth's resources." This mirrors other scholar's calls for a "blue curriculum" that mandates more formal learning about water (e.g., Boon, 2024). We also propose further research is required to examine how teachers enacting the F-10 Australian Curriculum exercise their individual reflexivity to realise potential opportunities to develop students' water literacy. Research findings can then inform teacher professional learning. Finally, our revised conceptualisation of water literacy presents another avenue for future research by examining the enactment of people's water literacies in different water-related contexts.

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