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Leveraging the South African water crisis for authentic learning in pre-service teacher education

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Background: Water quality education is a complex socio-ecological issue that preservice geography teachers are expected to address in school curricula.

Aim: This case study examined what preservice teachers learned about water quality education and how they conceptualised authentic learning opportunities.

Setting: The study was conducted in an undergraduate geography module incorporating water-testing fieldwork to deepen understanding of water quality conservation and its pedagogical application.

Methods: Anonymous open-ended questionnaire responses from 20 students were analysed using Kolb's experiential learning cycle and Mezirow's transformative learning theory.

Results: Findings indicate a strong reflective–practical learning orientation. 'Reflective Observation' and 'Active Experimentation' featured most prominently in Kolb's model, while 'Exploration of New Roles and Actions' and 'Reintegration' dominated Mezirow's. Students demonstrated meaningful critical reflection, linking scientific inquiry with human impacts on water systems, and reported behavioural and identity shifts reflecting increased environmental responsibility. Lower levels of 'Abstract Conceptualisation' and 'Recognition of Shared Experience' suggest limited theoretical integration and peer dialogue, highlighting the need for additional scaffolding activities to strengthen conceptual framing and collaborative learning.

Conclusion: The study underscores the value of experiential and participatory approaches in water education, enabling preservice teachers to engage with real-world environmental issues and enhance geographical understanding for future teaching practice.

Contribution: Fieldwork-based water testing builds preservice teachers' confidence to integrate authentic environmental learning into classrooms. Strengthening theoretical framing and peer dialogue may further support individual learning and collective transformation.

Keywords: water quality education; inquiry-based learning; education for sustainable development; sustainable development goals; citizen science; pre-service teachers.

Introduction

In 2018, Cape Town became the first major global city to come within days of exhausting its water supply as a result of drought and deteriorating water quality (Warner & Meissner 2021). Similar water-related crises continue to emerge in other urban centres, including Johannesburg (Adam 2025), and across various African countries. For example, Ghana and Morocco have comparable water scarcity and quality challenges (Ololade et al. 2023). Concerns extend beyond water scarcity to include the disturbing deterioration of water quality, usually as a result of anthropogenic factors (Cooper et al. 2007; Singh, Dent & Hill 2018; Stones 2022).

Teaching and learning water conservation is well-suited to geography education, which explores how human–environment interactions influence social and ecological outcomes (Edokpayi et al. 2018). In the South African curriculum, water-related topics are integral to developing environmental responsibility. However, water quality remains a national concern, with several water bodies, streams and rivers reported to be deteriorating (Ngcuka 2024). Teaching water conservation through a practical, inquiry-based approach allows learners to investigate real-world water issues through monitoring of water quality, applying geographical inquiry skills and linking scientific knowledge to local environmental contexts (Lotz-Sisitka 2024). This approach fosters

critical thinking, problem solving and active engagement with sustainability issues (Cankaya & Iscen 2015).

Consequently, water literacy is inherently tied to geographic place and spatial context. Given the multiple disciplinary pathways through which water can be studied, first clarifying and defining the scope of water quality from a geographical perspective is essential, as outlined in this paper. Water is a vital resource underpinning human consumption, agriculture, industry, transportation and energy production, thereby sustaining economic development and broader societal well-being (McCarroll & Hamann 2020). Water is discussed here as a resource for human consumption, hence the importance of water conservation. Higher levels of water-related knowledge can improve public engagement, responsibility and accountability when engaging with water issues (Dean, Fielding & Newton 2016).

Water education in the curriculum

Concerns about water scarcity and suitability for consumption have resulted in water education being integrated into educational curricula and programs (McCarroll & Hamann 2020), serving as essential tools for teachers to improve their pupils' knowledge, attitudes and behaviours towards water use. Sustainable water use has been incorporated into geography and Education for Sustainable Development (ESD) curricula in a range of international contexts. Examples include Australia (Maude 2014), China, the United States (US) (Li et al. 2024a), Taiwan (Chou & Wang 2023), Qatar, Singapore and New Zealand (Zguir, Dubis & Koc 2021), as well as the UK (Pointon 2010). Water sustainability topics are embedded into the curricula to enhance knowledge, shape attitudes and encourage children's actions that support responsible and sustainable water use (Amahmid et al. 2019; Imaduddin & Eilks 2024).

The South African Curriculum and Assessment Policy Statement document (CAPS), which was introduced in 2011, features water across several subjects and learning areas, including geography, social sciences, natural sciences and technology. Water features as a cross-cutting theme in geography, in which it can be linked not only to topics like droughts, floods and climate change but also to factors affecting water resources and development, water quality and action taken around water issues in the community (Department of Basic Education 2011). The document emphasises the importance of learners understanding the water cycle, the impact of human activities on water resources and the role of water in supporting ecosystems. Extra-mural fieldwork is also recommended in the Geography Further Education and Training (FET), Curriculum and Assessment Policy Statement (CAPS document (Department of Basic Education 2011), which includes observation, collecting and recording data, and processing, collating and presenting fieldwork findings. By incorporating water conservation into school curricula, learners can be equipped with the skills to advocate for the water needs of their communities (Olatoye & Fru 2025). Rivers in the local environment are given as an example for conducting fieldwork and developing functional knowledge, which is a bridging knowledge set that, in this study, is used as an example to connect water-related knowledge to real-world applications (McCarroll & Hamann 2020).

Geography education aims to foster environmental responsibility and socio-economic awareness of water by combining classroom-based instruction and experiential fieldwork activities (Department of Basic Education 2011). Whilst the Geography CAPS document advocates for including inquiry-based fieldwork, its implementation remains largely oriented towards classroom-based instruction (Naidoo 2025). The emphasis on theoretical rather than practical engagement has been criticised for constraining learner agency and marginalising the embodied, lived experiences of environmental issues (Naidoo 2025; Ngobeni, Chibambo, & Divala 2023), particularly those related to water quality. Shulman (2005) describes an inquiry-based approach as a 'signature pedagogy', which has been used in geography as an active teaching method, in which the learning is prompted by a problem, and is based on a process of constructing new knowledge and understanding (Spronken-Smith, Kingham & Ohlemüller 2022).

The majority of research on water quality education originates from the Global North (McCarroll & Hamann 2020). An expanded search revealed limited scholarship from the Global South, with notable examples addressing water insecurity across Africa (Olatoye & Fru 2025), the discharge of untreated sewage in Brazil (França et al. 2019) and acid mine drainage from tailings dams in South Africa (Dippenaar 2015). All these highlight significant anthropogenic impacts on water systems. This article seeks to address a gap by focusing on the training of pre-service high school geography teachers in water sustainability education from the perspective of the Global South, emphasising behavioural and affective learning.

Extensive studies highlight the strong correlation amongst water quality, sanitation and physical and mental health (Carr & Neary 2008; Li et al. 2024b; Wutich, Brewis & Tsai 2020). During the 1970s and 1980s, it became apparent that economic and population growth was seriously deteriorating hydrological, ecological and atmospheric systems (Khan, Dickinson & Heath 2014). Water is a fragile resource, with the death of two million people yearly worldwide attributed to water pollution and a lack of safe drinking water (Khan et al. 2014). In the developing world, most sewage directly goes untreated into the water supply, and tainted water is responsible for roughly 80% of illnesses in developing countries (United Nations 2003). The Brundtland report, titled *Our Common Future* and released in 1987, drew attention (amongst other elements) to the problem of water resources being threatened and the importance of preserving and improving water quality, under the now commonly accepted definition of sustainable development (SD) in which SD is defined as 'development that meets the needs of the present

without compromising the ability of future generations to meet their own needs' (UNESCO 2017:37).

The global challenges of water availability, quality and suitability are also reflected in South Africa. The fact that water is an important component of the environment is evidenced by its inclusion as one of the 17 United Nations Sustainable Development Goals (SDGs) under Sustainable Development Goal 6 (SDG 6), which focuses on ensuring access to clean water and sanitation for all (United Nations 2025). The goal aims to ensure the availability and sustainable management of water and sanitation. Climate change, desertification, poverty and other SD problems are directly or indirectly linked to water (Li et al. 2024b).

Global freshwater use is described by the Stockholm Resilience Centre as one of the nine planetary boundaries (Rockström et al. 2009), which create a safe operating space for humanity. Once these boundaries are surpassed through misuse and mismanagement, as well as through climatic shifts, humanity could reach sudden tipping points at which the ecological and hydrological systems could experience sudden and major shifts (Khan et al. 2014).

Recognising the importance of SD, in 2017, UNESCO released a guide for educators worldwide on the use of ESD in learning about the SDGs, and the way to contribute to achieving these goals. Chapter 6 ('Clean Water and Sanitation: Ensure availability and sustainable management of water and sanitation for all') of this guide focuses on SDG6 and 'identifies indicative learning objectives, suggests topics and learning activities' for water education and 'presents implementation methods at different levels, from course design to national strategies' (UNESCO 2017:1).

As noted earlier, water sustainability forms an integral part of the South African curriculum. In this context, geography education plays a role by equipping learners with knowledge of environmental changes, developing their practical investigative and analytical skills and fostering positive attitudes towards sustainably managing and protecting water resources (Spronken-Smith et al. 2022). Different modes of teaching can be implemented beyond a teacher-centred approach to learn about water effectively. Inquiry-based learning (IBL) has a place here as the structured and guided-inquiry approach supports the learning processes in which students engage directly with local real-world water problems. This method was relevant for the present study that aimed to develop water literacy by introducing students to water quality testing, but some structure was essential to ensure methodological rigour. Staver and Bay (1987) distinguished different modes of IBL, two of which were used in this study with different levels of scaffolding to encourage students to experiment with the methods, namely:

- Structured inquiry in which the lecturer provided an issue and an outline for addressing it
- Guided inquiry in which the lecturer provided questions to stimulate inquiry, after which the students undertook a self-directed study to explore the questions

Water quality education for pre-service teachers

The rationale for inquiry- and research-based pedagogies is supported by constructivist educational theory and a substantial body of research showing that students are more likely to adopt deep learning strategies when engaged in authentic tasks that use the methods and tools of their discipline (Lee, Kriewaldt & Roberts 2022; Levy & Petrulis 2012). It is important that teachers fully understand their role in educating their students for a sustainable future and are equipped to do so confidently. Teachers who themselves are environmentally knowledgeable, who harbour positive attitudes towards the environment and who demonstrate concern for environmental problems are more likely to produce environmentally literate learners (Esa 2010; Tuncer et al. 2009). The type of IBL adopted in this study is one of 'producing' (after Levy & Petrulis 2011), in which the inquiry task was designed to encourage students to explore water quality at a local water body as framed by the lecturer, with the intention that, one day, they will use the teaching method in the classroom.

Research design

This descriptive case study report results from a survey of pre-service high school geography teachers enrolled in a 5-week Geography IV module, called *Research and Applied Geographic Techniques* geared towards preparing the students to address water quality and conservation with their learners to reduce water pollution and improve water quality. The module is taught through face-to-face lectures and is geared towards preparing high school teachers to address water sustainability endeavours with their future learners. It will reduce human exploitation of water resources and preserve and/or improve human health. The students attended lectures on water sustainability and were provided with a framework to make the new body of knowledge useful and comprehensible (Wenning 2005). Following the lectures, students participated in a practical demonstration in the field to gain practical experience in using the water test kits. Inexpensive water test kits from a local vendor of education resources were sourced and provided for students.

The goals of the module are to develop an understanding of major contemporary issues in water conservation by providing content knowledge and teaching students how to independently research through inquiry-based fieldwork and to develop related pedagogical content knowledge. Students attended lectures on water quality and conservation, building on Education for Sustainability content and were instructed in the field on how to go about assessing basic water quality. The final project of the module consisted of students analysing the water quality of a water body near their residence, reporting the results and then reflecting on how they would incorporate their new learning into their teaching.

At the conclusion of the module, students were invited to complete a survey administered at the end of the first semester. Out of 94 students enrolled in the course, 21 consented to participate in the study. Results from the

20 students (21.3% of the class) who consented and completed the survey are described here.

Water education process

Prior to the fieldwork demonstration and the distribution of the task of water quality testing, students attended 12 in-person lecture sessions (presented by the author) over 5 weeks, during which relevant topics were covered, including the water cycle, the nature of potable water, reflection on relevant news reports about water shortages and pollution, basic water quality testing, water sustainability and actions to conserve water resources. Activities included guided reflections, quizzes and group discussions on water conservation and the adoption of more sustainable lifestyles. An external specialist with in-depth knowledge of water quality also addressed the students and discussed their knowledge of the importance of water conservation and of action to preserve water quality. This approach ensured an immersive and practice-oriented approach to water conservation education, equipping students with the knowledge and practical skills necessary to inspire meaningful change in their future classrooms. The content was deliberately designed to address experts' recommendations for integrating water conservation into the national education and training system (National Planning Commission 2015) and addressing the United Nations SDG 6 of ensuring availability and sustainable management of water and sanitation for all.

Fieldwork task

Students were encouraged to consider themselves citizen scientist members of their communities, in which their involvement could range from collecting and recording data to analysing results and contributing observations that could help shape or expand scientific understanding and action. During the lectures, students were instructed on field analysis of water quality, using a basic testing kit. These kits were designed to measure nitrate and/or nitrite levels, pH, hardness, chlorine, dissolved oxygen and coliform bacteria. Additionally, students had to visually observe the presence of litter in the water and along stream banks, detect any oily sheen and note unpleasant odours. Personal safety and good fieldwork practices were emphasised – for instance, using sterile gloves to minimise the potential exposure to unsafe water.

A field visit to a small lake (approximately 1200 m^2 in size) on the university campus was arranged to ensure a full grasp of the test method and of correct use of the materials, in which the techniques were demonstrated to the class, and they had the opportunity to work in groups to use a water testing kit, ask questions and demonstrate basic competence. Subsequently, each student was provided with a test kit and tasked with investigating the water quality of a stream or lake of their choice within their local area. As part of the assessment, they produced a report detailing their findings and proposing potential measures for pollution mitigation and water quality improvement.

Data sources and selection criteria

A questionnaire of seven open-ended questions was developed by the author to evaluate students' perceptions of changes in their values, sense of agency and motivation to apply newly acquired knowledge (Table 1). The instrument was piloted with colleagues, whose independent feedback informed its refinement. At the end of the course, students were invited to complete an anonymous questionnaire. Twenty responses were received, and the analysis was based on their answers.

Analytical framework and procedures

The analytical framework for this study is grounded in Kolb's Experiential Learning Cycles and Mezirow's Transformative Learning Theory. Both provide valuable perspectives for interpreting how the pre-service teachers made sense of their water quality and conservation learning experience. Kolb's Experiential Learning Theory (Kolb, Boyatzis & Mainemelis 2000) conceptualises learning as a continuous, cyclical process involving four interrelated phases: concrete experience, reflective observation, abstract conceptualisation and active experimentation. These phases are outlined below (K1–K4):

- The model differentiates between two ways of grasping experience:

  K1: *Concrete Experience (CE)* – directly engaging in a specific situation or activity

  K2: *Abstract Conceptualisation (AC)* – forming generalisations, theories or conceptual understandings
- It also identifies two ways of transforming experience:

  K3: *Reflective Observation (RO)* – critically reflecting on and interpreting the experience

TABLE 1: Questions included in the student questionnaire.

Question number	Question
1	In what ways do you think that attending the module, engaging with the materials and participating in the activities (for example: water quality survey, water testing and fieldwork) have helped you to better explain and understand the connections between the social world (people) and the natural world (water)?
2	How has this module and participation in its activities (for example: water quality survey, water testing and fieldwork) changed your understanding and thinking about water?
3	What was your favourite activity in this module? Please explain why it was your favourite and how it advanced your understanding of water.
4	In what ways has attending the module, engaging with the materials and participating in the activities helped you to go beyond the limits of your own experience?
5	How has attending the module, engaging with the materials and participating in the activities helped you to think about alternative ways of living with and using water? In what ways has the module equipped you to use water in different ways?
6	This module provided you with activities that modelled a learner-centred pedagogy. In what ways has this influenced your thinking about how you will teach water in your classroom?
7	In what ways has this module and your participation in the activities helped you to become more knowledgeable and confident to participate in current debates on water?

K4: *Active Experimentation (AE)* – applying insights to inform future action or practice

Complementing this, Mezirow's Transformative Learning Theory (ed. Mezirow 2003) emphasises the role of critical reflection in transforming perspective through seven stages (numbered M1–M7 below). The framework provides a lens for examining shifts in participants' assumptions, beliefs and understandings.

- Mezirow's model includes:
  - M1: Disorienting dilemma
  - M2: Self-examination
  - M3: Critical assessment of assumptions
  - M4: Recognition of shared experience
  - M5: Exploration of new roles and/or actions
  - M6: Plan of a course of action
  - M7: Reintegration

Together, these theories informed the coding and interpretation of the qualitative responses of participants by highlighting key cognitive and experiential dimensions of their learning about water quality and conservation. The analytical procedures focus on identifying evidence of reflective thought, transformative shifts and iterative learning processes in the students' narratives, which align closely with the theoretical constructs of both frameworks.

Seven questions and 20 participants provided 140 valid responses, a rich source for data analysis. As the students read, interpreted and responded individually and not in groups, all their responses were scrutinised and coded individually, according to the categories in Kolb and Mezirow's theories.

Data analysis of the responses proceeded manually, based on a systematic iterative process of 'code, retrieve and conceptualise', as described by Levy and Petrulis (2011). Related responses (similar and contrasting) were classified according to Kolb's Experiential Learning Cycles Theory and Mezirow's Transformative Learning Theory. In the second phase of the analysis, emergent patterns and concepts in relation to themes from the literature relating to IBL were considered. This structured approach was used to evaluate the depth of understanding and to link to broader concepts.

Ethical considerations

A full application for ethical approval was submitted to the University of the Witwatersrand Human Research Ethics Committee (Non-Medical), and ethical clearance was granted on 23 April 2024. The ethics certificate approval number is H24/03/09. Students were handed a letter inviting them to participate in the study and provide written consent before completing the questionnaire. Anonymity was maintained by not collecting any identifying information; instead, participants were assigned coded identifiers: P1, P2, P3 and so forth.

Results

The effectiveness of the module aimed at strengthening the knowledge of water conservation is examined through responses to questions across Kolb's (Figure 1) and Mezirow's (Figure 2) theories.

Amongst the participants, the data indicate a varied engagement with Kolb's four stages of learning (Figure 1).

Reflective observation (K3) recorded the highest percentage (37%; $n = 46$), which suggests a strong tendency amongst the respondents to reflect critically on experiences:

> 'I saw how theory always needs to be matched with practical to not only understand the content but why you are learning about the content.' (P3)
>
> and
>
> 'I didn't care much before the module. I did not question water quality where I grew up drinking from streams. Our actions have consequences.' (P9)

Active Experimentation (K4) also featured prominently (30%; $n = 37$), implying that the participants are applying insights in practical contexts, an important aspect of experiential learning. Respondent P19 shared a transformative learning moment:

> 'I had a chance to check the condition of water in a lake and see what is inside, rather than assuming that it is clean with eyes only, not knowing what it contains. I have never done water

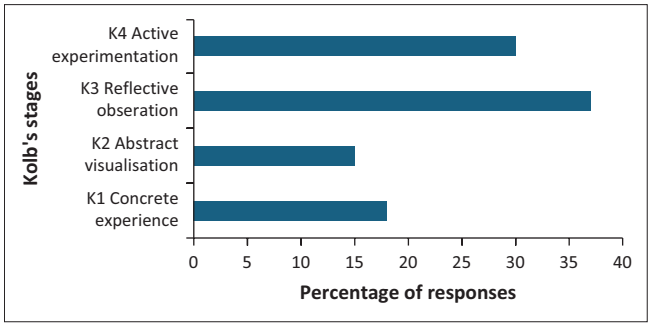


FIGURE 1: Percentages of responses classified according to Kolb's four Experimental learning cycle stages.

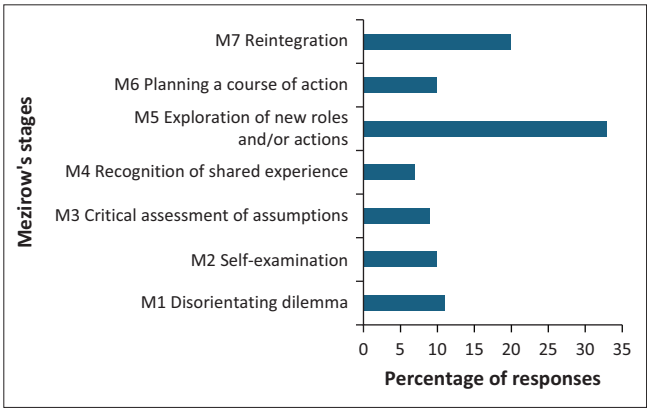


FIGURE 2: Percentage of responses classified according to Mezirow's seven transformative learning stages.

> testing in my life. It opened my eyes on how important water is and how its condition can positively/negatively affect human and aquatic organisms.' (Respondent P19)

Highlighting the connection between the theme of personal engagement and learning through scientific enquiry and social awareness, P2 noted:

> 'The water quality survey enhanced my understanding of how scientific analysis can reveal the health of water systems and how they are affected by human activities. I gained insight into water challenges faced by communities. I understand water is a complex issue beyond my personal experiences.' (P2)

Abstract Visualisation (K2) scored the lowest (15%; *n* = 18), suggesting a possible gap in forming conceptual understandings, but the provided responses showed that insight had developed: P2 stated:

> 'It helped me to understand that, as people, we need to take care of our natural environment and stop pollution. People and animals need water to survive.' (P2)

Analysing the survey responses, categorised according to Mezirow's seven phases of transformative learning, reveals notable trends in the participants' engagement with the process of transforming perspectives (Figure 2). The most frequently represented phase was *M5: Exploration of new roles and/or actions* (which impacts the theme of *Teaching and Learning*), accounting for 33% (*n* = 54) of responses.

Respondent P2 highlighted:

> '"[*T*]he value of engaging learners actively in their learning process through practical experiences like water testing, field trips and collaborative projects," [*noting that such activities*] "foster a deeper understanding by connecting theoretical knowledge with real-world applications." They added, "I will incorporate similar experiential learning activities in my teaching" and intend to "emphasise enquiry-based learning and student collaborations."' (P2)

Another participant (P10) reflected on the integration of theory and practice, stating:

> '"The module showed me the importance of using both theoretical and practical ways of teaching about water," and further noted that "fieldwork cultivated and emphasised the importance of water management."' (P10)

This view suggests that a significant number of participants are actively considering or experimenting with alternative perspectives and behaviours, indicating an inclination towards practical engagement.

The next most common phase was *M7: Reintegration* at 20% (*n* = 34), implying that participants are beginning to meaningfully incorporate these changes into their daily lives. Respondent P14 emphasised the educational potential of the module, stating:

> '"[*It*] showed me how one can encourage students to conduct their own water quality research and apply it to their own lives." [*They further reflected*] "I understand more deeply the role water plays on a micro-societal level," [*and added that the experience*] "promoted my understanding of water as a valuable resource."' (P14)

Reflecting on pedagogical growth, P20 highlighted the:

> '"value of active learning strategies, group discussion, [*and*] problem solving that can engage learners and promote deeper understanding," [*adding that they*] "learnt to use open-ended questions to encourage learners to think critically and gain in-depth knowledge of water-related issues through exposure to current debates on water."' (P20)

In contrast, early-stage phases, such as *M4: Recognition of shared experience* (7%; *n* = 12) and *M3: Critical assessment of assumptions* (9%; *n* = 15), were less frequently cited, possibly indicating limited peer dialogue or introspective challenge amongst participants. Mid-level reflection stages, like *M2: Self-examination* and *M6: Planning a course of action*, each represented 10% (*n* = 16), whilst *M1: Disorientating dilemma* stood at 11% (*n* = 17). This overall pattern suggests that, whilst foundational reflective triggers are present, the strongest emphasis lies in applying and integrating new understanding. This result indicated that many respondents may already be progressing through to the higher levels of transformative learning.

Discussion

This paper contributes to the body of work focused on preparing pre-service high school teachers as change agents for water sustainability in society. From the response to the question of what pre-service geography teachers learnt about water quality education from the module, the weight of the data reveals a dynamic interplay between experiential and transformative learning processes. The module suggests that water quality education can happen through making knowledge accessible, by choosing to give the students resources through which they can create their own knowledge and demonstrate their competence and readiness to teach in a classroom.

As shown in Figure 1, *Reflective Observation (K3)* was the most prominent of Kolb's learning modes, with 37% (*n* = 46) of responses classified according to Kolb's modes, followed by *Active Experimentation (K4)*, at 30% (*n* = 37). This pattern suggests that learners are engaged in critical reflection and active application of their insights, both of which are essential in facilitating transformative learning.

From Mezirow's phases of transformative learning in Figure 2, the transformative learning element *Exploration of New Roles and Actions (M5)* was the most frequently coded (33%; *n* = 54), followed by *Reintegration (M7:* 20%; *n* = 34). These stages indicate learners progressing beyond critical self-reflection (i.e. M2 and M3) to actual behavioural transformation and identity shift, thus paralleling Kolb's emphasis on testing new ideas through Active Experimentation. The prominence of *Self-examination*

(M2: 10%; *n* = 16), along with *Critical assessment of assumptions (M3:* 9%; *n* = 15), underscores the centrality of reflection in both models. However, the under-representation of *Abstract Visualisation (K2:* 15%; *n* = 18) and *Recognition of shared experience (M4:* 7%; *n* = 12) may suggest a need for enhanced opportunities for conceptual integration and dialogic learning. Together, these findings highlight a strong reflective–practical orientation in the learning process. The transformation occurred through cycles of experience, reflection and action but with less emphasis on abstract theorising and collective meaning-making. Instructional interventions might, therefore, benefit from scaffolding activities that encourage theoretical framing and peer dialogue, thereby enriching both individual learning and communal transformation.

At this point, revisiting both the aims of geography education as outlined in the CAPS document, as well as the aims of the Geography IV module attended by the students, is useful to evaluate the extent to which students benefited from the module. The CAPS aims include:

- Enabling learners to interpret the physical and human elements and geographical processes
- Explaining and understanding inter-relationships between the physical and the human
- Being able to make critical decisions and informed judgements on issues
- Encouraging learners to explore the areas in which they live, to understand the importance of water in their lives

The Geography IV module aims include:

- To develop an understanding of major contemporary topics in geography (including water quality)
- To develop the skills required for geographical studies
- To conduct independent research
- To develop competence in fieldwork through practical work

The data show that students embraced the idea of fieldwork outside of the classroom to enrich learning experiences, as seen in the following excerpt from P20:

> 'Water quality testing has helped to contextualise social issues such as water management within the natural world, highlighting the interconnectedness of social and environmental factors. Through hands-on activities, I've seen the impact of human activities on water systems, including pollution, over-extraction and climate change.' (P20)

P20's reflection illustrates how the experiential activity of water quality testing catalysed transformative learning. In Mezirow's terms, the hands-on engagement provided a context for critical reflection, enabling the student to challenge assumptions about the separation of human and natural systems and to reconstruct water management as a socio-ecological issue. Such shifts in perspective highlight the potential in authentic, field-based learning to foster deeper, transformative understandings within pre-service teacher education and align with the aims of both the CAPS document and the Geography IV module.

Recent research shows that pre-service teachers' confidence in their sustainability-related competencies, referred to as self-efficacy, is a critical factor in translating knowledge effectively into classroom practice. (Malandrakis et al. 2018; Munoz et al. 2025; Schutte & Bhullar 2017). The student responses in the present study indicate an intention to apply knowledge gained from lectures and water testing fieldwork to their future teaching practice. Singh et al. (2018) demonstrated that both teachers and learners in KwaZulu-Natal responded positively to field-based water testing activities, recognising them as meaningful and engaging learning experiences. Teachers reported that integrating cognitive engagement with practical, hands-on participation enhanced the overall effectiveness of the activities. This perspective resonates with the work of Newson, Lewin and Raven (2023), who emphasise the importance of water-related education across all age groups. They highlight its role in equipping individuals and communities with the knowledge, behaviours and actions needed to build resilience and respond effectively to environmental and societal change. Geography education, when embedded in thoughtful syllabus design, curriculum development and applied practice across all formal educational stages, is positioned as a pivotal driver of this adaptive capacity.

However, pre-service teachers cannot be assumed to be able to replicate such approaches in their own classrooms, as the logistical and material demands involved pose considerable challenges. Newly qualified teachers also require time to establish their professional identities whilst simultaneously recalling and integrating the skills and pedagogical strategies acquired during their training.

Conclusion

This paper is, in part, a response to Munoz et al.'s (2025) recommendation to address sustainability challenges through behaviour-focused interventions, experiential learning, institutional support and post-course engagement. The transition from simple water conservation literacy to practical actions for sustainability needs to be assessed and strengthened. Transformative learning is increasingly recognised as a significant approach in school-based education, informed by Education for Sustainability narratives and positioned as a means of addressing contemporary global challenges (Wilmot et al. 2025). Actionable items and the assumption of ongoing personal responsibility need to be addressed. Where there are gaps in water quality education, teachers can play a foundational role in addressing the multifaceted challenges (Attari, Poinsatte-Jones & Hinton 2017). This role can help to overcome the structures of power, culture and cognitive biases that shape how people engage with water conservation (McCarroll & Hamann 2020).

Sustainability education challenges should be embedded in teacher education programmes. Education and capacity development are key to addressing this challenge (UNESCO 2024). Efforts to build a water-sensitive and engaged populace must include cognitive, emotional and behavioural domains to go beyond traditional classroom teaching and textbook curricula and build water literacy through experiential learning (Dean et al. 2016).

The inquiry-based fieldwork approach adopted in this study strengthened pre-service teachers' conceptual understanding of water conservation and related environmental issues. The approach also influenced their perspectives on water pollution and management, shaping their conservation-oriented behaviours, sustainability practices and intentions to incorporate water quality education into their future teaching. Pre-service teachers are anticipated to integrate water activities based on fieldwork into their geography classrooms, drawing on themes such as the natural environment and water, the physical environment and water, and the interactions between human activities and water systems. Through this approach, their learners should not only learn to 'analyse' and 'explain' the quality of water resources but also advance to engaging with preserving water resources and making informed decisions about how this should be done. Foregrounding practical skills is essential, as these equip learners to meaningfully act following their education. This practical aspect will signify a robust capability, often facilitated by fieldwork and environmental public welfare activities (Li et al. 2024a), which can enhance the Earth's environment and mitigate the tension between humanity and the planet (Li et al. 2024a; McCarroll & Hamann 2020).

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CRediT authorship contribution

Paul L. Goldschagg: Conceptualisation, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. The author confirms that this work is entirely their own, has reviewed the article, approved the final version for submission and publication, and takes full responsibility for the integrity of its findings.

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Data availability

The data supporting this study's findings are available from the corresponding author, Paul Goldschagg, upon reasonable request. However, in accordance with the ethics clearance certificate, the data are not publicly accessible in order to protect the anonymity and confidentiality of the research participants.

Disclaimer

The views and opinions expressed in this article are those of the author and are the product of professional research. They do not necessarily reflect the official policy or position of any affiliated institution, funder, agency, or that of the publisher. The author is responsible for this article's results, findings and content.

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