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Assessing the integration of content knowledge of selected Sustainable Development Goals into lesson delivery among Geography pre-service and in-service teachers in Gauteng, South Africa

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How to cite this article: Chidzungu T. & Schoeman T. (2026). Assessing the integration of content knowledge of selected Sustainable Development Goals into lesson delivery among Geography pre-service and in-service teachers in Gauteng, South Africa, *Journal of Geography Education in Africa*, 9, 125-138. <https://doi.org/10.46622/jogea.v9i.7116>

Article history: 28 March 2026 | Accepted 28 May 2026 | Published 09 June 2026

ABSTRACT

This study explores the level and integration of Sustainable Development Goals (SDGs) Pedagogical Content Knowledge into Geography lessons among pre-service (n=182) and in-service teachers (n=120) in Gauteng, South Africa. Data were collected through online and hard-copy surveys from purposive- and snowball-sampled participants. Drawing on Shulman's Pedagogical Content Knowledge theory, results show that there is inadequate knowledge of the SDGs amongst participants, with 40 out of 120 (33.3%) and 64 out of 182 (35.2%) rating it as 'average'. Pre-service teachers mainly learn about SDGs through university courses, while in-service teachers rely on their experience. In-service teachers achieved higher mean Likert-scale scores for their content knowledge of selected SDGs (scores of SDG 4: 3.42; SDG 7: 3.38; SDG 13: 3.39) compared to pre-service teachers (SDG4: 2.95; SDG 7: 3.02; SDG 13: 3.01). However, pre-service teachers more frequently integrated SDGs into lessons, with a stronger correlation between SDGs 7 and 13 ($r=0.816$) than in-service teachers ($r=0.696$). The study recommends strengthening sustainability education in all stages of teacher development.

Keywords: In-service teachers, Pedagogical content knowledge, Pre-service teachers, Sustainable Development Goals, Teacher training.



INTRODUCTION

Globally, education is widely recognised as a key driver of sustainable development and plays a central role in achieving the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) (UNESCO, 2017). Beyond its direct focus on education, SDG 4 serves as a cross-cutting enabler for achieving the other 16 SDGs, in which education is a common feature throughout (UNESCO, 2017; Leal Filho, 2021). Education equips learners and wider society with the knowledge, skills, values, and attitudes to address contemporary global sustainable development challenges, such as climate change and energy transition. The interconnected nature of the SDGs, therefore, highlights the importance of sustainability education in educational policy, curriculum development, and classroom practice. Despite this recognised role of education in advancing the SDGs, global efforts to integrate sustainability education into higher education, including teacher education curricula, remain slow, resulting in a gap in the development of SDGs-related Pedagogical Content Knowledge (PCK) (Leal Filho, 2021; Bhoi et al., 2025). The concept of PCK, introduced by Lee Shulman in the 1980s, extends beyond subject-matter knowledge to encompass knowledge of how to teach the subject effectively (Shulman, 1986; Almonacid-Fierro et al., 2023). Thus, PCK provides an important framework for understanding how teachers integrate SDG concepts into Geography teaching, as it explains how subject knowledge is transformed into effective classroom practice.

Internationally, countries such as the Philippines, Scotland, and India have incorporated sustainability education into higher education; teacher education curricula or teacher professional standards and school curricula (Duran & Mariñas, 2024; Evans et al., 2017; Joseph et al., 2025). In southern Africa, UNESCO (2018) reports that a flagship action-learning initiative under the Global Action Programme supports capacity building amongst secondary school teachers to address regional sustainable development challenges linked to the SDGs. However, teacher education initiatives lack coherent sustainability curricula, prescribed reference materials and structured pedagogical approaches needed to prepare pre-service teachers for sustainability education (Evans et al., 2017; UNESCO, 2018). To address this, programmes must shift from traditional teacher-centred teaching methods to learner-centred pedagogies such as project-based learning.

In South Africa, sustainability-related concepts are embedded within the Geography Curriculum and Assessment Policy Statement (CAPS), developed by the Department of Basic Education (DBE), which includes topics such as climate, weather, ecosystems, resources, and sustainability in Grade 10; climate systems and human-environment interactions in Grade 11; and environmental geography and global issues in Grade 12 (DBE, 2011). These topics are directly aligned to the study's three selected SDGs: SDG 4 (Quality Education), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action). A gap was identified by Chidzungu & Schoeman (2026) in a study of in-service teachers in Gauteng, South Africa, which found that many teachers struggled to understand the SDGs, climate change, and energy-related concepts. The study also revealed inadequate training in sustainability-related content knowledge and pedagogical skills.

Furthermore, while sustainability-related concepts are embedded within the South African Geography curriculum, limited research has examined how Geography teachers develop and apply pedagogical content knowledge related to SDGs 4, 7, and 13. Existing studies tend to focus either on curriculum content or general sustainability education, with limited attention given to comparative analyses between pre-service and in-service Geography teachers (García-González et al., 2020; Bhoi et al., 2025; Chidzungu & Schoeman, 2026). This study, therefore, seeks to address this gap by adopting a comparative approach to examine content knowledge and pedagogical competencies for integrating SDGs 4, 7, and 13 among Geography pre-service teachers from the University of Johannesburg, and in-service teachers in Gauteng, South Africa.

Sustainable Development Goals

The concept of global responsibility and integrated sustainability became more pronounced during the Rio+20 Conference in 2012, where the outcome document *The Future We Want* formally proposed the SDGs and advocated for broader stakeholder engagement (United Nations, 2015). Building on this momentum, the United Nations adopted the SDGs in 2015 through the document *Transforming Our World: The 2030 Agenda for Sustainable Development*, which introduced 17 SDGs and 169 targets in the commitment to 'leave no one behind' (United Nations, 2012). Thus, the 2030 Agenda highlights the interconnected nature of the SDGs, whereby SDG 4 plays a pivotal role in achieving the other selected goals, namely SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action).

Sustainable Development Goal 4: Quality Education

According to the United Nations (2012), SDG 4 aims to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.' Achieving this goal largely depends on teachers' competencies, particularly on their content knowledge and pedagogical knowledge. However, research indicates that both pre-service and in-service teachers often lack adequate understanding of the SDGs, limiting their ability to integrate sustainability concepts effectively into classroom practice (Encabo-Fernández et al., 2023; Authors, 2026). Studies further show that many educators require additional training and pedagogical support to integrate SDG 4 effectively into teaching and learning (Sayed & Ahmed, 2015; UNESCO, 2017; Nakidien et al., 2021). Therefore, there is a need for teachers to continually learn and adapt their knowledge in response to the economic, environmental, and social dimensions of sustainability (Vieira, 2020; Leal Filho, 2021). Consequently, continuous, lifelong, and transformative learning on the SDGs among teachers and student teachers is imperative.

Sustainable Development Goal 7: Affordable and Clean Energy

SDG 7 aims to 'ensure access to affordable, reliable, sustainable, and modern energy for all' (United Nations, 2012). Effective teaching of energy topics requires teachers to possess strong content knowledge and pedagogical competencies that foster critical thinking, problem-solving, and real-world application of sustainability concepts (Mochizuki & Bryan, 2015). However, teachers often lack adequate knowledge on energy systems and related topics, such as the Just Energy Transition, that are closely linked to climate change, sustainability, and energy resources (Bodzin, 2012; Chidzungu & Schoeman, 2026). Research shows that teacher development programs and energy literacy initiatives help improve teachers' knowledge and support the use of sustainability concepts in the classroom through interdisciplinary and participatory teaching methods (Burmeister et al., 2012; UNESCO, 2017; Bhoi et al., 2025). Collaborations among educational institutions, industry stakeholders such as Eskom (in South Africa), and civic organisations can support knowledge acquisition, dissemination and awareness of energy literacy.

Sustainable Development Goal 13: Climate Action

Furthermore, SDG 13 deals with 'climate action calls for taking urgent global action to combat climate change and its impacts by reducing greenhouse gas emissions' (United Nations, 2012). This goal places further demands on teachers to possess both content and pedagogical knowledge related to climate change education. Henderson et al. (2017) argue that teachers' understanding of climate change strongly influences the effectiveness of their teaching practice. Teacher collaborations across disciplines play a pivotal role in providing a more holistic and contextualised understanding of climate issues (Bhoi et al., 2025). This is not only important for learners but also for practising teachers themselves. Research further demonstrates that professional development opportunities improve pedagogical strategies for climate action and sustainability education (Shepardson et al., 2012; Mochizuki & Bryan, 2015; Henderson et al., 2017). Recognising that climate education is inherently interdisciplinary can help bridge the gaps in teacher subject expertise and pedagogical competencies. The literature suggests that SDGs 4, 7, and 13 in particular require substantial teacher development, as many educators lack the necessary content and pedagogical knowledge competencies to integrate these sustainability concepts effectively into classroom practice.

MATERIALS AND METHODS

This study adopted a qualitative design in which data were initially qualitative, coming from open-ended questions on an anonymous questionnaire that were analysed thematically. Complementary quantitative analysis was used for the answers to closed questions. Participants were 182 purposively sampled Geography pre-service teachers from the authors' institution (University of Johannesburg), and 120 purposively and snowball-sampled in-service Geography teachers from public schools within the Gauteng Department of Education (GDE) region. Participants either completed an online or hard-

copy questionnaire, depending on their preference. The instrument comprised four sections: demographics, and their knowledge, process, and application of the examined SDGs. Closed-ended items included multiple-choice, single-responses and 5-point Likert-type scales (ranging from No Knowledge (value of 1) to Excellent Knowledge (value of 5)), enabling quantification of attitudes and perceptions. Mean scores were used to indicate central tendency, while standard deviation reflected response variability for responses. Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS), employing both descriptive and inferential statistics such as correlation. The collected qualitative data were analysed using thematic analysis as proposed by Braun & Clarke (2006). This method was suitable for the study because it enabled the researchers to explore participants' experiences and perceptions regarding SDGs content knowledge and integration in Geography education. The identified themes focused on respondents' sources of SDG knowledge, and the integration of the SDGs into Geography lesson delivery. Ethical clearance for this study was obtained from the University of Johannesburg (Ref: 2024-09-02) and the GDE (Ref: 2024/163A). Participation was voluntary, with informed consent obtained, and anonymity and confidentiality maintained throughout.

RESULTS

Demographics of the participants

Participants were predominantly African in both groups (in-service: 93.3%; pre-service: 97.3%), with minimal representation from other racial groups. Gender distribution was balanced among in-service teachers (50% male, 50% female), while pre-service teachers were slightly female dominated at 50.5% female, 47.8% male, and 1.6% as non-binary. All in-service participants taught Geography, with it being a major for most participants (95%) and a minor for 5% of the participants. Their qualifications ranged from an Advanced Certificate in Education to a Masters degree, with the majority holding Honours degrees (59%). The largest proportion of respondents (74.2%) had 0-10 years of teaching experience. Pre-service teachers were all enrolled in Geography as a major or minor subject and had limited teaching experience, typically restricted to teaching practice only.

Teachers' sources of SDGs content knowledge

In-service teachers stated that they developed content knowledge of the SDGs through personal study, online courses, and teacher development programmes, while others stated that they still need to learn more about SDGs. Some said that they developed content knowledge through self-study during their preparations for lesson delivery and through online resources and collaborating with colleagues (Table 1).

Table 1. Examples of in-service teacher responses on how they develop content knowledge of the SDGs.

Relevant supporting quotation	Participant number
'After reading books and updating myself via news'	Respondent 2
'As a teacher, I developed my SDGs knowledge through training, online resources, and collaboration with colleagues. I also learned it by incorporating SDGs into my lesson plans and staying up-dated on relevant literature and research'	Respondent 66
'Through teaching Grade 9 content'	Respondent 64
'Through reading academic literature and following current affairs in sustainable development'	Respondent 87
'From YouTube, I watch videos about sustainable development'	Respondent 104

Some in-service teachers also said that they acquired knowledge of the SDGs formally through university courses, or through other non-formal means (Table 2).

Table 2. Examples of in-service teacher responses on how they develop content knowledge of the SDGs through other formal or non-formal means.

Relevant supporting quotation	Participant number
'For SDG 4, I gained more awareness through the second-year Honours course, which I did in Education Management, Law, and Policy... SDG 7 and 13 knowledge has improved through the creation of class teaching materials and through research done by me to improve my own knowledge'	Respondent 57
'I am currently busy with my Honours in Geography; I am learning a lot as one of my lecturers invites guests externally, including from other universities'	Respondent 95
'The University of Johannesburg integrated curriculum has integrated SDGs in the Geography content, so attending lessons has helped me develop the knowledge'	Respondent 180

Some in-service teachers said that they acquired SDG knowledge through attending workshops at the school departmental level or those organised by organisations. For example, respondent 117 said: 'There was an organisation that came to school and educated the geography teachers about SDGs.' Other participants described how they have limited to no knowledge about the SDGs and therefore require training in teaching competencies in this area. For example, respondent 81 said: 'More training is needed to enhance skills.' Respondent 83 said: 'I need to learn more about these because I have been selective with what I read or watch.'

For sustainability literacy to take root within in-service teachers, it should be supported at the school, departmental, district, provincial, and national levels, working in collaboration with non-governmental organisations and civil society. The pre-service teachers expressed that they developed it during high school, through lectures at

university and during workshops offered by organisations (Table 3). Notably, both pre-service and in-service teacher groups included those who had little to no knowledge of the SDGs. Both formal and informal means of knowledge acquisition were also mentioned.

Table 3. Examples of pre-service teacher responses on how they develop content knowledge of the SDGs.

Relevant supporting quotation	Participant number
'I developed the knowledge through school during my time of study'	Respondent 6
'Through school competitions in primary school'	Respondent 19
'Mostly topics we focus on in geography have insight into SDGs, like topics of natural resources'	Respondent 37
'I have developed it from a workshop on sustainability through my educational journey'	Respondent 39
'Through lectures and organisations coming to schools to impart the knowledge'	Respondent 45
'Lectures were the most efficient way to develop my knowledge'	Respondent 75
'Through my studies in Geography in school and ongoing studies in universities'	Respondent 82
'Through lessons delivered by my lecturers and mentors' teachers during work-integrated learning'	Respondent 94

Teachers' pedagogical content knowledge ratings of SDGs 4, 7, and 13

The pre-service and in-service teachers were asked to rate their own content knowledge about the SDGs. The results indicate that in-service teachers demonstrated relatively high levels of knowledge regarding SDG 4 compared to pre-service teachers, with more varied responses among pre-service teachers (as indicated by a higher standard deviation of values) (Figure 1). For SDG 7 and for SDG 13, in-service teachers had a higher mean score compared to pre-service teachers. Overall, the modal rating for content knowledge across the two participant groups was 'average', with 33.3% (40 out of 120) of in-service teachers and 35.2% (64 out of 182) of pre-service teachers falling within this category.

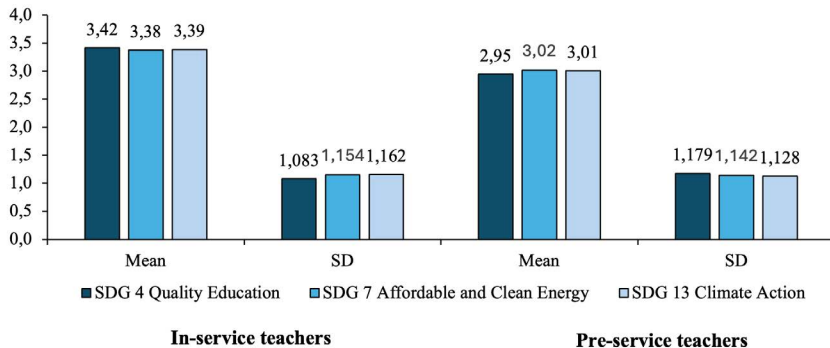


Figure 1. Self-rating of SDGs 4, 7, and 13 according to the teachers’ pedagogical content knowledge. The whisker indicates standard deviation (SD).

Comparative integration of SDGs 4, 7, and 13 into Geography lesson delivery

Pre-service teachers demonstrate higher mean integration scores for SDG 4 (Quality Education) than in-service teachers, but with greater variability in their responses (SD=1.312) (Figure 2). These findings show significant awareness of climate and sustainability education. For SDG 7, pre-service teachers also show a relatively higher average (mean=2.81) and moderate variability of responses (SD=1.198). For SDG 13, pre-service teachers also show a high mean score (2.97). This could indicate a high implementation of climate action and sustainability in teacher education programs, positively influencing their integration into the classroom. Responses from pre-service teachers on how they integrated SDGs in their teaching are shown in Table 4.

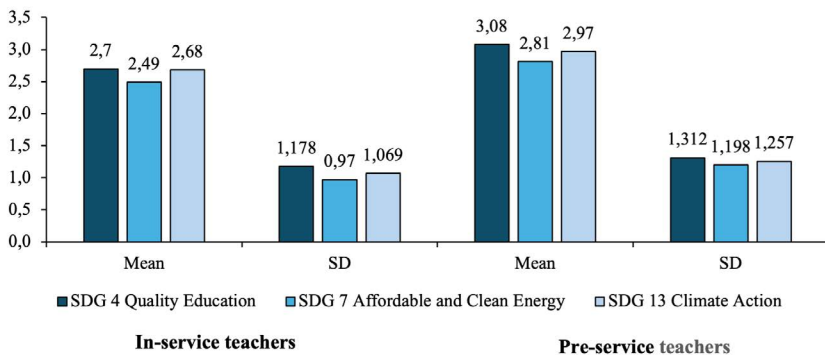


Figure 2. Integration of SDGs 4, 7, and 13 among pre-service and in-service teachers.

Table 4. Examples of pre-service teacher responses on how they integrate the SDGs into classroom activities.

Relevant supporting quotation	Participant number
'I would do a class discussion on sustainable development and put them in groups to do an assignment researching SDGs'	Respondent 12
'Project work would give the students time to engage with SDGs'	Respondent 14
'I would give learners topics to research and discuss as a group and present to the entire class; I would be there to guide and correct them'	Respondent 16
'I would use a project-based strategy to make learners do research about their area and critically analyse their area for any factors that might link with the SDGs'	Respondent 80

Discussions and project work dominated the approaches the pre-service teachers would use. Responses from in-service teachers are shown in Table 5.

Table 5. Examples of in-service teacher responses on how they integrate the SDGs into classroom activities.

Relevant supporting quotation	Participant number
'In project-based assessments they can do research based on SDGs'	Respondent 10
'Games will make concepts to be visualised'	Respondent 28
'An individual component and a research project followed by a class discussion of findings'	Respondent 52
'Through project-based learning'	Respondent 72
'Current stories linked to sustainability'	Respondent 75
'Showing learners videos and pictures that are relevant to the topic in hand'	Respondent 96

The in-service group had several different pedagogical approaches (project-based, discussions, individual work, stories, videos and games) they used in integrating SDGs into their teaching. This showed greater variability of pedagogical approaches that could be attributed to their greater experience although, from the quantitative findings, in-service teachers had low levels of SDG integration (Figure 2).

Correlation between teachers' content knowledge of the SDGs

Pearson's correlation coefficient was used to quantify relationships between teachers' content knowledge scores for the SDGs. The results in Table 6 show a positive correlation of content knowledge for both in-service and pre-service teachers. However, pre-service teachers show stronger correlations for SDGs 7 and 13 ($r=0.718$, 0.816 respectively) compared to in-service teachers ($r=0.606$, 0.696 respectively). Overall, pre-service teachers demonstrated stronger interconnections among the three SDGs than in-service teachers. This may be attributable to the increased incorporation of sustainability literacy into recent teacher training curricula.

In-service teachers demonstrated significantly higher mean content knowledge scores than pre-service teachers across all three SDGs ($p < 0.05$). Their content knowledge was developed through self-study, experiential learning in the field, and qualification upgrades (Tables 1, 2). In contrast, pre-service teachers integrated the three SDGs more into their lessons and developed their knowledge mostly in high school and university (Table 3).

Table 6. Pearson's correlation coefficient values for content knowledge of the SDGs for pre-service and in-service teachers.

Sustainable Development Goals	SDG 4 Quality education		SDG 7 Affordable and clean energy		SDG 13 Climate action	
	In-service	Pre-service	In-service	Pre-service	In-service	Pre-service
SDG 4: Quality Education	1.000	1.000	0.606	0.777	0.632	0.718
SDG 7: Affordable Energy and Clean Energy	0.606	0.777	1.000	1.000	0.696	0.816
SDG 13: Climate Action	0.632	0.718	0.696	0.816	1.000	1.000

Discussion

The results presented in this study show that in-service teachers demonstrate high levels of knowledge across the three SDGs compared to pre-service teachers (Figure 1). This is similar to a study at Osun State University, Nigeria, where academics had higher content knowledge of SDGs than university students (Omisore et al., 2017). The high average scores among in-service teachers could be attributed to their greater teaching experience, which provides greater exposure to sustainability-related content. Professional teaching experience and environmental and climate education in schools could enhance in-service teachers' knowledge of sustainability topics (Anderson, 2012; Leal Filho et al., 2015; UNESCO, 2017). These findings indicate that initial teacher education at the pre-service stage is not sufficient to enable pre-service teachers to integrate sustainability education into school practice, as their knowledge is a key determinant of how confidently and accurately these topics are taught in their classrooms. At the same time, the variability observed even among in-service teachers (Figure 1) highlights the need for continuous professional development that moves beyond basic awareness toward deeper, subject-specific competence. In the broader context of sustainability literacy, these findings emphasise the importance of strengthening both preservice and in-service teacher education.

In the in-service group, self-study, online learning platforms, and workshops were the main sources of SDGs CK acquisition (Tables 1, 2). However, both groups included respondents with little or no knowledge of the SDGs, indicating the need for targeted training. Teachers' knowledge is obtained from formal education (e.g., school subjects and lectures) and informal learning sources such as self-study and online platforms (Omisore et al., 2017; Dzotor et al., 2020; David & Maroma, 2025). The findings confirm and highlight

the diverse and self-directed nature of SDG knowledge acquisition amongst participants. The identification of multiple learning pathways suggests a lack of coordinated integration of SDGs in formal teacher-training curricula and in-service teacher development programmes. Consequently, there is a need for a more systematic inclusion of SDGs-related content in teacher training curricula and professional development initiatives.

Pre-service teachers demonstrated higher average integration scores for the SDGs in Geography lesson delivery (Figure 2); however, they adopted fewer pedagogical approaches for integrating the SDGs compared to the in-service teachers (Table 4). In contrast, the in-service teachers highlighted a wider variety of approaches for integrating SDG concepts (Table 5). This is likely due to their greater experience in the field. This supports Leal Filho's (2021) view of experiential learning as being shaped through experience. It has been argued that to effectively integrate SDG concepts such as climate literacy and sustainability into teacher education, pedagogical methods must evolve beyond traditional approaches to include simulations, case studies, and project-based learning (Bhoi et al., 2025). Similarly, Leal Filho (2021) identifies a variety of non-traditional learning methods, including transformative learning, whereby thinking is adjusted based on new information. The gap between high integration scores and moderate conceptual understanding indicates that integration alone does not necessarily reflect strong content knowledge and practical application skills amongst teachers. This highlights the need for improved training and greater exposure to innovative pedagogical approaches to sustainability education in teacher development programmes. Pre-service teachers exhibited the strongest correlation between SDG 7 and SDG 13 (Table 2) which is higher than that of in-service teachers. This could be linked to the fact that the SDGs are topical issues that pre-service teachers are exposed to extensively during training. The literature also suggests that many SDGs are interconnected and mutually reinforcing (UNESCO, 2017; Zaini & Osman, 2024). Overall, the strong correlations found in this study support the idea that sustainability education is most effective when it adopts an integrated approach.

CONCLUSIONS

The study examined the level of pedagogical content knowledge and the integration of SDGs 4 (Quality Education), 7 (Affordable and Clean Energy) and 13 (Climate Action) in lesson delivery among pre-service and in-service teachers. The findings revealed that most pre-service teachers developed their content knowledge during high school and university education, whereas in-service teachers mainly acquired it through self-study and further education (Tables 1-3). Overall, the modal rating for content knowledge across the two participant groups was 'average' with around one third of all participants falling into this category. In-service teachers demonstrated consistently higher levels of content knowledge than pre-service teachers. This could be attributed to their greater classroom experience which is also linked to the greater variety of pedagogical approaches that in-service teachers use in teaching SDG concepts (Table 5). Although

pre-service teachers demonstrate comparatively lower content knowledge, they exhibit higher levels of integration in lesson delivery (Figure 2). This could be due to the emphasis placed on climate change, energy, and sustainability within teacher education curricula, as well as their own engagement with SDGs-related topics (Tables 1, 2). Therefore, pre-service teachers may be more inclined to incorporate these topics into their teaching practices. Overall, the integration of the SDGs into Geography lessons, as well as the teachers' content knowledge, is influenced by teaching experience, exposure to SDG-related concepts, and both formal and informal SDG training acquired through schools, universities, and civic organisations.

In summary, this study recommends:

- Integrating more comprehensive sustainability modules for teacher education curricula to improve content knowledge of key sustainability concepts;
- Teacher education curricula and in-service teacher sustainability education manuals should be aligned with national and international policy imperatives on SDGs;
- Providing continuous context-specific in-service teacher development programmes on SDGs, climate change, and energy topics explicitly aligned with the geography content and assessment of the CAPS in South Africa;
- Developing and providing manuals on pedagogical strategies in the integration of sustainable development goals in lesson delivery among in-service teachers.

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