

RETHINKING SCIENCE EDUCATION IN GHANA: A FEYERABENDIAN APPROACH TO INNOVATION AND INQUIRY

¹Dr. Thomas Nipielim Tindan, ²Agongo Abdul-Rahaman, ³Dick Samuel Yaw, ⁴Tadaana Stephen Buolamegna,

⁵Amadu Mamudu Timbilla

¹CKTedad-University of Technology and Applied Sciences, Box 24 Navrongo, Ghana

ORCID: <https://orcid.org/0000-0002-4208-1617>

²Bolgatanga Girls' Senior High School, Box 60, Bolgatanga, Ghana,

ORCID: <https://orcid.org/0009-0004-6795-8675>

³Department of Science Education, CKTedad-University of Technology and Applied Sciences, Box 24, Navrongo,

⁴Department of Science Education, CKTedad-University of Technology and Applied Sciences, Box 24, Navrongo,
Ghana,

⁵STEM SHS-Kpasenkpe, Box WL62,

ABSTRACT

This paper calls for a reconceptualisation of science education in Ghana through the lens of Paul Feyerabend's epistemological anarchism. The paper seeks to highlight the restrictive, Eurocentrically-bound models of science teaching, and how Feyerabend's philosophy draws out ways for local relevance, innovation and critical thinking—especially his advocacy of methodological pluralism, including the infamous "anything goes." The paper advances the position of integrating indigenous knowledge systems, decentralising curricular control, and developing methods that support the numerous ways science can be taught in ways that are equitable and rights-based. The paper offers the case for a conceptualisation of science learning based on fostering critical inquiry, cultural relevance and epistemic diversity. Viewing science education through a Feyerabendian lens offers exciting possibilities for decolonising science education, and preparing learners to contribute towards addressing complex global challenges.

KEYWORDS: Anarchism Education, epistemology, Philosophy, Science.

1. INTRODUCTION

Paul Feyerabend (1924–1994) was an Austrian-born philosopher of science known as one of the 20th century's most obscure, most combative philosopher of science, and his most read work, *Against Method* (1975 [1]), made a very good case against embracing the idea of a unique, universal method to science. In it, he suggested what has been termed epistemological anarchism, candidly saying that in the quest for knowledge, "anything goes." For Feyerabend, the history of science has always involved historical aberration, contradiction, and a creative mix of methods—often including the scientific method. He questioned science's privileged position among other types of knowing, and he claimed that no tradition, scientific or cultural, should be privileged as the one and only truth.

In terms of science education, Feyerabend's ideas suggest a radical re-thinking of the way individuals understand, create, teach and appreciate knowledge. It also stimulates re-thinking with regard to non-Western understandings of knowledge systems as well as acknowledging plurality, creativity and freedom. His critique of the pedagogic orientation of methodological monism - particularly where science is externally framed as an objective and rigid process - resonates with postcolonial and decolonial education movements, particularly in areas like Ghana that are still coming to terms with colonial legacies in educational systems.

Specifically, in Ghana, science education benefits from Euro-American models and frameworks that rely on a rigidity of methods, objectivity, and hierarchical epistemologies. There are benefits to these models but in many contexts, they diminish local relevance, learner agency, and creativity. One response to this rigidity may come from Paul Feyerabend - one of the most radical of the philosophers of science - who stated famously that there is not one scientific method to be universally applied, but instead "anything goes" in the quest for knowledge (Feyerabend, 1975 [1]). A Feyerabendian view implies a re-evaluation of what scientific knowledge may be, and figure an alternative to rigid models of teaching scientific knowledge.

This paper argues that Ghana's science education system should embrace a Feyerabendian model, which would promote innovation, local relevance, and critical thought. Epistemological pluralism proposes that under an "anything goes" model of knowledge, engaged with pluralism would counter dogmatism in science, while incorporating indigenous perspectives, embodied learning, and crossing disciplinary boundaries.

2. FEYERABEND'S EPISTEMOLOGICAL ANARCHISM AS A CATALYST FOR INNOVATION IN SCIENCE EDUCATION

In Ghana, science education is still predicated on rigidity, linear definitions of instruction and curricula that privilege uniformity over creativity. Even with national commitments to a "critical thinking" and "inquiry-based" approach (Ministry of Education, 2018 [2]) in policy documents, science classrooms in Ghana still instantiate rote learning and teacher-directed practices (Mohammed et al., 2021; Akyeampong et al., 2013 [3]). The present discussion contends that Ghana's science education framework can do little to produce genuine innovation because it does not allow learners the freedom to explore, experiment or envisage alternative possibilities. This framework is consistent with Feyerabend's (1975 [1]) maximal criticism of "methodological monism—the erroneous belief that there is a scientific method that works for everyone."

Feyerabend's epistemological anarchism takes issue with this rigidity, asserting that "there is no one method in science" and that it is a case of "anything goes" in pursuing knowledge (Feyerabend, 1975, p. 23 [1]). This radical idea is an interesting and timely way of thinking about science education in Ghana. Feyerabend does not argue for rigor, but rather for intellectual freedom and diversity of thought. This review is an exploration of how his philosophy can help in conceiving innovation through flexible pedagogies, curricular pluralism, and democratic practices of knowledge-making.

Feyerabend's argument that scientific progress is predicated on breaking with standardized procedures invites pedagogical innovations. Feyerabend's critique emphasizes openness to divergent inquiry rather than the rejection of structure (Preston, 1997 [4]). The context of Ghana where pedagogy emphasizes strict scheme of work, accepting alternative modes of inquiry when using pedagogical innovation, like community-based projects, storytelling, role-play, or artistic modelling, can encourage scientific imagination. Learner engagement and creativity increased when indigenous ecological knowledge was incorporated into teaching practices (Adom &

Harvey-Brown, 2024 [5])

Ogunniyi (2007 [6]) presents important ideas for how science can be taught in postcolonial contexts, stressing that teaching needs to be inclusively pluriversal and experiential. In classrooms where learners are negotiating between Western and Indigenous epistemologies, plural practices support a more balanced and inclusive approach to teaching without necessarily privileging one or the other. These types of practices correspond to Feyerabend's epistemological anarchism, which advocates pedagogical change that brings together Indigenous knowledge, practical experimentation, and inquiry-based learning.

The science curriculum in Ghana is extremely centralized, leading to systemic constraints on teachers' pedagogical ingenuity and students' agency in their own inquiry and creativity (Takyi, Korankye, & Akolbila, 2023 [7]). The top-down programmatic form of organization controls creative thinking and decreases inquiry. Feyerabend's critique is applicable: centralized curricula serve as material ideological apparatus that constrain thought and make science dogmatic. Teachers should be encouraged to abandon official content in favour of student inquiry that is local and troublesome, but deemed relevant to the learners' lives.

Freire's (1970 [8]) pedagogy of dialogue and Bruner's (1961 [9]) notion of discovery learning advocate for similar learner-centred pedagogy, where students create their own knowledge from experience and productively engage in science. Also, science is substantively strengthened when many perspectives are included, particularly those of women, colonized groups, and Indigenous people (Harding, 1998 [10]). What this approach signifies for Ghanaian science education is the acknowledgement of the lived knowledge of rural learners - knowing how to use herbal medicine, predict the weather, or farm in an ecological context - acknowledging that their lived knowledge is an important area of science.

Tabulawa (2013 [11]) critiques donor-driven reforms in Africa for advancing Western ideologies and models without adaptation to the culture they intended to affect. A Feyerabendian response would assert that authentic change is initiated through the acceptance of disorder, allowing for variance, and demonstrably avoiding prescriptive obligations.

Feyerabend (1975 [1]) has history to remind readers when he states that advances in science came not from following accepted methods, but from violating accepted methods. For example: Galileo's thought experiment violated Aristotelian orthodoxy; Einstein's theory of relativity disregarded Newtonian certainties; and Darwin's theory of evolution brought together theologies, naturalistic, and empirical accounts of existence in a way that was innovative (to name but a few cases). These advances are due in part, because the scientists were in essence violating 'standard', accepted methodologies and entertaining ideas that most people would consider 'out there'. The lesson for curriculum developers and science teachers in Ghana is to focus less on totalising science knowledge as a body of fixed fact, and instead change the narrative to one where they focus on teaching students that scientific knowledge is evolved knowledge and still evolving. It has been debated, and it emerges largely from a space of creative disobedience. The approaches identified by Aikenhead and Jegede (1999 [12]) as "cultural border crossing" in science, as well as Snively and Corsiglia's (2001 [13]) notion of "two-eyed seeing" for integrating Indigenous and Western knowledge systems, exemplify practical manifestations of pedagogical innovation and epistemic diversity. In a similar vein, philosophers from Africa such as Kwame Nkrumah (1963 [14]), Kwame Gyekye (1997 [15]), and Kwame Anthony Appiah (1992 [16]) affirm pluralistic reasoning traditions that recognize and celebrate Africa's contribution to global knowledge. Recognizing them in science

education strengthens Feyerabend's claim that science does well under diversity and not conformity.

2.1 ENHANCING LOCAL RELEVANCE THROUGH A FEYERABENDIAN LENS: INTEGRATING INDIGENOUS KNOWLEDGE

The marginalization of indigenous knowledge systems (IKS) in formal science education remains a significant obstacle to relevance, inclusivity, and innovation in classrooms in Ghana. The prevalence of Western scientific paradigms in curricular knowledge and content, assessment, and pedagogy has resulted in forms of epistemic imperialism that bypass or deny local ways of knowing (Odora Hoppers, 2002; Agrawal, 1995 [17]). Feyerabend's epistemological anarchism, particularly his call for pluralism and methodological tolerance, provides a powerful theoretical framework for countering this hierarchy and rethinking science education in Ghana.

Feyerabend (1975 [1]) critiques a singular definition of scientific method, promoting instead the idea that knowledge develops through multiple methodologies however stubbornly “non-scientific” they may be in the eyes of regular scientific rules. The famous line “anything goes” was not a proposal for chaos but a philosophical provocation against a fixed definition of method. This position affirms the possibility of accessing indigenous epistemological methods that may have been ignored because they did not fit the empiricist or positivist definition. Pluralism in Ghanaian science education allows for the incorporation of indigenous knowledge, including ecological knowledge of native species and sustainability practices, as demonstrated in recent pedagogical models (Adom & Harvey-Brown, 2024; Acharibasam & McVittie, 2023 [18]).

The epistemological tension surrounding Indigenous knowledge and Western science is a colonial legacy that continues to influence educational systems in Africa, such as in Ghana, where knowledge systems located as “merely local” are often delegitimized by formal curricula that prominently place Western science as universal and superior (Prempeh, 2022 [19]). This process of constructing knowledge binaries is not confined to a curriculum, but in educational systems that privilege certain knowledge systems over others. The impact significantly undermines students’ engagement with their cultural identities and local knowledge systems, as well as innovation and risk taking (emissions of alternative knowledge systems that otherwise inform local realities).

Feyerabend's pluralism encourages the decomposition of knowledge binaries with the support of “epistemological democracy” – the space where knowledge systems are able to be co-used under equal value (Feyerabend, 1987 [20]). In other words, it promotes science education curricula that are culturally inclusive, community informed, and locally responsive. Overwhelmingly, research is showing that culturally relevant pedagogy improves student engagement and understanding when encountering science (Jegade & Okebukola, 1991 [21]). For example, the use of indigenous agricultural calendars and rainmaking rituals in environmental science lessons in Northern Ghana have helped to close the conceptual gap between science taught in school and science encountered in everyday life (Aniah, Aasare, & Bonye, 2019 [22]).

Furthermore, including IKS in science education not only generates a more critical and reflective type of scientific literacy, but moves science education away from simply imparting factual knowledge to students, to asking students to compare, critique and synthesize knowledge systems - a method consistent with Feyerabend’s understanding that contradictions and diversity are the propellers of knowledge development. This approach also increases a student’s cognitive flexibility and creativity in addressing complex problems in the real-world; like, issues such as climate change, public health, and food security, which typically require cross-disciplinary, culturally-rich solutions (Mazzocchi, 2006; Owusu-Ansah & Mji, 2013 [23]).

Nonetheless, meaningful integration means much more than a token inclusion, but rather involves an epistemological shift by educators, policymakers, and curriculum developers. As Feyerabend (1999 [24]) points out, simply appending indigenous knowledge on to existing structures of knowledge is a way of reproducing the same hierarchies under another description. On a more principled level, true pluralism will mean re-thinking the base characteristics of science education; who decides, what is knowledge?

2.2 PROMOTING CRITICAL THINKING THROUGH METHODOLOGICAL DIVERSITY: CHALLENGING CONFORMITY

The current status of science education in Ghana exhibits an ingrained reliance on conventional and rigid teaching practices which favour rote learning over inquiry-based practices. Often, science is perceived as an established body of scientific knowledge and not necessarily a journey of discovery (Davis, 2021 [25]). All of these practices have established a narrow lens of science predominantly defined by the limitations of ongoing examination, performance on those examinations, and requirements of curiosity, contemplation, or problem-solving. The dominance of teacher practices that favour teacher-centred instruction, standard curricula, and limited assessment approaches allow little space for intellectual autonomy and inquiry-based approaches (Kwarteng & Andoh, 2020; Anamuah-Mensah, 1995 [26]). Many Ghanaian students perceive science as abstract, meaningless, and isotonic from their lived experience, thus undermining its potential impact on society.

In response to these challenges, Paul Feyerabend's philosophy of methodological pluralism presents a striking counter-narrative. At the heart of his epistemological anarchism is the claim that there is not a single valid method of scientific inquiry which is universally applicable. In contrast, Feyerabend (1975 [1]) believes progress in science involves variation in methods, viewpoints, and intellectual traditions. Feyerabend claims "anything goes" when it comes to advancing knowledge and conveys an emphasis on establishing a learning space that legitimizes a more pluralistic interpretive nature of science and provides a more democratic and experimental basis for learning. His argument takes direct aim at the conformity baked into Ghana's science education establishment, favouring a premise that advances creativity, criticality, and pedagogical experimentation.

Methodological pluralism as established by Feyerabend could radically change science education as it allows different ways of knowing and thinking to coexist. It would mean accepting storytelling, role-play, project-based learning, local problem-solving, and debate beside laboratory work and reading textbooks. This would support variation in learning styles as well as develop students' abilities to challenge assumptions, weigh alternatives, and articulate rationale, (Matthews, 2014; Ogunniyi, 2007 [27]). These are essential elements of criticality. Criticality is significant for scientific literacy and democratic citizenship.

The focus on critical thinking in science classrooms also requires re-conceptualizing pre-service teacher education and curriculum development. It is essential to prepare teachers to transition from transmission-based models of teaching to adopting a facilitative role of inquiry in which they support students in open-ended experimental investigations and reflective dialogues (Akyeampong, Adu-Yeboah, & Kwaah, 2018 [28]). Feyerabend taught that intellectual freedom requires dissent which would be consistent with teaching practices which embrace questioning, dialogic exchange and metacognition—pedagogical components that are absent from Ghana's testing-driven classrooms. The ability to challenge science claims, consider evidence and evaluate competing explanations reflects the practice of science which is much more authentic and empowering educationally (Hodson, 2009 [29]).

Feyerabend's radical challenge to intellectual ownership of monistic methodologies can point to the need to dislodge dominant cultures of obedience and passive learning processes that continue to dominate many Ghanaian science classrooms. This is especially salient in postcolonial contexts because colonial schooling systems continue to hold sway over the language used to suppress many indigenous epistemologies and limit learners' agency (Odora Hoppers, 2002 [30]). Given this complexity, it is possible that science education in Ghanaian schools may offer a shift from socio-behaviourists uniformity and conformity toward a culture of questioning rather than obedience, of dialogue instead of dictatorial practice and inquiry and exploration instead of rote memorization.

3. CONCLUSION

Feyerabend's epistemological anarchism does not preclude one function of science education, but instead stimulates innovation by breaking down didactic structure, further creativity, and legitimizing competing epistemologies and ways of knowing. This would mean, in Ghanaian contexts, greater teacher empowerment, culturally relevant content, and student-centred inquiry. In this case, science education is converted from a model of reliance on instructional knowledge to infusing a more transformational approach where learners are co-producers of knowledge for themselves instead of passive recipients of fact.

Feyerabend's philosophy provides both an alternative critique of the hegemonic Western science curriculum, and a means to more fully develop indigenous knowledge in ways to make it more contextually relevant, open knowledge production, and foster innovation. For science education to truly be transformational, it will involve and centre the epistemic diversity of its culturally contextualized arrangements, and affirm substantive notes of inquiry, rather than serve it as a controversial add-on.

Encouragement of critical thinking via methodological pluralism, as suggested by Feyerabend, is more than an adjustment in pedagogy, it is a philosophical turn. It seeks to shift away from a dogmatic view of the existence of one scientific truth and creates educational spaces where learners think for themselves, question authority and engage in the collaborative process of building knowledge. Such a turn will be vital for Ghana if science education is to provide liberation and local relevance within an evolving global landscape.

4. RECOMMENDATIONS

In order to realize the transformative promised by Feyerabend's epistemological anarchism for science education, it is suggested that educators and curriculum designers revise the current legal structures to allow for greater autonomy to teachers, methodology, and student-led inquiry. Through professional learning experiences, teachers can be ready to utilize creative and contextually sensitive pedagogical approaches that feel local and creative instead of prescriptive. In essence, students will be active knowledge producers rather than passive knowledge recipients.

Feyerabend's epistemic pluralism can be operationalized in recommending that indigenous knowledge systems, located as unique sense-making systems, should be indigenous knowledge systems established as a principal part of the science curriculum in the subject area rather than as a supplement. Education policy and curriculum writers with local communities, traditional knowledge holders, and academics could co-design (for co-production purposes) the educational material to represent the cultural and ecological reality of the country. This approach would allow for relevant, culturally inclusive curricula, and democratize knowledge, while also enabling innovation and creativity through robust acknowledgement of the existence of multiple ways of knowing.

To actualize the philosophical reorientation that Feyerabend called for, Ghana's science education system must establish institutional diversity of methods, with critical thinking as a central learning outcome. This work requires interest-led inquiry, debate, and philosophical thinking as fundamental components of scientists at all levels of science education in Ghana. There will also be the matter of putting history and philosophy of science into teacher education and preparing educators to help learners interrogate ideas, to interrogate evidence, and actively engage in conversations around science. These sectors of possible reform will create scientifically literate citizens who will draw on civic evidence and cultural resources to solve complex global problems.

REFERENCES

1. [1] Feyerabend, P. K. (1975). *Against Method: Outline of an anarchistic theory of knowledge*. New Left Books.
2. [2] Ministry of Education. (2018). *National pre-tertiary education curriculum framework for Ghana*. Accra: Curriculum Research and Development Division (CRDD).
3. [3] Mohammed, S. M., Amponsah, K. D., Ampadu, E., & Kumassah, E. K. (2021). Extent of implementation of inquiry-based science teaching and learning in Ghanaian junior high schools. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(2), Article e9373. <https://doi.org/10.29333/ejmste/9373>.
4. [3] Akyeampong, K., Lussier, K., Pryor, J., & Westbrook, J. (2013). Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal of Educational Development*, 33, 272–282. <https://doi.org/10.1016/j.ijedudev.2012.09.006>.
5. [4] Preston, J. M. (1997). *Feyerabend: Philosophy, Science and Society*. Polity Press.
6. [5] Adom, D., & Harvey-Brown, Y. (2024). Development and Implementation of an Elementary School-Based Indigenous Knowledge Pedagogical Model on Native Tree Species for Environmental Sustainability Education in Ghana. *Futurity Education*, 4(1), 147-185. <https://doi.org/10.57125/FED.2024.03.25.09>
7. [6] Ogunniyi, M. B. (2007). Teachers' stances and practical arguments regarding a science–indigenous knowledge curriculum: Part 1. *International Journal of Science Education*, 29(8), 963–986. <https://doi.org/10.1080/09500690600931020>.
8. [7] Takyi, B., Korankye, S., & Akolbila, V. (2023). Innovating within constraints: Basic school teachers' experiences with pedagogical reform in Ghana. *International Journal of Quality Assurance in Teaching and Learning*, 4(2), 45–60. <https://injoqast.net/index.php/INJOTEL/article/view/308>
9. [8] Freire, P. (1970). *Pedagogy of the Oppressed*. Herder and Herder.
10. [9] Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31(1), 21–32.
11. [10] Harding, S. (1998). *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies*. Indiana University Press.
12. [11] Tabulawa, R. (2013). Teaching and learning in context: Why pedagogical reforms fail in Sub-Saharan Africa. CODESRIA.
13. [12] Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, 36(3), 269–287.
14. [13] Snively, G., & Corsiglia, J. (2001). “Discovering indigenous science: Implications for science education.” *Science Education*, 85(1), 6–34.
15. [14] Nkrumah, K. (1963). *Consciencism: Philosophy and Ideology for Decolonization*. Heinemann.
16. [15] Gyekye, K. (1997). *Tradition and Modernity: Philosophical Reflections on the African Experience*.

- Oxford University Press.
17. [16] Appiah, K. A. (1992). In *My Father's House: Africa in the Philosophy of Culture*. Oxford University Press.
18. [17] Odora Hoppers, C. A. (2002). *Indigenous knowledge and the integration of knowledge systems: Towards a philosophy of articulation*. New Africa Books
19. [17] Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, 26(3), 413–439. DOI: 10.1111/j.1467-7660.1995.tb00560.x.
20. [18] Adom, D., & Harvey-Brown, Y. (2024). Development and Implementation of an Elementary School-Based Indigenous Knowledge Pedagogical Model on Native Tree Species for Environmental Sustainability Education in Ghana. *Futurity Education*, 4(1), 147-185. <https://doi.org/10.57125/FED.2024.03.25.09>
21. [18] Acharibasam, J. B., & McVittie, J. (2023). Connecting children to nature through the integration of Indigenous Ecological Knowledge into early childhood environmental education. *Australian Journal of Environmental Education*, 39, 349-361. <http://dx.doi.org/10.1017/aee.2022.37>
22. [19] Prempeh, C. (2022). Polishing the pearls of indigenous knowledge for inclusive social education in Ghana. *Social Sciences & Humanities Open*, 5(1), Article 100248. <https://doi.org/10.1016/j.ssaho.2022.100248>
23. [20] Feyerabend, P. (1987). *Farewell to Reason*. Verso.
24. [21] Jegede, O. J., & Okebukola, P. A. O. (1991). The effect of instruction on socio-cultural beliefs hindering the learning of science. *Journal of Research in Science Teaching*, 28(3), 275–285. <https://doi.org/10.1002/tea.3660280308>
25. [22] Aniah, P., Aasare, B. A., & Bonye, S. Z. (2019). Integrating indigenous knowledge into climate change adaptation strategies in the Savannah ecological zone of Ghana. *Climate and Development*, 11(1), 1–11. <https://doi.org/10.1080/17565529.2017.1410089>
26. [23] Mazzocchi, F. (2006). Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other. *EMBO Reports*, 7(5), 463–466. <https://doi.org/10.1038/sj.embor.7400693>
27. [23] Owusu-Ansah, F. E., & Mji, A. (2013). African indigenous knowledge and research. *International Journal of Educational Sciences*, 5(1), 1–11. <https://doi.org/10.31901/24566322.2013/05.01.01>
28. [24] Feyerabend, P. (1999). *Conquest of Abundance: A Tale of Abstraction Versus the Richness of Being*. University of Chicago Press.
29. [25] Davis, J. (2021). Rethinking science teaching in postcolonial Africa: From factualism to relevance. *Journal of African Education*, 3(2), 59–73.
30. [26] Kwarteng, K., & Andoh, C. (2020). Rote learning and its impact on science achievement among Ghanaian SHS students. *Journal of Curriculum Studies in Ghana*, 10(1), 92–105.
31. [26] Anamuah-Mensah, J. (1995). The race against underdevelopment: A mirage or a possibility for science and technology education in Africa? In M. Ogunniyi (Ed.), *Science, technology and mathematics education in Africa* (pp. 23–35). ADEA.
32. [27] Matthews, M. R. (2014). *Science teaching: The contribution of history and philosophy of science*. Routledge.
33. [27] Ogunniyi, M. B. (2007). Teachers' stances and practical arguments regarding a science–indigenous knowledge curriculum: Part I. *International Journal of Science Education*, 29(8), 963–986. <https://doi.org/10.1080/09500690600931020>
34. [28] Akyeampong, K., Adu-Yeboah, C., & Kwaah, C. Y. (2018). Assessing the actual needs of untrained

- teachers with previous teaching experience in Ghana. In Y. Sayed & A. Badroodien (Eds.), *Continuing professional development of teachers in Sub-Saharan Africa: Challenges and prospects* (pp. 91–110). Bloomsbury Academic.
35. [29] Hodson, D. (2009). *Teaching and Learning about Science: Language, Theories, Methods, History, Traditions and Values*. Sense Publishers.
36. [30] Odora Hoppers, C. A. (2002). *Indigenous knowledge and the integration of knowledge systems: Towards a philosophy of articulation*. New Africa Books.