Critical Thinking as a Catalyst - Transforming First-Year Chemistry Education

Abstract

The study investigated integrating critical thinking skills in first-year university chemistry modules. It was guided by the research question: How are lecturers integrating critical thinking skills into their teaching to foster these skills in students?

The theoretical foundation of this study is grounded in the Paul and Elder Critical Thinking Framework, which provides a robust and well-structured basis for understanding the core components of critical thinking and their intended outcomes. One of the primary advantages of this framework is its widespread adoption by higher education institutions globally, making it one of the most extensively implemented models in critical thinking pedagogy (Han & Brown, 2013). The framework offers a comprehensive approach with an explicit and systematic process and illustrative examples (Payette & Ross, 2016).

This empirical study employed a descriptive case study approach suited to research where variables such as critical thinking cannot be manipulated or controlled within real-world educational settings (Yin, 2003). The selection of this methodology aligns with its capacity to explore phenomena in depth, particularly in environments where contextual influences are inseparable from the phenomenon under investigation. In this case, the focus was on university lecturers' pedagogical strategies to foster critical thinking skills in a chemistry module. Specifically, the research examined what lecturers were doing in their teaching, their conceptions of teaching and learning, and how these conceptions informed the integration of critical thinking into their instructional practices.

Ethical approval was obtained following institutional protocols, allowing for the conduct of eight interviews. Participants were recruited via personal email invitations, following an introduction to the study provided by the head of the department during a staff meeting. To ensure confidentiality and anonymity, pseudonyms were assigned to all participants and the institution involved in this research. Specific citation details are omitted to safeguard the regional university's identity in the southwestern Pacific Ocean. This paper uses the pseudonym "Oceania University" to refer to the institution. Similarly, the participating lecturers are referred to by pseudonyms: Julia, Idris, Blake, Pedro, Siji, Grant, Allen and Destiny. The chemistry department at Oceania University comprised nine lecturers responsible for teaching CHEM01 (Foundation Chemistry I) and CHEM02 (Foundation Chemistry II), with first-year cohorts of approximately 420 and 320 students, respectively. Eight of the nine lecturers volunteered to participate, and their involvement formed the basis for nested case studies within this research. The decision to focus on first-year students addresses a gap in the literature, as there is limited research on critical thinking development within first-year chemistry programmes within the region.

This study addressed the research question, "*How are lecturers integrating critical thinking skills into their teaching to foster these skills in students?*" It found unanimous recognition among the eight interviewed lecturers of the essential role critical thinking plays in first-year chemistry instruction. Siji and Destiny highlighted how they incorporated critical thinking into their pedagogical philosophies to support student learning; however, neither elaborated on specific demonstrations of these principles in their teaching practices. Analysis of the interviews revealed the absence of a cohesive critical thinking framework for teaching CHEM01 and CHEM02 at Oceania University. While no participant opposed adopting such a framework, the lack of its formal implementation remains evident.

Pedro and Julia distinguished themselves as the lecturers who articulated and demonstrated the integration of critical thinking within their chemistry modules. Pedro provided concrete examples of

how his understanding of critical thinking was translated into specific teaching practices, enabling students to relate problems to real-life situations. This approach exemplifies aspects of the 'intellectual standards' component within the Paul-Elder Critical Thinking framework, thereby informing and enhancing the 'elements of reasoning' dimension.

Similarly, like Julia, Idris emphasised an approach that encouraged students to ask questions. However, Julia went further by detailing how she employed this strategy by posing questions to her students, prompting them to critically reflect on and interrogate the material presented during both instructional sessions and laboratory work. This approach cultivates an environment where both students and staff continuously evaluate the validity of their learning experiences. In contrast, the other five lecturers shared their interpretations of critical thinking and unanimously highlighted its importance in chemistry education, yet they did not demonstrate how these insights influenced their instructional methods, particularly in the first-year curriculum.

Destiny and Allen proposed that critical thinking skills develop implicitly over time, with Allen asserting that students acquire such skills naturally through exposure. This paper asserts that reliance on implicit learning alone is insufficient to cultivate robust critical thinking skills. Instead, these skills necessitate deliberate and explicit integration into the chemistry curriculum as demonstrated in the Paul-Elder Critical Thinking framework. Thus, Destiny and Allen's perspectives reflect a limited approach that may hinder comprehensive skill development for first-year university students.

Participants also identified various obstacles to implementing a critical thinking framework and described its complexity. Pedro highlighted the need to balance content delivery with the integration of critical thinking, while Destiny cited constraints such as time, workload, a lack of teaching assistants, and insufficient resources. Allen emphasised the risk of overwhelming students, and Grant reiterated that large class sizes represent a formidable barrier to integrating a standardised approach to critical thinking in chemistry instruction.