Using concept maps to surf semantic waves in the pursuit of powerful knowledge structures

Article *in* Knowledge Management & E-Learning An International Journal · September 2023

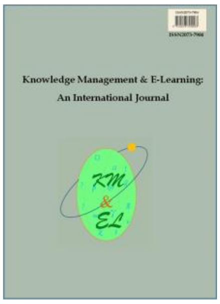
DOI: 10.34105/j.kmel.2023.15.022

Paulo Rogério Miranda Correia
University of São Paulo

Ian Kinchin
University of Surrey

Using concept maps to surf semantic waves in the pursuit of powerful knowledge structures

Paulo R. M. Correia
University of São Paulo, Brazil
Ian M. Kinchin
University of Surrey, UK
Adriano N. Conceição
University of São Paulo, Brazil



Knowledge Management & E-Learning: An International Journal (KM&EL)
ISSN 2073-7904

Recommended citation:
Correia, P. R. M., Kinchin, I. M., & Conceição, A. N. (2023). Using concept maps to surf semantic waves in the pursuit of powerful knowledge structures. *Knowledge Management & E-Learning*, *15*(3), 381–391. https://doi.org/10.34105/j.kmel.2023.15.022

Knowledge Management & E-Learning, 15(3), 381–391

Using concept maps to surf semantic waves in the pursuit of powerful knowledge structures

Paulo R. M. Correia*

School of Arts, Sciences and Humanities
University of São Paulo, Brazil
E-mail: prmc@usp.br

Ian M. Kinchin

Surrey Institute of Education
University of Surrey, UK
E-mail: i.kinchin@surrey.ac.uk

Adriano N. Conceição

Interunit Graduate Programme in Science Education
University of São Paulo, Brazil
E-mail: adriano.yanc@usp.br

*Corresponding author

Abstract: The evolution of concept mapping has benefitted from the robust theoretical basis provided by Ausubelian learning theory. However, for concept mapping to maintain its relevance and to keep pace with the evolutionary changes in the educational context, it is vital that educational researchers and classroom practitioners can augment this theoretical base with contemporary learning theories that will help to improve the application of concept mapping and increase the likelihood that the goal of meaningful learning will be achieved in practice. This involves shifting the focus of concept mapping from product to process and the role of the learner from 'being' to 'becoming.' The act of concept mapping needs to be viewed as a way of mastering learning rather than of mastering specific content. We propose the consideration of the explicit role of semantic waves as an improvement from simplistic knowledge representation towards the development of more complex knowledge modelling as a way of developing powerful knowledge structures.

Keywords: Concept map; Knowledge modelling; Threshold concepts; Semantic waves; Pedagogic resonance

Biographical notes: Dr. Paulo Correia, an Associate Professor in Didactics at the University of São Paulo, teaches and researches within the School of Arts, Sciences, and Humanities. He has been involved in researching application of concept mapping to teaching and learning since 2005. His current research considers ways to optimise the use of concept mapping in understanding human cognitive architecture. Paulo was the chairman of the Sixth International Conference on Concept Mapping (CMC2014) organised by USP and IHMC. In 2019, he led the USP and Coursera partnership to launch the first MOOC dedicated to developing novices' skills to learn and collaborate using concept maps.

Dr. Ian M. Kinchin is Emeritus Professor of Higher Education within Surrey Institute of Education, University of Surrey. Ian has a PhD in Science Education and a DLItt in Higher Education. His research interests are centred around the development of the Ecological University, and he has used concept mapping as a tool to investigate the links that academics make between elements of the teaching and research environments at university. His most recent book (2022) is called: Dominant Discourses in Higher Education: Critical perspectives, cartographies and practice, published by Bloomsbury, London.

Adriano N. Conceição is currently a doctoral candidate in the Interunit Graduate Program in Science Education at the University of São Paulo. His research interests primarily revolve around concept mapping, learning assessment, and science teaching. He is expected to complete and defend his PhD thesis in 2023.

1. Introduction

It has been 50 years since Joseph Novak created concept maps for representing knowledge (Correia & Aguiar, 2022). Unlike other visual organizers, concept mapping is built on a solid theoretical foundation from the ideas developed by David Ausubel (Ausubel, 2000). The Ausubelian notion that knowledge is formed by concepts and propositions justifies the need to include the linking phrase to explain the nature of conceptual relationships (Novak, 2010). The research involving concept maps developed from this starting point, as Novak and Cañas (2010) remind us:

> *"The research program was based on Ausubel's […] Assimilation Theory of cognitive learning, and an emerging constructivist epistemology that viewed knowledge as a human creation involving the construction on new concepts and propositions through the process of high levels of meaningful learning, as described by Ausubel, and Novak's Human Constructivist epistemology." (p.1)*

Re-examining the theoretical foundations of concept mapping is critical for achieving the expected outcomes (Cañas & Novak, 2006). Meaningful learning, a consequence of creating meanings from previous knowledge, is one the most often presumed results when teachers and students choose to use concept maps. Unfortunately, it is not so common in practice because concept mapping is often placed into a context that has low recipience for teaching innovation (Kinchin, Winstone & Medland, 2021) so that the higher-level objectives are never attained. Teaching and learning are complex, even 'messy' activities (Simmie, Moles & O'Grady, 2019), demanding a theoretical understanding that goes beyond the historical origins of concept mapping. This wider understanding is often lacking among teachers and students. In other words, it is necessary to explore contemporary educational theories to avoid the 'Ausubelian trap,' which limits the use of concept maps within a single theoretical perspective. This is a specific example of the 'rigidity trap' in academic practice that can be observed when teachers continue to engage in practices that run contrary to available evidence (Kinchin, 2022). It is critical to challenge the dominant discourses in education (Kinchin & Gravett, 2022). The concept mapping community has acknowledged this and according to Kinchin (2015):

> *"At the 6th international conference in Brazil in 2014, comment was made that it was now time for academics to challenge the dominant discourses in education*

> *through the application of concept mapping by integrating the tool with contemporary educational theories from both the psychology and the sociology of education." (p.3)*

Considering learning based on changes in knowledge structures is a way of expanding the theoretical horizon that informs the use of concept maps (Kinchin & Correia, 2021). Fig. 1 presents three remarkable events in the learning process that need to be considered more carefully to appreciate their role in meaningful learning: periods of disjuncture, threshold concepts, and semantic waves.

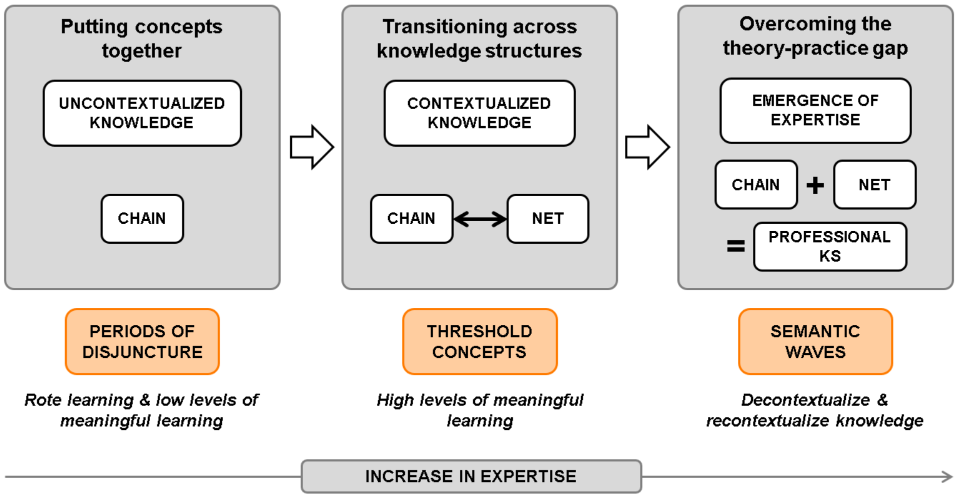


Fig. 1. Changes in knowledge structures during the learning process to increase expertise. Periods of disjuncture, threshold concepts, and semantic waves occur throughout the way

- Periods of disjuncture: the transition between uncontextualized (linear structures) and contextualized knowledge (networks) does not follow a smooth path. It is an uncomfortable time for learners, requiring an ever-greater commitment to meaningful learning, in the detriment of rote learning (Hay, Kinchin & Lygo-Baker, 2008). The periods of disjuncture mark the abandonment of linear structures, which prove to be useless to accommodate new information (Kinchin & Correia, 2021).
- Threshold concepts: the establishment of relationships between linear and networked structures is essential to contextualize knowledge, by bridging the gap between theory and practice. This relationship between different types of knowledge structures (chain and net) occurs through threshold concepts (Meyer & Land, 2006). They are responsible for the most significant conceptual changes (Kinchin & Correia, 2021).
- Semantic waves: are pulses of cumulative knowledge-building where knowledge is transformed between relatively decontextualized, condensed meanings and context-dependent, simplified meanings, offering a means of enabling cumulative classroom practice (Maton, 2013). The semantic waves are critical to overcoming the gap between theory and practice, i.e., the emergence of expertise.

This paper aims to explicitly acknowledge the role of semantic waves in the learning process to show the role that concept maps have in knowledge modelling. This goes beyond mere knowledge representation. The next section of the paper considers feedback experiences as an indicator of the learning conception (i.e., whether learning is seen as the acquisition of content or development of metacognitive skills), which informs the use of concept maps in the classroom. Next, we define the semantic waves and present their role in the knowledge modelling process. Finally, we discuss practical implications for teachers and researchers who want to surf deeper waves, going beyond the familiar shallow waves we already know.

2. Experiences of feedback to unveil the purpose of concept mapping

The educational values to be pursued throughout the learning process influence the impact that concept mapping will have in the classroom. Cañas, Novak, and Reiska (2012) state the essential purpose of concept mapping in education is to assist learners in building powerful knowledge structures. They also pointed out that task instructions can broadly vary in terms of content and structure, resulting in activities from 'memorize the teacher's map' (low freedom of content and structure) to 'create your own concept map' (high freedom of content and structure). There are many intermediate options available between these extremes that can be chosen to align teaching methods to the educational values shared within an educational institution.

The evaluation of activities with maps can be valuable to characterize the educational values of the learning environments. McLean, Bond, and Nicholson (2015) show four feedback experiences that help us identify whether the focus of learning is on a final product to be obtained, or on the process that develops throughout the classes:

- Feedback as telling (TEL): uni-directional transmission of 'correct' answers puts emphasis on a single, expert voice. This view of feedback assumes a passive role for the student in which dialogue does not contribute to understanding.
- Feedback as guiding (GUI): the students are being pointed in the right direction so that they may learn by applying knowledge to practice. In such instances, students may start to think about feedback to help them work out the answer.
- Feedback as developing understanding (DUN): requires students to be more active, using feedback as a tool in the construction or adjustment of knowledge structures.
- Feedback as opening up a different perspective (OPE): it deliberately introduces different views and requires students to be actively engaged in interpreting and evaluating knowledge. It resonates with the idea of acquiring threshold concepts (Meyer & Land, 2006).

Fig. 2 characterizes some of the differences in learning environments. The preference for the 'feedback as telling' and 'feedback as guiding' indicates that the teacher's focus is on student acquisition of specific knowledge – the product. In such cases, feedback is passive and uni-directional, moving students towards an agreed and fixed knowledge structure that serves as an arbitrary endpoint for learning. In this context, concept maps serve to represent knowledge, facilitating the negotiation of meaning. However, discussions between teacher and student tend to be convergent and centered on the 'right answer,' that is, on the reference knowledge to be understood (e.g., the atomic model or how to solve a math problem). Frequently, students' understanding is verified after the teaching period to check if the result is satisfactory for approval, ending the course's activities and closing down further discussions. Most current applications of concept maps fit this description.

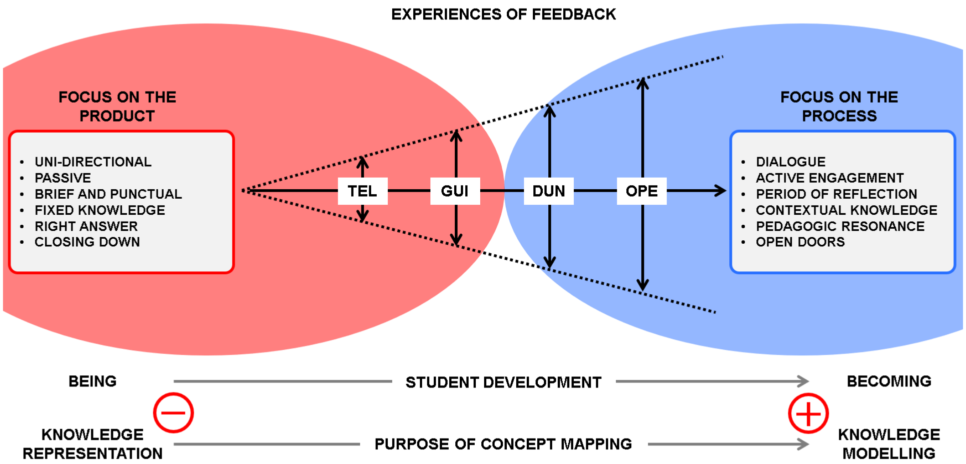


Fig. 2. Characterizing the learning environment from the experiences of feedback (TEL, GUI, DUN, and OPE). Focus on the product (red) represents most applications, whereas the focus on the process (blue) is likely to assist learners in building powerful knowledge structures. The purpose of concept mapping addresses different goals (grey boxes) in each case

The focus on the process extends the purposes of concept mapping in the direction of knowledge modelling. The preference for ‘feedback as developing understanding’ and ‘feedback as opening up a different perspective’ requires more active student engagement and tends towards the construction of personal knowledge structures. The discussions between teacher and student are divergent and involve a ‘contextual knowledge’ that does not present a single ‘right answer’ (e.g., choose a preferred painter among famous artists or select political initiatives to deal with the pandemic). The coherence in argumentation is under scrutiny, and it is developed only after a period of reflection. Different viewpoints may be accommodated, which opens doors to further learning. The concept maps assist knowledge modelling rather than be limited to the representational stance. Therefore, pedagogic resonance, i.e., the bridge between teacher knowledge and student learning, moves the student development from ‘being’ to ‘becoming.’ It increases the levels of metacognition that are implicit in this context and encourages a better fit with the development of powerful knowledge structures. Unfortunately, the applications of concept maps in the classroom rarely fit this description, and activities are often terminated prematurely once the content has been ‘covered,’ and before any critical, higher-order learning has been activated.

The development of ‘powerful knowledge structures’ (as described by Young & Muller, 2013) requires a learning cycle that includes both product and process focus (Fig. 2). The first helps deal with the periods of disjuncture when knowledge is uncontextualized (occurrence of rote learning and low levels of meaningful learning, see Fig. 1). The latter contributes to overcoming threshold concepts, which is necessary for the contextualization of knowledge (high levels of meaningful learning, see Fig. 1). As the most recurrent applications of concept maps value the focus on the product (knowledge representation), the implications for the learning process end at the periods of disjuncture and do not reach the following critical stages (threshold concepts and semantic waves, see Fig. 1). The role of threshold concepts in understanding is described by Meyer and Land (2006) as follows:

> *"A threshold concept represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress. As a consequence of comprehending a threshold concept there may thus be a transformed internal view of subject matter, subject landscape, or even world view. […] Such a transformed view or landscape may represent how people 'think' in a particular discipline, or how they perceive, apprehend, or experience particular phenomena within that discipline (or more generally)." (p. xv-xvi)*

Meyer and Land (2006) also offer key characteristics of threshold concepts that distinguish them from other important ideas within a discipline. Threshold concepts are likely to be:

- Transformative: they result in a change in perception of a subject and may involve a shift in values or attitudes.
- Irreversible: the resulting change is unlikely to be forgotten.
- Integrative: it 'exposes a previously hidden interrelatedness' of other concepts within the discipline.
- Bounded: it serves to define disciplinary areas or to 'define academic territories.'
- Potentially troublesome: students may have difficulty coping with the new perspective that is offered.

If the threshold concepts are helpful to bridge the gap between theory and practice, the semantic waves are vital to overcoming it (Fig. 1).

3. Surfing semantic waves

Not all 'knowledge' is the same (Kinchin, Möllits, & Reiska, 2019) – it can be distinguished qualitatively in terms of its technical density (semantic density, SD) and its closeness to practice (semantic gravity, SG) as described by (Maton, 2013). Fig. 3 show a concept map to represent the main conceptual relations SD and SG.

Semantic gravity (SG) refers to the degree to which meaning relates to its context. Semantic gravity may be relatively stronger (+) or weaker (−) along a continuum of strengths. The stronger the semantic gravity (SG+), the more meaning is dependent on its context; the weaker the semantic gravity (SG−), the less dependent meaning is on its context. Semantic density (SD) refers to the degree of condensation of meaning within socio-cultural practices, whether these comprise symbols, terms, concepts, phrases, expressions, gestures, clothing, etc. Semantic density may be relatively stronger (+) or weaker (−) along a continuum of strengths. The stronger the semantic density (SD+), the more meanings are condensed within practices; the weaker the semantic density (SD−), the less meanings are condensed.

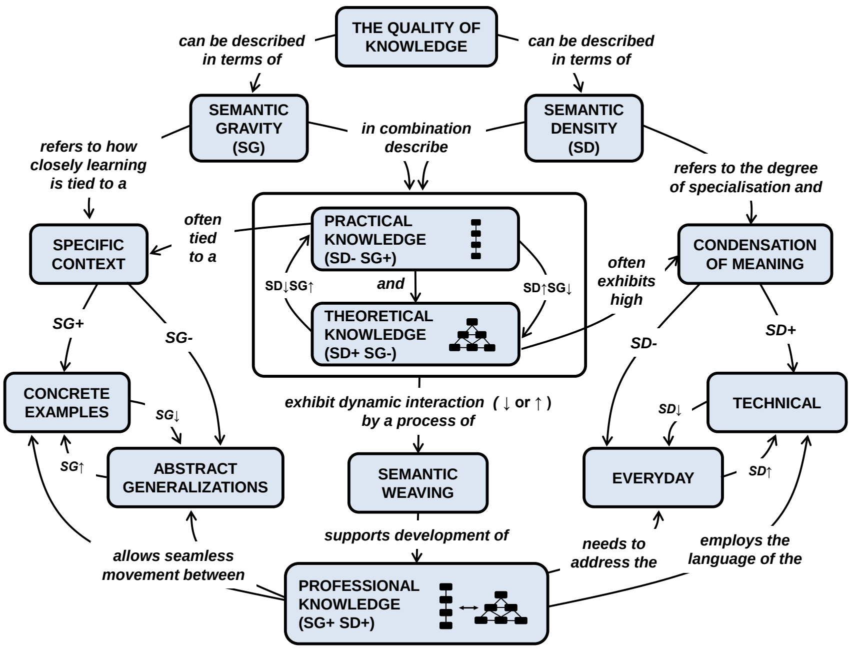


Fig. 3. A concept map of the relations between semantic density and semantic gravity, Adapted from Kinchin, Winstone, and Medland (2021, based on Maton, 2013)

Conceptualizing processes of strengthening and weakening semantic gravity and semantic density (SG↑↓, SD↑↓) enables research to trace the semantic profile of practices over time (Fig. 4), suggesting that:

- It is necessary to go beyond 'unpacking' educational knowledge into context-dependent and simplified meanings, in a process related to progressive differentiation (A in Fig. 4).
- It is necessary to 'repack' educational knowledge into generalized and highly condensed meanings, in a process related to integrative reconciliation (B in Fig. 4).
- Modelling knowledge is not a sudden transformation. It involves cycles of decontextualization (progressive differentiation) and recontextualization (integrative reconciliation).
- The typical use of concept maps focuses on the product (knowledge representation) and does not allow reaching the expert student (knowledge modelling). The semantic waves show the importance of decontextualizing and recontextualizing understanding, providing intertwined moments of segmental and cumulative learning.
- Surf the semantic wave reduces the T-P gap and impacts the overall Cmap quality.

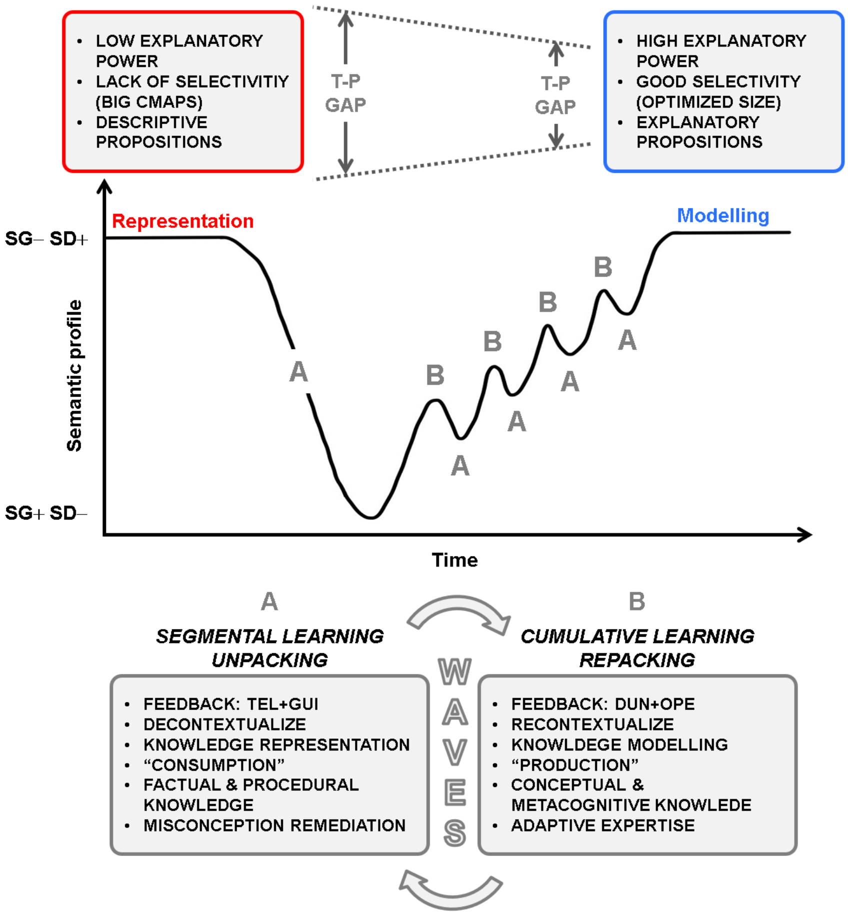


Fig. 4. Moving concept mapping from representing (red) to modelling knowledge (blue) through the cyclic process involving segmental (A) and cumulative (B) learning. Surfing the semantic waves reduces the theory-practice (T-P) gap (gray) and fosters the expertise development

4. Practical implications: going beyond the shallow waves

The typical use of concept maps reported in the literature explores the representation of knowledge to be transmitted to students (Fig. 5). This condition presents a restricted coherence involving 'stating the fundamentals,' which keeps classroom practice relatively simple, and is analogous to 'shallow semantic waves.' Surfing the semantic waves requires 'leaving the beach and entering the sea to catch deep waves.' This is where major leaps in understanding may be achieved, though it requires acknowledgment of the complexity of the classroom and the challenges this may present. This challenge requires two changes: firstly, the teaching approach (see 1 in Fig. 5), and secondly, the intentions when using concept maps (see 2 in Fig. 5). Both changes present threshold concepts to be overcome for the teacher. They are deep and transformative changes in scholarship of teaching.

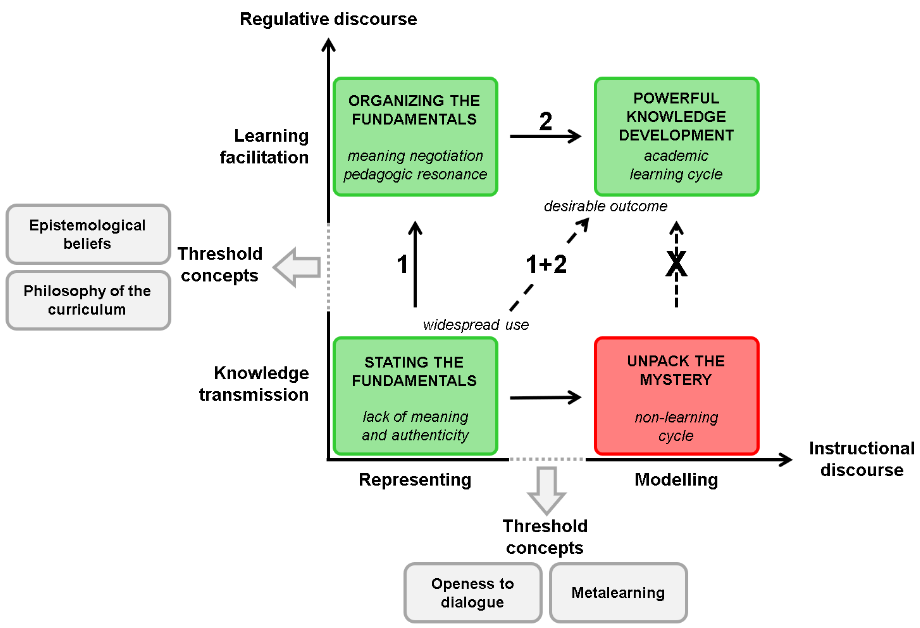


Fig. 5. Combinations between teaching approach and Cmap purpose to show the way from the widespread use to the desirable outcome (1, 2 and 1+2). Coherent and incoherent conditions are indicated in green and red, respectively. Threshold concepts represent a gap in the middle of the axes.

The use of modelling in the transmission of knowledge results in an incoherent condition (red in Fig. 5), where the knowledge to be modelled is not available to the students. It only appears to them after ‘organizing the fundamentals’, when we create space for the ‘development of powerful knowledge’.

5. Final remarks

In this paper we suggest that the intended outcomes (higher order thinking skills and meaningful learning) of concept map application in many classrooms are never achieved as the theoretical underpinning of the concept mapping activity is too narrow (and hence restrictive) and poorly understood by many practitioners (and researchers) who have failed to think critically about contemporary learning theory. This lack of criticality has led may researchers into the ‘Ausubelian trap’, where it is all too easy to ‘cut and paste’ research rationales and methodologies from earlier works without giving adequate consideration to their fit to the context of 21st Century education. We contend that researchers need to adopt a greater degree of epistemological and methodological flexibility when applying concept mapping and to consider the contribution of philosophical and methodological plurality that may contribute to future research by creating a level of discomfort that is needed to promote critical reflection.

Author Statement

The authors declare that there is no conflict of interest.

Acknowledgements

P.R.M.C. thanks the grants #2016/24553-7 and #2022/05340-3 from the São Paulo Research Foundation (FAPESP). A.N.C. thanks Coordination of Improvement of Higher Education Personnel (CAPES) for his PhD scholarship.

ORCID

Paulo R. M. Correia https://orcid.org/0000-0003-2419-7103

Ian M. Kinchin https://orcid.org/0000-0001-5425-4688

Adriano N. Conceição https://orcid.org/0000-0002-9397-7552

References

Ausubel, D. P. (2000). *The acquisition and retention of knowledge: A cognitive view*. Kluwer.

Cañas, A. J., & Novak, J. D. (2006). Re-examining the foundations for effective use of concept maps. In *Proceedings of the Second International Conference on Concept Mapping* (pp. 494–502). Retrieved from https://cmc.ihmc.us/cmc2006Papers/cmc2006-p247.pdf

Cañas, A. J., Novak, J. D., & Reiska, P. (2012). Freedom vs. restriction of content and structure during concept mapping—Possibilities and limitations for construction and assessment (2012. In *Proceedings of the Fifth International Conference on Concept Mapping*. Retrieved from http://cmc.ihmc.us/cmc2012Papers/cmc2012-p192.pdf

Correia, P. R. M., & Aguiar, J. G. D. (2022). Mapas conceituais no ensino de ciências: Estagnação ou crescimento? *Investigações Em Ensino de Ciências*, *27*(3), 198–218. https://doi.org/10.22600/1518-8795.ienci2022v27n3p198

Hay, D., Kinchin, I., & Lygo-Baker, S. (2008). Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education*, *33*(3), 295–311. https://doi.org/10.1080/03075070802049251

Kinchin, I. M. (2015). Editorial: Novakian concept mapping in university and professional education. *Knowledge Management & E-Learning*, *7*(1), 1–5. https://doi.org/10.34105/j.kmel.2015.07.001

Kinchin, I. M. (2022). An ecological lens on the professional development of university teachers. *Teaching in Higher Education*, *27*(6), 831–839. https://doi.org/10.1080/13562517.2021.2021394

Kinchin, I. M., & Correia, P. R. M. (2021). Visualizing the complexity of knowledges to support the professional development of university teaching. *Knowledge*, *1*(1), 52–60. https://doi.org/10.3390/knowledge1010006

Kinchin, I. M., & Gravett, K. (2022). *Dominant discourses in higher education: Critical perspectives, cartographies and practice*. Bloomsbury.

Kinchin, I. M., Möllits, A., & Reiska, P. (2019). Uncovering types of knowledge in concept maps. *Education Sciences*, *9*(2): 131. https://doi.org/10.3390/educsci9020131

Kinchin, I. M., Winstone, N. E., & Medland, E. (2021). Considering the concept of recipience in student learning from a modified Bernsteinian perspective. *Studies in Higher Education*, *46*(11), 2296–2308. https://doi.org/10.1080/03075079.2020.1717459

Maton, K. (2013). Making semantic waves: A key to cumulative knowledge-building. *Linguistics and Education*, *24*(1), 8–22. https://doi.org/10.1016/j.linged.2012.11.005

McLean, A. J., Bond, C. H., & Nicholson, H. D. (2015). An anatomy of feedback: A phenomenographic investigation of undergraduate students' conceptions of feedback. *Studies in Higher Education*, *40*(5), 921–932. https://doi.org/10.1080/03075079.2013.855718

Meyer, J., & Land, R. (2006). *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge*. Routledge.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations* (2nd ed.). Routledge.

Novak, J. D., & Cañas, A. J. (2010). The universality and ubiquitousness of concept maps. In *Proceedings of the Fourth International Conference on Concept Mapping*. Retrieved from http://cmc.ihmc.us/cmc2010Papers/cmc2010-p1.pdf

Simmie, G. M., Moles, J., & O'Grady, E. (2019). Good teaching as a messy narrative of change within a policy ensemble of networks, superstructures and flows. *Critical Studies in Education*, *60*(1), 55–72. https://doi.org/10.1080/17508487.2016.1219960

Young, M., & Muller, J. (2013). On the powers of powerful knowledge. *Review of Education*, *1*(3), 229–250. https://doi.org/10.1002/rev3.3017