Emerging Perspectives
ep.journalhosting.ucalgary.ca

The Hyperlinked Visual-Spatial Map as a Novel Way to Explore an Academic Discipline

Bogumila Gierus*, Brent Davis

University of Calgary

Becoming familiar with the overabundance of learning theories is daunting for most graduate students pursuing PhDs in education. This think-piece explores three strategies to support graduate students in familiarizing themselves with learning theories in education, emphasizing the third strategy of using visual-spatial digital maps. As a first strategy, a graduate student might conduct searches in the hope of finding theories that fit with one's interests. This scattershot approach involves randomness, as the relative novice is compelled to navigate and make sense of diverse ideas from a vast field of knowledge. A second, more systematic strategy is to read a textbook written or assembled by highly regarded authorities in the field. This approach affords a much more coherent way of reviewing relevant theories in a field of study, but the biases of authors and editors can skew it. A third strategy involves using emergent, hyperlinked, visual-spatial digital maps. Two such maps are presented and used to illustrate current and emerging possibilities for exploring and locating oneself in a vibrant research domain.

Keywords: Learning theories, Graduate Education, Visual-spatial Digital Maps, Research Strategies

Gierus, B., & Davis, B. (2020). The hyperlinked visual-spatial map as a novel way to explore an academic discipline. *Emerging Perspectives Special Edition: Designing for Digital Futures*, *7*(1), 1–14.

Introduction

When I started my Ph.D. program in educational research last year, I was overwhelmed. Having taught for many years, I was confident in my teaching practice, and I thought I was a knowledgeable person overall. However, the imposter syndrome hit in my first graduate class while listening to other students and the professor using terminology entirely new to me to discuss theories I had never heard of. The reading journey to become part of such conversations

*bogumila.gierus@ucalgary.ca

seemed daunting. Exploring and making sense of the abundance of learning theories felt overwhelming, especially with the thousands of theoretical ideas at play in the field (Davis & Francis, 2021).

In this article, I discuss different approaches to getting to know a discipline, ranging from the highly structured (e.g., reading a textbook or taking a course) to the more random (e.g., searching on the internet or chasing specific keywords). Then, I present a third way involving the hyperlinked visual-spatial digital map of a domain. Focusing on two such maps as exemplars, I explore how this type of medium can enable a deep and interconnected understanding of the field as compared to a textbook or article reading. With this think-piece, I hope to share valuable information with incoming graduate students in education so that they may make sense of a dynamic field.

Ways of learning the theoretical framework of a new discipline.

There are several ways of learning the theoretical underpinnings of a discipline: reading a textbook or reference book, reading relevant peer-reviewed articles from journals in the field, or using a hyperlinked visual-spatial digital map of a domain, to name a few. These tools have different purposes, are useful at different stages of research, and can be used in unison to achieve a richer understanding of the field. I review these three distinct ways in this section.

Reading a textbook of the discipline

Textbooks are typically used as a foundation for a course and are selected based on the instructor's ideas of what the discipline looks like. In lower-level introductory courses, textbooks typically present generalized overviews of a field. With higher-level specialized courses, textbooks become more specialized as well. However, for work at the master's and Ph.D. level, which is considered on the cutting edge of knowledge, appropriate and up-to-date textbooks on specific topics are not always available. Even when they are, the reader is subject to an author's or editor's choices and interpretations; books are not bias-free artifacts.

Examples abound. In my recent experience, in an "Introduction to Learning Sciences" course, the primary reading assignments came from *The Cambridge Handbook of The Learning Sciences*, edited by Sawyer (2022). This text served as a foundation for the course and the discipline—or so I thought. My passion for the Learning Sciences discipline resided in visual representations, and I was surprised there was no chapter about how students learn from representations, visual or otherwise. Although quite specific, this topic is a robust part of the field. When I commented on the matter, my instructor recommended checking the *International Handbook of Learning Sciences* (Fischer et al., 2018), which included a chapter on multiple representations (Ainsworth, 2018).

"Handbooks" are intended to portray entire domains, so editors' decisions on what to include or omit are consequential. I admit to being unsettled that my field of study, multiple representations, did not meet the bar for this particular version of the Learning Sciences handbook.

Scattershot approach (reading random articles from a discipline)

Another way of exploring a discipline is the scattershot approach, where a graduate student hunts for peer-reviewed literature based on keywords that might interest them. Using combinations of keywords, synonyms, phrases, and logical operators (AND or OR), one can scour Library Catalogues, institutional repositories, or even Google Scholar. One relevant article can lead to another, enabling more and deeper searches.

Typically, this approach also produces an overabundance of literature, presenting the need to limit searches by adding keywords or using more restrictive logic. There is a certain art to such searches, though, as the results should not eliminate articles that are relevant, even if they are peripheral. For effective searches, the student must already have a well-developed sense of both the broad contours and the specific terminology of the discipline. Lacking these, there are risks of getting sidetracked and going down rabbit holes. Further, the student needs to find out whether the articles chosen are the ones that are the most influential or relevant. With this approach, the guidance of a supervisor, teacher, or other mentor is essential.

This type of research approach led me to my topic for my master's thesis. I remember reading article after article on visual representations, noting the other articles listed in the literature review sections. Then, I would read those articles and try my hardest to figure out which authors and papers were the most widely cited in the visual representations field and which I thought would be most renowned. I felt like a cave diver with just a tiny flashlight, seeing bits and pieces of a large cave that would never be available.

Hyperlinked visual-spatial digital map of a domain (hypermedia)

A third approach to probing a discipline involves using a visual-spatial digital map. Although such tools have not yet been developed for many disciplines, a map of this kind affords a spatial orientation to the field by showing relationships between different topics and theories in the field that may otherwise be available only to experts. For instance, within Education, spatial reasoning is closely related to embodied cognition (see Figure 1). However, there is no reason that detail would be apparent or intuitive to the novice graduate student.

Figure 1. Discourses on Learning in Education Map

With this type of visual-spatial representation, one can quickly see how the various discourses are related. Since it is hyperlinked, instant descriptions of the various notions can be accessed along with links to further related ideas.

A graphic organizer to systematize thoughts is a concept that has been introduced previously. For instance, in school, students are exposed to mind maps, thought maps, thinking maps, and other spatial ways of collecting and organizing ideas (Budd, 2004; Hyerle, 1996; Peer et al., 2021). Even Venn diagrams—so well-liked by math, science, and social studies teachers—are a form of graphical representation of ideas (Gunstone & White, 1986; Otto & Everett, 2013). Across these strategies, non-spatial ideas are arranged two-dimensionally, aiming to highlight relationships through links, shared regions, or proximity. Citizens of the Information Age have grown increasingly familiar with such devices (Newcombe & Huttenlocher, 2003). As access to information has exploded in recent decades, interfaces with that information have become more and more spatial (Burbules et al., 2020). As a result, visual-spatial organizations of knowledge can be quite intuitive. Arguably, by graduate school, visual-spatial maps of disciplines are appropriate ways of representing relationships and interconnections.

Contrasted with the scattershot approach, exploring a discipline in this way enables one's agency. The learner decides which path to take through the map but does not leave the experience to chance. Compared to the textbook approach, a spatialized introduction offers comparable structure. However, its contents are less subject to editor opinion and bias, as there is no pretense that the signposts on a map are actual destinations.

I turn to two exemplars of hyperlinked visual-spatial digital maps to develop these points.

Two Exemplars

Math Ed Atlas

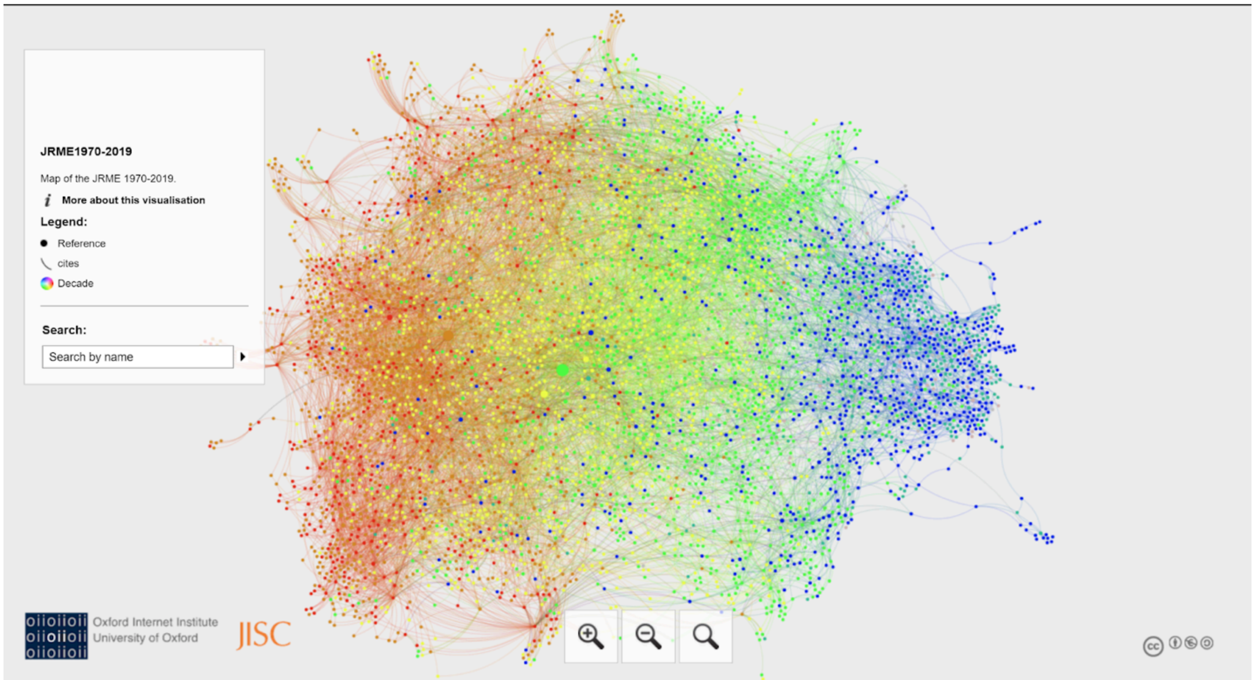
When writing an article for publication, I situate my ideas in an established but evolving network. For example, in this article, I cite articles that were, in turn, cited by other articles. Looking into the future, my writing will hopefully be cited by others, who will be cited by others, and so on. The article I am writing will be a node in an interconnected web of articles comprising the discipline.

That discipline constantly changes as new articles are published and connections are formed. The more an article is cited, the greater its influence—signified in greater numbers of links to wider distributions of nodes. In a sense, the discipline emerges in the collection of articles, like connections between neurons in the brain. However, that is not a sufficient picture: The connections among articles are also essential to define a domain. A discipline's coherence resides among interconnections of citations. In other words, a discipline might be understood as a complex, dynamic system of nodes and connections constantly changing and updating itself.

This level of interconnectedness has led some researchers to use social network analysis to model disciplines (Dubbs, 2021; Kong et al., 2019). Social network analysis is the process of investigating social structures using networks and graph theory (Scott, 2012). It characterizes networked structures in terms of nodes and the ties, edges, or links that connect them.

Dubbs (2021) offers one example in his network analysis maps (visual-spatial hyperlinked maps) of *Journal of Research in Mathematics Education* (JRME) articles from 1970 to 2020. The map is presented in Figure 2, and interpreting it can be confusing if not properly understood. For instance, the proximity and location of nodes mean something, colour means something else, and the size of the node means something completely different.

Figure 2. Interactive network map of articles published in JRME from 1970 to 2020.



Information on the structuring and how to read these maps are presented in Figure 3. Once appreciated, examining the clusters of research topics in these visual-spatial maps can provide extraordinary and rapid insights into the discipline of mathematics education research. For instance, one can select "bubbles" and find publications that are within these research topic bubbles. Or, one can search for a specific article to find others within the same research bubble. Dubbs (2021) also suggests looking at the "foam" (the collection of bubbles; see Figure 4) to see the overall interests of the discipline. For emerging scholars, there is an obvious benefit to being able to zoom out from an article to see how it connects to the entire discipline or, conversely, to zoom from the big picture of mathematics education research to a specific topic or article.

Figure 3. An explanation of how JRME maps are laid out

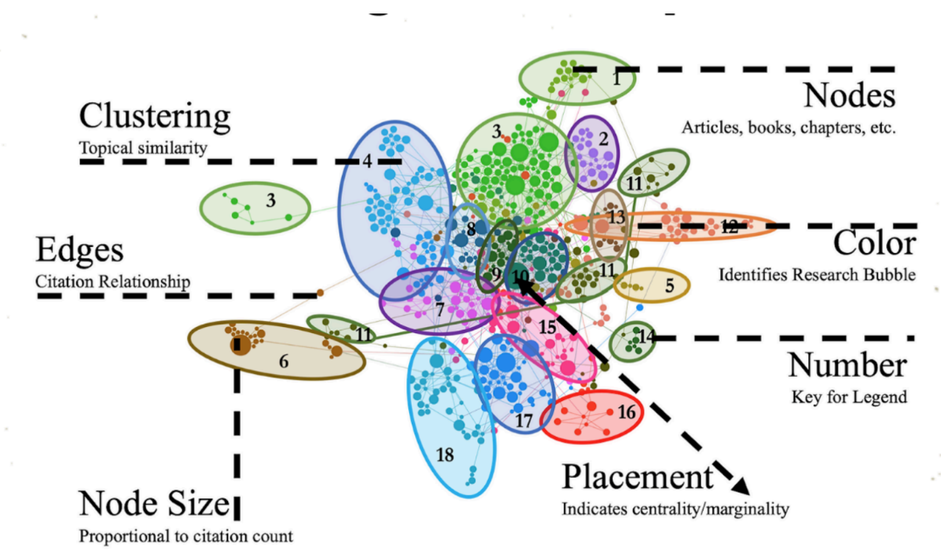
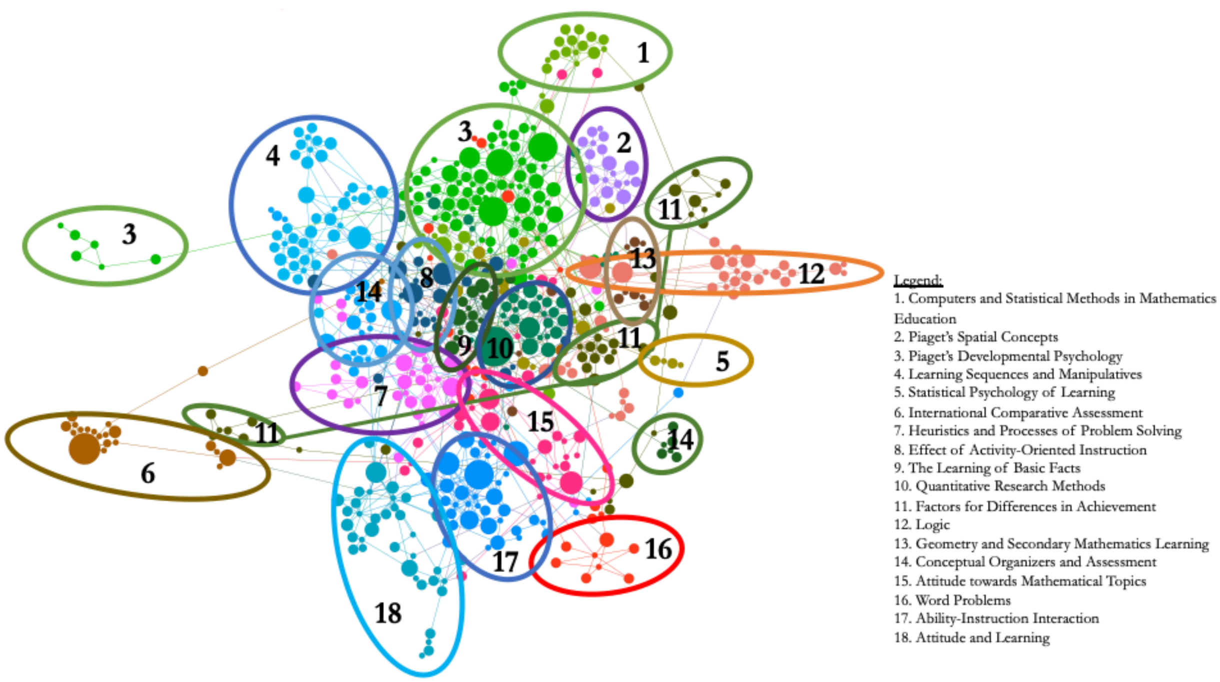


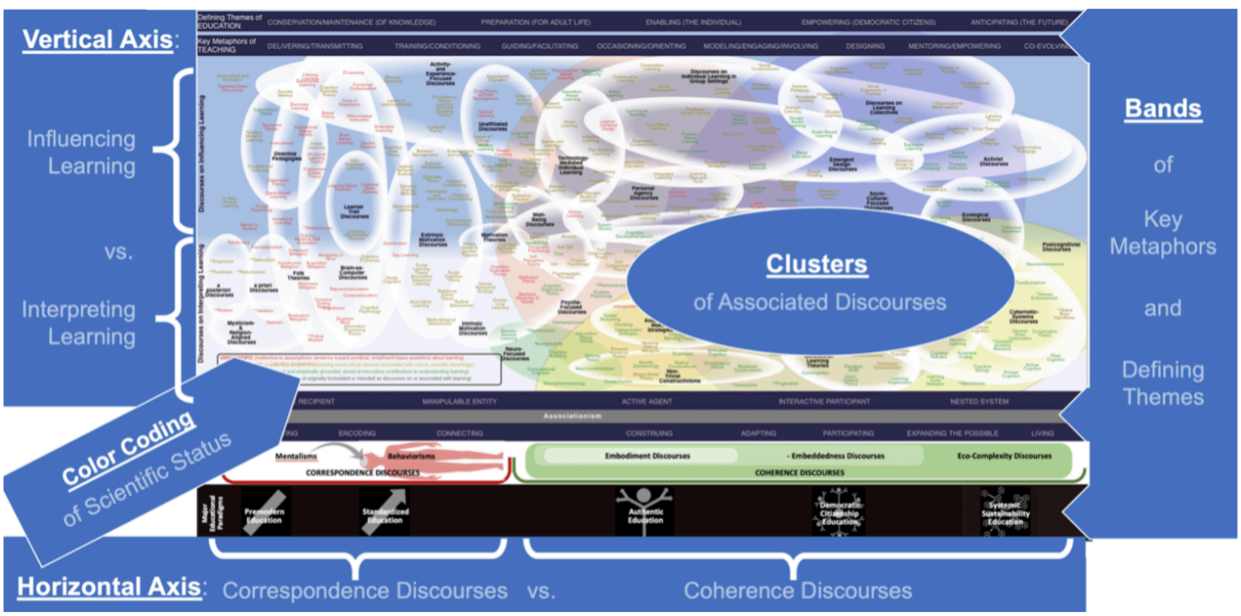
Figure 4. The foam (collection of topic bubbles) of a map



Discourses on Learning in Education

Another visual-spatial hyperlinked discipline map is offered on the Discourses on Learning in Education website (Davis & Francis, 2021). Specifically for the field of education, its developers took a slightly different approach: instead of linking and grouping entries, they relied on overlapping clusters to show relationality. Similar to Dubbs' JRME Maps, clustering was used for similar topics. However, as illustrated in Figure 5, other choices were implemented to foreground different categories of information. For example, bands of key metaphors and defining themes were placed around the map to signal broad themes.

Figure 5. Discourses on Learning in Education: Reading the Map



Another strategy involves using colour to differentiate between scientific, quasi-scientific, and unscientific discourses. The working definition of "scientific" on this site is based on four criteria that are commonly associated with robust inquiry—namely: being explicit about assumptions (including metaphors and imagery used to describe learning), being associated with a body of replicable evidence, none of which flatly contradicts the discourse;

being open to revision (or rejection) in the face of new evidence or interpretation; and preferably, but not necessarily, meshing with other theories that address related matters.

Two more strategies are introduced through the use of axes. The horizontal axis spans "correspondence discourses" and "coherence discourses." A correspondence discourse assumes a separation of the physical and the mental. It thus describes learning in terms of a correspondence between what happens in physical reality and what is happening in one's mental world. In contrast, a coherent discourse approaches learning in more integrated and systemic terms, in which the learner is understood as an agent that is part of a grander dynamic system, and learning is seen as a continuous process of co-evolution. "Cognitive Load Theory" would be considered a correspondence discourse, while "Social Constructivism" is a coherent discourse.

The vertical axis is a continuum that is used to organize discourses according to their relative emphases on "interpreting learning" and "influencing learning"—that is, the extent to which they are concerned with making sense of the nature, aspects, and dynamics of the phenomenon as contrasted with the extent to which they are concerned with prompting learning and characterizing learners. For instance, "Cultural-Historical Activity Theory," a theory that supports *interpretations* of learning, describes how human activity is shaped by the complex web of participants and their systemic constraints, while "Design-Based Learning," a discourse that attempts to *influence* learning, is structured around the making of artifacts through iterative processes of design, build, test, and revise.

Discussion and conclusions

Both exemplars take advantage of dynamic and user-friendly technologies, offering each user a unique experience oriented by personal interest and open to serendipitous possibilities.

Moreover, in the case of the Discourses on Learning in Education map, the experiences of someone interested in, say, spatial reasoning will be very different from those of someone interested in “wild pedagogies”—a fact that is signalled immediately by different locations, different clusters, and different colour-coding.

Like a piece of artwork or a detailed geographical map—or, indeed, like disciplines themselves—the entire map cannot be analyzed in one sitting, and every viewer will see it differently. It is not a resource to memorize but a reference to visit and revisit, partly because the contexts are extensive and partly because the map is dynamic. It changes with new research in the discipline. Much in contrast to the print limitations of even the best textbook, a visual-spatial, hyperlinked map invites the user into the ever-evolving realities of a discipline.

Visual-spatial hyperlinked maps have much to offer the academic world. In my case, they turned on the light in the dark cave, and I could see the enormous cavern and chose my path with more confidence. In addition to supporting students as they explore and locate themselves in a discipline, hyperlink technologies can potentially be used to “level up,” enabling the mapping of disciplinary structures by presenting evidence of connections among disciplines (Harries et al., 2004)—as might be inferred from the successes of Wikipedia and online newspaper articles in infiltrating our everyday lives. It is not a great leap to envision academic articles hyperlinked and then visually mapped to show in- and inter-system networks. As they reveal hidden patterns and unnoticed relations, these ever-changing maps could give access to domains in ways that have never been available to researchers.

References

Ainsworth, S. (2018). Multiple representations and multimedia learning. International handbook of the learning sciences, 96-105.

Budd, J. W. (2004) Mind Maps As Classroom Exercises. *The Journal of Economic Education, 35*:1, 35-46. doi: 10.3200/JECE.35.1.35-46

Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. *Geography and Sustainability, 1*(2), 93-97. Doi: 10.1016/j.geosus.2020.05.001

Davis, B., & Francis, K. (2021). Discourses on learning in education: Making sense of a landscape of difference. *Frontiers in Education*, *6*. doi:10.3389/feduc.2021.760867

Dubbs, C. H. (2021). Using the maps. Math Education Atlas. MathEdAtlas.org

Fischer, F., Hmelo-Silver, C. E., Goldman, S. R., & Reimann, P. (2018). *International Handbook of the Learning Sciences*. Routledge.

Gunstone, R. F., & White, R. T. (1986). Assessing understanding by means of Venn diagrams. *Science Education, 70*(2), 151-158.

Harries, G., Wilkinson, D., Price, L., Fairclough, R., & Thelwall, M. (2004). Hyperlinks as a data source for science mapping. *Journal of Information Science*, *30*(5), 436–447.

Hyerle, D. (1996). Thinking Maps: Seeing Is Understanding. *Educational leadership, 53*(4), 85-89.

Kong, X., Shi, Y., Yu, S., Liu, J., & Xia, F. (2019). Academic social networks: Modeling, analysis, mining and applications. *Journal of Network and Computer Applications, 132*, 86-103. doi: 10.1016/j.jnca.2019.01.029

Newcombe, N., & Huttenlocher, J. (2003). *Making space: The development of spatial representation and reasoning.* MIT Press.

Otto, C. A., & Everett, S. A. (2013). An instructional strategy to introduce pedagogical content knowledge using Venn diagrams. *Journal of Science Teacher Education, 24*, 391-403.

Peer, M., Brunec, I. K., Newcombe, N. S., & Epstein, R. A. (2021). Structuring knowledge with cognitive maps and cognitive graphs. *Trends in cognitive sciences, 25*(1), 37-54. doi: 10.1016/j.tics.2020.10.004

Sawyer, R. K. (Ed.). (2005). *The Cambridge Handbook of the Learning Sciences*. Cambridge University Press.

Scott, J. (2012). *What is social network analysis?* Bloomsbury Academic. doi: 10.1027/1614-2241.2.1.2