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A bibliometric methodology to assess the developmental stage of promising new research directions: the case of transdisciplinary learning science

It is claimed by many that the rapid progress that is made by neuro and cognitive scientists in understanding the brain is of great relevance for improving teaching and educational practices (OECD, 2002, 2007). It is claimed that in order to make these high expectations come true, a new type of research is needed, which should be transdisciplinary, that is crossing the borders between different academic disciplines as well as between academia and practice (Jolles et al., 2006; OECD, 2007). In this paper we present the results of a study which aims for a diagnosis on where we stand in the development of transdisciplinary learning science. Does it form an established specialty or subfield, is it emerging as a specialty or subfield or is it still in its embryonic stage, dominating agenda setting, but not yet visible in formal scholarly communication? Where exactly in the broad field of neuro- and cognitive neuroscience can we find linkages with the broad field of research in education and teaching? Where lie barriers and where lie opportunities to develop a transdisciplinary learning science?

The results of our study and the methods developed are relevant for science policy administrators. When administrators call for more socially relevant and strategic research, they need instruments to assess scientists' claims that a specific field of research is developing into a promising and socially-relevant direction and therefore qualifies for extra research funding. Administrators need to distinguish between promises that are highly uncertain and potentially overstated and those expectations that are more realistic. For premature developments, the return on investment will be more uncertain. Apart from the question whether to invest money, the question of how to invest is as important. A field of transdisciplinary research that is not yet well established and organized and in which collaboration between different disciplines still needs to be initiated, requires different kinds of science policy measures than a more mature transdisciplinary field.

To answer the questions on the developmental stage of transdisciplinary learning science, we first studied the dynamics of the involved research fields in terms of the emerging, stabilizing and changing formal communication networks. This was done at two levels. A citation analysis at the level of scientific journals was made to study the dynamics of research fields and specialties (Van den Besselaar & Leydesdorff, 1996). A word-reference co-occurrence analysis was made at the level of research papers to study the dynamics of research topic and research front (Van den Besselaar & Heimeriks, 2006).

The journal-journal citation analysis builds on the premise that journals belonging to the same subfield a) cite each other at a reasonable level, and b) refer in the same way to the relevant literature. The core journals of a field – as indicated by specialists - formed the entrance journals for the analysis. We determined the citation environment of these entrance journals, by including all journals in the analysis that cite or are cited by the entrance journals. The resulting set of journals was used to create a journal-journal citation matrix, using ISI's Journal Citation Reports. Then, a factor analysis of the journal-journal citation matrix was

made. Journals that have similar citation patterns cluster within the same factor, each representing a specific research subfield.

The dynamic relations between the various subfields can have three forms (Van den Besselaar, Heimeriks, forthcoming): 1) Over time, parts of the mentioned fields merge into a new *interdisciplinary* research field of neuro-cognitive learning sciences; 2) A single *multidisciplinary* journal functions as integrator between different subfields; 3) No new subfield is emerging, but the various relevant research subfields become *increasingly related*. This means that citation relations between the subfields emerge and become more intensive. We made an analysis for the year 2007 and found 1) no emerging interdisciplinary factor of neuro-cognitive learning sciences; 2) no strongly multidisciplinary journals bridging the fields of neuroscience, cognitive science and educational research; 3) no significant citation relations between the fields of educational research and neuroscience; 4) a modest citation relation between the subfield of educational psychology and cognitive psychology. 5.1% of all citations in educational psychology are to the field of cognitive psychology.

To study the emergence of transdisciplinary learning science at the level of research papers, we first did an extensive topic word search in the ISI database to create a large set of articles, which could potentially belong to an emerging subfield or specialty of transdisciplinary learning science. We then calculated similarities between these journal articles, based on the sharing of word-reference combinations. When two articles have a high similarity it indicates that they are close to each other both in terms of the knowledge they use (indicated by the sharing of references) as well as in terms of subject matter (indicated by the sharing of title words). The analysis is based on the premise that subfields or specialties of research should become visible as clusters of articles with a high similarity in terms of shared word-reference combinations. We made two separate analyses, one for the period (1997-2002), and one for the period (2003-2007). We visually inspected the thematic article clusters and found that only a small number were relevant for the field under study (8 for the first period, 12 for the second period) and that these clusters were quite small (an average of 1-3 articles a year for the first period, and an average of 1-8 articles a year for the second period.

In answering the question to what extent the field is practice oriented, we focused on the Dutch situation. We analyzed the institutional background of Dutch authors publishing in the international educational literature. Are these mainly researchers that work at universities, or do researchers that work for more practice-oriented research groups also contribute their knowledge to the international academic literature? The answer to that question forms an indication of whether Dutch educational research is of transdisciplinary nature. We found a very low share (7%) of non-university research in the literature and a low percentage of research collaborations between universities and public and semi-public research organizations (18%). This seems to reflect the fragmentation within educational research and educational innovation, which according to (Jochems, 2007) is connected to the way in which educational research and innovation are funded in the Netherlands.

Our bibliometric analyses, discussed above, are confined to research articles that are published in ISI journals. However we found one journal, the journal *Mind, Brain and Education,* established in 2007 and not (yet) processed in the ISI Web of Knowledge, that claims to cover the field of transdisciplinary learning sciences. We used bibliometric methods as well as qualitative content analysis to identify the topics addressed in this journal and to determine the knowledge base – i.e. the cited references - of the articles in this journal. The results corroborate the conclusion that can be drawn from analyzing the ISI literature viz. that transdisciplinary learning science does not yet form a substantial subfield or specialty.

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