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Book Review: Networking theories as an example of boundary crossing. Angelika Bikner-Ahsbahs and Susanne Prediger (Eds.) (2014) *Networking of theories as a research practice in mathematics education*

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Abstract This review essay first discusses a book authored by the Networking Theories Group and argues that the strategies for networking of theories are very similar to the learning mechanisms identified in the literature on boundary crossing. I propose that these two theoretical perspectives may be put into a fruitful dialogue.

1 The Networking Theories Group

The Congress of European Research in Mathematics Education (CERME) is organized in a special way: Working Groups (WG) stay together to work on one theme until the last day, when they share their insights with participants of other working groups. On two occasions (2011 and 2013), I attended the session of the WG entitled *Different Theoretical perspectives/approaches in research mathematics education research*. Both times, a buzz was in the air: This group really was on to something in an open-minded atmosphere.

On the first occasion (2011), I was taken by the idea of the networking of theories. Participants in this group were in a serious dialog to explain their own theoretical approaches to others and to understand those of others. They were neither ignoring other theories nor naively trying to unify theories into one grand system but rather trying to find productive ways of dealing with diversity. For any researcher, this diversity of theories in mathematics education and related disciplines is challenging, so I was excited to see how the participants approached this challenge and tried to make genuine connections.

On the second occasion (2013), the group leaders presented the group's ideas about how the networking of theories could be done (based on Bikner-Ahsbahs & Prediger, 2006; Prediger,

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Bikner-Ahsbahs, & Arzarello, 2008). There appeared to be a collection of different networking strategies. I was struck by how similar these strategies were to the learning mechanisms that we had found in a review study about boundary crossing (Akkerman & Bakker, 2011). Although this review study concerned a completely different body of literature—boundary crossing within and between work, school, and home contexts—the strategies or mechanisms turned out to be very similar to the networking strategies (see Table 1 for a brief comparison). Such an unexpected theoretical connection across disciplines seems to offer support for both the networking strategies and boundary-crossing mechanisms. Could there be something about making connections that makes the dialog between different theoretical approaches, on the one hand, and dialog between practices, on the other, similar? Before I elaborate in this review essay on this observation and question, let me review the book that was authored by the Networking Theories Group (Bikner-Ahsbahs & Prediger, 2014).

2 Review of the networking of theories book

Given the interesting work that this working group did, I was pleased to see that the group members have produced a book to enable those who were not part of the original discussions to engage with its yields. Bikner-Ahsbahs and Prediger have edited it very carefully. In the concise and lucid introductory chapter (Chap. 1), the group members summarize the purpose, the main ideas, the journey made by the group, and the structure of the book. A key question addressed is how to deal with the diversity of theories in mathematics education.

One extreme attitude is to ignore the diversity and just work within one paradigm. The other extreme is to aim for one grand unified theory, as do people in disciplines such as physics. In a social science and design-oriented field such as mathematics education, unification seems infeasible, perhaps even essentially impossible. The authors of the working group argue that the lack of a unifying theory is not a sign of immaturity of the discipline. Rather, the complexity of the research domain asks for diversity. This diversity of theories subsequently raises questions about how to make fruitful connections.

One attractive feature of the working group was that the participants worked on a single data set presented in Part I, Chap. 2, by Sabena. Part II of the book, Diversity of Theories, details how each of four sub-groups approached the data from the perspectives of their own "home-grown theories": the approach of Action, Production, and Communication (APC) (Chap. 3), the Theory of Didactic Situations

Table 1 A comparison of networking strategies and the learning mechanisms involved in boundary crossing

Networking strategies (Prediger et al., 2008)	Learning mechanisms involved in boundary crossing with examples of characteristic processes (Akkerman & Bakker, 2011)
Understanding others and making the own theory understandable	Mutual reflection (perspective making and taking)
Contrasting and comparing	Identification (othering; legitimating coexistence)
Combining and coordinating	Coordination (e.g., communicative connections and efforts of translation)
Synthesizing and integrating locally	Transformation (e.g., hybridization)

(TDS) (Chap. 4), the Anthropological Theory of the Didactic (ATD) (Chap. 5), the approach of Abstraction in Context (AiC) (Chap. 6), and the theory of Interest-Dense Situations (IDS) (Chap. 7). For a newcomer, it may be hard to understand these approaches from the brief discussions, but they do provide a useful starting point for anyone who is interested in the theoretical approaches considered.

From reading these chapters on home-grown theories, it becomes apparent how one's own theoretical lens influences what one sees and what one is interested in. Moreover, the lens codetermines the type of data required. For example, the initial data set is a video recording of two Italian boys working with dynamic geometry software on a task involving exponential functions. This allows for the analysis of their gestures in relation to their reasoning, but, for anyone interested in the wider context of their learning, what is missing is the students' background and prior knowledge, the intentions of the teacher, the curriculum, and the students' interests. For these reasons, the Italian researchers provided additional data so that their networking colleagues could perform their preferred types of analyses from the perspective of their own theoretical lenses.

Part III of the book is devoted to case studies of networking based on combinations of the aforementioned theoretical approaches. In Chap. 8, Prediger and Bikner-Ahsbahs explain the different ways of dealing with the theoretical diversity of research practices, namely by using the networking strategies as summarized in Table 1. I could not find an explicit definition of networking, but from the book I inferred that networking in this context means actively establishing connections at empirical, theoretical, or methodological levels.

Chapter 9 reinforces that different theoretical approaches may require different data. Because the available data did not ultimately provide the detail needed for the AiC team, the AiC team only expanded their view on the available data with the help of the APC team. The learning of the teams points to an asymmetry that is also common in boundary-crossing analyses: It is actually quite rare that different practices contribute in the same way to the dialog (Daniels, 2011). Networking experiences that are "deeper" (p. 150) than expanding any one team's view can be seen in the three remaining chapters in this Part III. In Chap. 11, local integration is claimed, whereas Chaps. 10 and 12 point to contrasting and coordinating. Chapter 12 explicitly addresses the question of progress: What was actually gained by the networking exercise? The two teams authoring this chapter have revised their original interpretation of an episode, which not only helped them understand the data better but also led to more precise demarcations of the theoretical constructs used.

What makes the chapters in Part III interesting is that readers can "take a look into the kitchen" (as we say in Dutch) of other researchers. The actual processes of doing research typically stay unreported in mathematics education; rather, they seem to belong to the sociology of science and it may be that the Networking Group can learn from this subdiscipline (e.g., Star, 2010).

Part IV is devoted to chapters offering reflections. In Chap. 13—entitled "Beyond the official academic stage"—Halverscheid presents, in journalistic style, the participants' experiences in an interview format. In this way, the reader is able to form an idea of the history of the group, the motivation for the choice of the data offered in Chap. 2, and other considerations not typically found in journal articles. This chapter most clearly demonstrates the benefit of the book format over, say, a special issue in a journal.

In Chap. 14, Bikner-Ahsbahs and Prediger reflect on the empirical, theoretical, and methodological benefits of the networking discussed in the earlier chapters. First, they argue that the networking activity has helped researchers to make their own ideas *more explicit*.

Second, they suggest that the *empirical scope* of different theoretical approaches can become clearer, also in terms of grain size. Third, they propose that relatively new approaches can become more *stable* by exploring connections between established approaches and by offering complementary views. Finally, they assert that increased *argumentative connectivity* can be established by using networking strategies.

An interesting move is made by Artigue and Bosch in Chap. 15. The Anthropological Theory of the Didactic (ATD) is used here for a different purpose than originally intended (Chap. 5), namely to study the networking of research practices rather than mathematics education itself. I highlight this because it links well with the point I make later—that networking is a form of boundary crossing. The theoretical approaches presented in Chaps. 3–7 are conceptualized in Chap. 15 as research praxeologies. A praxeology is a basic unit in which human action can be analyzed, consisting of practice (types of tasks, techniques) and theory (technological-theoretical discourse). The move of focusing on praxeologies emphasizes the pragmatic and dynamic vision of theories endorsed in this book, very much in line with the constant need for making dialogic connections with other research practices—a vision that I would characterize as being in the tradition of Hegel, Vygotsky, and Bakhtin.

Ruthven (Chap. 16) presents "a critical appreciation" of the networking of theories project and does so with admirable clarity and depth. First, he observes that the reader cannot find any reflection on the choice of the five theoretical approaches. Neither, he suggests, could the authors explain within their brief chapters how theories were "home-grown." As Ruthven writes, each of the approaches arose through interaction with theoretical approaches that were not specific to mathematics education, but it is unclear just how this happened. The emergence of the networking project thus comes across as rather incidental, just starting and possibly ending somewhere in history. Ruthven thus points to another interesting area of research, namely how theories in mathematics education emerge more generally. From my own perspective as a member of an international group exploring the value of inferentialism in mathematics education (Inferentialism in Statistics and Mathematics Education), I would indeed be interested in this process. Rather than expressing criticism, I take this interest to be an invitation: to present more of such reflective work in mathematics education.

A second issue raised by Ruthven is how "modular tools" can be derived from the networking of theories. He notices the discomfort of the working group with the notions of synthesis and integration and offers a more modest alternative: integrability of components. From a pragmatic stance, he wonders if the core theories discussed in the book could have commensurable components that could be shared among theoretical approaches.

In the final chapter, Radford (Chap. 17) makes some brief comments on what theory is and uses Heidegger to summarize the complex meaning of theory over many centuries. His commentary is sometimes so dense that it becomes hard for the reader who is not well-versed in Heideggerian thinking to follow. Like Ruthven, Radford notices that examples of synthesis are not presented in the book. It is apparently the most difficult form of making connections. What I find interesting is that Radford speculates on "unresolved synthesis" (p. 285): No new integrated theory is created, but the original theories "are radically shaken and transformed" (p. 285). This line of thinking sounds Hegelian and Bakhtinian to me, in line with the cultural-historical and activity theories inspired by Hegel and Vygotsky and many other great thinkers. Theoretical development is not a linear process toward truth. Rather, tensions become visible in the dialog between different practices or praxeologies. In resolving these

tensions, the implicit is made explicit (Brandom, 1994). In this way, new concepts and methods can emerge, which at some point in history require further scrutinizing or refinement. Older theories are not dismissed but rather sublated (cf. Roth, 2011, on constructivism). The Hegelian idea of sublation (*Aufhebung*; Palm, 2009) means that the old is preserved in a new way at a higher level.

This idea of sublation made me wonder about quality criteria for both theories and the results of networking theories. In Chap. 12, the issue of progress is explicitly addressed, but overall, the authors of the Networking Theories Group seem to have avoided the question of quality in their book. I appreciate that in order to work together, mutual respect and an open mind are crucial. A democratic or symmetrical relation seems conditional, although not always possible (see Chap. 9) or realistic (Daniels, 2011, on power relations). However, it would have been useful to formulate quality criteria for what counts as a suitable theory in a particular situation or as productive yield of applying networking strategies. Having reviewed the book as valuable in itself, I now move to an interesting connection between the networking and boundary crossing.

3 Networking as boundary crossing

I would like to return to the similarity between the networking strategies and learning mechanisms involved in boundary crossing mentioned earlier (see Table 1) and use this observation to theorize further on the connectivity underlying networking. I do this to get a better understanding of what is going on in the process of networking—a process that is not explicitly defined in the book. This move helps to address the problematic issue of synthesis or integration as well as other issues from a fresh perspective, that of boundary crossing. Networking theories is an example of boundary crossing, I propose.

In a project on promoting techno-mathematical literacies through boundary crossing between school and work in vocational education, Akkerman and Bakker (2011) reviewed the boundary-crossing literature to identify common mechanisms of boundary crossing from which we could learn and also to formulate clearer definitions. The concept of boundary crossing had previously been widely used but hardly defined and thus needed clarification. We came to define boundaries as "sociocultural differences leading to discontinuities in action and interaction" (p. 152). As a consequence, we defined boundary crossing as "the efforts by individuals or groups at boundaries to establish or restore continuity in action or interaction across practices" (Bakker & Akkerman, 2014, p. 225; see also Akkerman & Bruining, 2016).

In the boundary-crossing review study (Akkerman & Bakker, 2011), all dialogical learning processes between practices could be characterized as falling into one of four categories. Without suggesting hierarchy or sequentiality, we formulated them as follows:

(a) identification, which is about coming to know what the diverse practices are about in relation to one another; (b) coordination, which is about creating cooperative and routinized exchanges between practices; (c) reflection, which is about expanding one's perspectives on the practices; and, (d) transformation, which is about collaboration and co-development of (new) practices. (p. 150)

We also discovered that these mechanisms were typically exemplified in particular characteristic processes. For example, identification often includes processes of legitimating coexistence or of othering—reasoning in terms of "we vs. you" or "this vs. that" (Akkerman & Bruining, 2016, p. 245).

To show the similarity of networking with boundary crossing, let me now compare the four networking strategies formulated by Prediger and Bikner-Ahsbahs as shown in Table 1 (see also Chap. 8, pp. 118–119) with the four learning mechanisms found in the review study by Akkerman and Bakker (2011).

1. *Understanding others' theories and making the own theory understandable to others*. In light of the boundary-crossing literature, we would refer to this as *mutual reflection*, exemplified in the characteristic processes of perspective making and taking. This is a common mechanism between all sorts of practices, whether between or within work, school, or home contexts. Such perspective making and taking is also a process that can be deliberately promoted through interventions (e.g., Bakker & Akkerman, 2014). Mutual reflection demands that the listener's perspective is taken into account while explaining. Simply making one's own theory understandable to others without any consideration of the audience would be characterized as identification, which is described next.

2. *Comparing and contrasting theories*. This pair of networking strategies can be seen as a form of *identification*: boundaries between theories are identified and left as they are or even established more emphatically. They keep their own identity but in a more explicit way. As mentioned before, characteristic processes we found were othering and legitimizing coexistence. The same happens when theories are compared and contrasted: They are taken seriously but keep their own identities. However, if the theories are "shaken," as Radford describes in Chap. 17 (p. 285) in the case of unresolved tension, then each may be transformed.

3. *Combining and coordinating strategies*. These fall under the learning mechanism of *coordination*. In general, practices can be coordinated in many different ways. The characteristic processes we found were making communicative connections and efforts of translation, increasing boundary permeability, and routinization. What Ruthven (Chap. 16) suggested in terms of modular tools seems to fall under this heading of coordination: Theoretical tools can routinely be used as boundary objects (Star & Griesemer, 1989) in other practices, possibly after making communicative connections and translation efforts, by which initial boundaries between research practices become permeable.

4. *Synthesizing and integrating locally*. These strategies are forms of *transformation*. The characteristic processes we found in the review study were certainly not all formations of new boundary practices that are the synthesis or integration of different prior practices. The formation of really a new boundary practice such as biochemistry, from the interaction between biology and chemistry, is rare. Rather, we found less radical transformation processes such as confrontation, recognition of a shared problem space, hybridization, crystallization, and continuous joint work at the boundary. As Ruthven and Radford observed, no examples of synthesis were presented in Part III of the book. This is not surprising because synthesis is the most drastic change in the dialog between two theoretical approaches, comparable to the emergence of biochemistry. If the characteristic processes we found in the review essay under the heading of transformation were also found within the Networking Group's wider experiences, then the fourth pair of networking strategies of synthesizing and locally integrating theories in mathematics education could be enhanced with findings from the boundary-crossing framework.

The comparison above suggests a strong similarity between the networking strategies, as found in the specific situation of trying to make connections between research practices, and

the boundary-crossing mechanisms found in the broad review study on dialog between and within work, school, and home practices. In hindsight, it seems less surprising. After all, the Networking Group and boundary-crossing theorists were studying a similar phenomenon: how people seek to make connections between practices or praxeologies that have different origins and purposes. Dialogicality (in our case inspired by Bakhtin) is considered important when establishing relationships between aspects of theoretical approaches or other practices, while continuing to respect the identity of the other approaches. It could be expected that between such practices, scholars experience boundaries as defined above and that boundary crossing is required, hence that mechanisms at stake in boundary crossing are similar to those of networking strategies. It is for these reasons that I consider networking theories as an example of boundary crossing.

What else could be learned by "networking" the networking strategies and the boundary-crossing mechanisms? Prediger and Bikner-Ahsbahs (Fig. 8.1, p. 119) represent the networking strategies on a linear representation with "ignoring other theories" at one extreme and "unifying theories globally" at the other. I would like to challenge this linearity. Why would *contrasting* be to closer to synthesis than *making understandable*? When contrasting, boundaries are established more explicitly, whereas when making understandable, people are inclined to take the other into account and even use the other's terms to explain something. I have the impression that Prediger and Bikner-Ahsbahs are not comfortable with the linear representation either because in the caption of their Fig. 8.1, they characterize it as a "landscape of strategies for connecting theoretical approaches." I recognize this tension from how the four learning mechanisms in boundary crossing were sometimes interpreted as representing a hierarchy between identification, as leaving practices intact, up to transformation, as the most radical form of practices being changed. The latter was sometimes even interpreted as being the most desired form of boundary crossing. However, it was never intended to suggest such a hierarchy. There are examples where identification was to be preferred over transformation, for instance, when two different occupations had to be defined so that they did not experience each other as competing (e.g., Timmons & Tanner, 2004). Moreover, drastic coordination may involve substantial change of practices comparable to some forms of transformation.

In my view, it would therefore be worth rethinking the linear representation of networking strategies. The networking strategies may also benefit from sharper demarcations. For example, it seems that "making understandable" is understood by the Networking Group as a unidirectional process, whereas "mutual reflection" seems to be preferable. Another example is that characteristic processes of transformation found in the boundary-crossing literature may point to a more refined formulation of the synthesis and local integration strategy. Conversely, networking experiences that cannot be labeled within the existing boundary-crossing framework would point to the need of enhancing this framework.

The work of the Networking Theories Group, as presented in this book, seems to be an example of what Wenger (1998) calls *boundary interaction*: Scholars with a home-grown theory interact with those who subscribe to another theory that they know well. However, any exposé of boundary crossing is incomplete without discussion of *brokers* and *boundary objects* (Wenger, 1998). I mention these concepts because they can inspire theory networkers to foster connections in new ways. Brokers are boundary crossers, people who work in different practices and bring elements of each practice into the other. The existence of such people suggests that networking could be fostered by education researchers who are at home with several different research traditions. Another way in which boundary crossing can be promoted

in networking theories is by using boundary objects, artifacts that live in different practices but can be used in different ways, even without consensus (Star, 2010; Star & Griesemer, 1989). Ruthven (Chap. 16) talks about modular tools which could be used in different research practices. If so, they can be considered as boundary objects. Here, I am thinking of particular methodological approaches or instruments that could be exchanged between practices where they can be adapted to local usage. Thus, they are (in Star's terminology) robust enough to stay recognizable but are flexible enough to be used in different settings for different purposes.

I foresee that one word of warning may be worth writing down. Readers of this review essay may form the impression that networking two or more theories will produce new interesting theories and that they may use these strategies as a method for writing papers with coauthors schooled in another research tradition. This in itself sounds laudable (cf. Caduri & Heyd-Metzuyanim, 2015; diSessa, Levin, & Brown, 2015), but from the networking book, I infer that the challenges of productive networking should not be underestimated. Networking sounds like a rich and satisfying learning experience for scholars, but whether it will lead to new insights worth sharing in a scientific paper can only be decided once these scholars have undergone the networking processes or have engaged in substantial boundary crossing.

4 Conclusion

The Networking Theories Group has produced a highly commendable book for anyone interested in theories in mathematics education. Its target audience seems to be scholars with at least some familiarity with one or more of the theories represented in the book and readers who are willing to digest rather dense summaries of abstract concepts. But for those with an open mind and willingness to make this effort, a lot could be learned. As pointed out above, this book is a forerunner for more such work, not only on networking but also on the emergence of new theories or development of existing ones. Future conferences such as ICME, PME, and CERME (Dublin, 2017; Utrecht, 2019) will hopefully offer opportunities for such follow-up studies.

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