Connecting theories in mathematics education: from bricolage to professionalism

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Connecting theories is a normal activity in the practice of mathematics education researchers and the theories come from within the field of mathematics education ("home-brewed" theories) or from outside (psychological, sociological, anthropological; philosophical, linguistic etc. theories). Thus, the researcher needs methods and strategies for connecting theories; e.g. comparing/contrasting and integrating/synthesizing. I argue that a meta-language is also needed in order to move from bricolage to professionalism in the work of theory connection. Drawing on Radford's morphology of theories as triplets of principles, methodologies and research questions, I suggest a set of quality criteria for research papers and reports which focuses on the explicitness in reporting theory connection.

Criteria for research quality and relevance are closely related to the identity and status of mathematics education as a research field or a scientific discipline. Thus, any work on the identity of the field naturally gives rise to a debate on quality. This also happened in the ICMI-study *Mathematics education as a research domain: a search for identity* where criteria for quality were debated in relation to for example classroom practice, to foundation disciplines like psychology and sociology, and to mathematics (Sierpinska & Kilpatrick, 1998). Now, if one agrees with the view of mathematics education research as "the collective effort to study *and to shape* the relationship between humans, on the one hand, and mathematics, on the other" in society (Fischer, 1993, p. 113) and if one realises that this relationship has a societal dimension as well as a cognitive and an affective dimension, then one must acknowledge multi- and inter-disciplinarity

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as a fundamental feature of the research. At the same time, this view of the field presents a criterion for relevance in research. In the study of teaching, learning and knowing mathematics, there is a need for inquiry from psychological, sociological, anthropological, mathematical, philosophical, linguistic and other perspectives. Thus, theories, concepts and methods are imported from other disciplines and reconstructed for the purpose of mathematics education research and, in papers and reports there are references to scientists like Piaget, Bourdieu, Lévi-Strauss, Klein, Wittgenstein, and Saussure.

Connecting theories is another activity in the practice of many mathematics education researchers. I understand this as a feature related to the multi-disciplinarity of the field. Broadly speaking the theories – or theoretical perspectives – being connected come from within the field of mathematics education (”home grown” theories) or from outside (psychological, sociological, anthropological; philosophical, linguistic etc. theories), and they come from the same discipline or from different disciplines. Examples of home grown theories are Chevallard's (1985) theory of the didactical transposition and Skovsmose's (1994) theory of critical mathematics education. Examples of theories from outside mathematics education are Bernstein's (2000) theory of recontextualisation, Bourdieu's (1980) theory of habitus and Lave & Wenger's (1991) theory of situated learning. As a consequence the researcher needs methods and strategies for connecting theories. Thus a meta-language for dealing with this issue is required and the theory group at the Conference of the European Society for Research in Mathematics Education (CERME) has been working on this in 2005, 2007 and 2009. A preliminary result is presented in ZDM (Vol. 40, no.2, 2008) entitled *Comparing, combining, coordinating – networking strategies for connecting theoretical approaches*[1]. Here Prediger, Bikner-Ahsbahs and Arzarello (2008) have taken the first steps towards a conceptual framework with the construction of a terminology, which presents *strategies for connecting theories* within a scale of degree of differentiation and integration from ”ignoring other theories” to ”unifying globally”. As a contribution to this work, Radford (2008) creates a *morphology of theories* by conceptualising theory in mathematics education as a triplet formed by a system of theoretical principles, a methodology and templates of research questions. The terminology for connecting theories, which is under construction, offers researchers a tool for being conscious of and explicit about aims and considerations when combining or coordinating theories.

Transparency and explicitness are general quality criteria for scientific texts. In this article, I present and discuss terminology related to strategies for connecting theories in mathematics education which allows for explicitness in the research reports. The article deals only with criteria for quality of papers and reports not with criteria related to the research itself. However, the suggested quality criteria for presentation of theory connection can also guide ongoing processes of design in research projects in mathematics education. I argue that a meta-language like the one under construction is needed for the researcher to move from being a bricoleur (a handyman) to a professional or a reflective practitioner.

Diversity of theories

For the purpose of this article, I adapt the broad understanding of "theory" as proposed by Prediger, Bikner-Ahsbahs and Arzarello (2008); i.e. my basic frame – or working definition – for discussion of conditions for connecting theories is

> a dynamic concept of *theory* [or *theoretical approach*] whose notion is shaped by its core ideas, concepts and norms on the one hand and the practices of researchers – and mathematics educators in practice – on the other hand. (p. 176; my insertion and italics)

According to this dynamic understanding, theories and theoretical approaches in mathematics education are constructions in a state of flux and they guide and are influenced by observation. The notion of theory is wide when "theory" is synonymous with "theoretical approach". A first consequence is that theory is not only a guide for thinking but also for acting – for methodology. In his article *Theories of mathematics education: Is plurality a problem?*, Lerman (2006) examines the diversity of theories. He does not define "theory" but by looking at the examples and the proposed categorization of social theories within the mathematics education research community (1. Cultural psychology; 2. Ethnomathematics; 3. Sociology; 4. Discourse) it is obvious that Lerman's understanding of "theory" encompasses methodology and even problematique understood as a paradigm for mathematics education research (cf. Wedege, 2006). The same goes for Lester (2005) in his article O*n theoretical, conceptual, and philosophical foundations for research in mathematics education* where he, among other issues, addresses, the basic question "What is the role of theory in education research?" He argues that this role should be determined as a research framework which provides a structure for conceptualising and designing research studies. For example, a theory determines the nature of the research questions asked and what are acceptable research methods. This dynamic conception is different from Niss' (2007) who presents a static definition of theory as a stable, coherent and consistent system of concepts and claims with certain properties; for example, the concepts are organized hierarchically and the claims are either basic hypotheses and axioms or statements derived from these axioms. In contrast to Niss (2007), who puts forward requirements for a "full-fledged theory of mathematics education" (pp. 107–108), which he sees as an ideal – though unattainable – objective, Lester (2005) argues that "a grand 'theory of everything' cannot ever be developed and efforts to develop one are very likely to keep us from making progress toward the goals of our work" (p. 460). In line with the latter, Artique (2007), after more than ten years of involvement in international research on the design and educational use of digital technologies in mathematics education, states "that theoretical diversity is something inherent to our field" and that she is deeply convinced that the unification metaphor is not appropriate and "that more than integration we have to look for networking" (pp. 78–79).

There are different kinds of reasons for pluralities and diversity of theories in mathematics education research. One kind of reasons refers to the complexity of the subject area to be studied which cannot be understood by one comprehensive theory alone. Lerman (2006) has for example given this reason for plurality:

> To ignore the complexity is to lose the possibility of critique and hence I am not surprised by the multiplicity of theories in our field and the debates about their relative merits [...]. (p. 12)

Another kind of rationale is that theoretical traditions are independently formulated in different regions of the world and in different educational cultures (see Sriraman & English, 2005). A third kind of reasons might be the diversity of the researchers' educational background and expertise. Some have their main qualification in mathematics others in philosophy or sociology and consequently they have found their theoretical perspectives in these disciplines (see Wedege, 2008).

I agree with Cobb (2007), Lerman (2006), Lester (2005) and Prediger et al. (2008) when they regard pluralities and diversity of theories in mathematics education research as a resource of richness. However, variety is not a quality in itself and the co-existence of isolated, arbitrary theoretical frameworks can create difficulties. Arzarello et al. (2007) point out three kinds of challenges for the community: (1) Challenges for communication when researchers from different theoretical frameworks sometimes have difficulties understanding each other. (2) Challenges for the integration of empirical results when different theoretical perspectives cause different results in the empirical studies. (3) Challenges for scientific progress when the different theoretical frameworks and results cannot be linked to each other and when the research field is unable to discuss, contrast and evaluate its own production. These are the reasons for Prediger et al. (2008) to claim that the "richness of plurality can only become fruitful, when different approaches and traditions come into interaction" (p. 169). They distinguish theories by a series of criteria, for example the structure and relationship of their concepts, by the role of the theory to determine what kinds of insights are gained, what kinds of objects and methods are chosen and what counts as research questions, and by the view on the research itself.

Theoretical approaches and perspectives

What is regarded as research in mathematics education? According to Zan (2004), several scholars within the field accept a definition of research as disciplined and intentional inquiry and consequently a scientific study must, for example, be intentional enquiry aimed to face a specific problem and be connected with theory[2]. Following from the active notion of theory presented above, there is a dynamic interplay between theory and empirical investigations in research practice. In a simple structure for research design, purpose, theory/theories, research questions, methods and sampling strategy are inter-related. The *purpose* gives an answer to the question: What is this study trying to achieve? In my opinion, the purpose is closely related to the practical and/or theoretical problems which fuel the research process: Why is this study being done? The *theory* is chosen to inform and guide the study and research activities. If necessary for the purpose of the study more theories – or theoretical perspectives – are connected. The *research questions*, which are the basis and run all through the study, are stated within the conceptual apparatus of the theory/ies. They operationalise the objectives of the study: What do we want and need to know? The relevant and acceptable *methods* for empirical investigations and data analysis (survey, semi-structured interviews, participant observations, discourse analysis etc.) are chosen to provide answers to the research questions. The *sampling strategy* is guided by methodology and research questions and it provides an answer to the question: From whom – where and when – are the data to be generated. The possibility and the need of connecting theories in a research project depend on the purpose, the theories involved and the research questions. When a research problem – formulated as research question – becomes specific; i.e. conceptually formulated within the theoretical principles of a specific theory, the space for connecting theories becomes smaller. Radford (2008) points to the fact that, at a certain stage of the research process, a combination is no longer possible. He uses the example that, beyond a certain point, it would be like borrowing methods of Liberal economy to solve problems formulated within a Marxist theory of values.

Radford (2008) conceives the creation of a new conceptual space of networking theories and its meta-language as a condition for implementation of a network of theories in mathematics education. He suggests a morphology of theories for investigating differences and potential connections considering theories as triples $\tau = (P, M, Q)$, where:

- A system, *P*, of *basic principles*, which includes implicit views and explicit statements that delineate the frontier of what will be the universe of discourse and the adopted research perspective.

- A *methodology*, *M*, which includes techniques of data collection and data-interpretation as supported by *P*.

- A set, Q, of paradigmatic *research questions* (templates or schemas that generate specific questions as new interpretations arise or as the principles are deepened, expanded or modified).

(Radford, 2008, p. 320)

Radford suggests that theories can be conceived as implicitly or explicitly organised in accord with the three main components (*P*, *M*, Q) which are interrelated in specific ways. He emphasizes that he uses the term "system" instead of "set" for basic principles *P* of a theory. The reason is the existence of a specific hierarchy organising the principles in any theory. As an example he takes "social interaction" and "cognition" which are important components of several theories in mathematics education but without playing the same role, having the same relationship and the same importance in the structure of their principles. The system *P* of a theory is characterised by its hierarchical structure and the following meaning of its concepts. "Social interaction" and "cognition" are involved in corresponding principles *P* of the three theoretical approaches, *Constructivism*, *Theory of didactic situations* and *Activity theory*, but they have a different meaning. The methodology *M* of a theory has to meet at least two conditions: operability and coherence in relation to *P*. O*perability* means that the methodology must be able to produce and deal with the data in a way that "satisfactory" answers to the research questions are made available. These answers depend on e.g. statistical methods, interviews, discourse analyses, participating observations in classrooms. *Coherence* means that the discourse of the methodology is consistent with the basic principles. The set of paradigmatic research questions Q of a theory are articulated strictly within the conceptual framework of the theory:

> Because theories emerge as forms of understanding and action, and because they emerge as responses to particular problems, they bear the imprint of the initial questions that they sought to answer.
>
> (Radford, 2008, p. 321)

An initial research question in any socialisation theory in sociology deals with the relationship individual versus structure and in any learning theory in mathematics education the question deals with the relationship between humans and mathematics (Wedege, 2006). In the following the triplet (*P*, *M*, Q) of a theory is called its *theoretical structure*.

"Theory" and "theoretical approach" being used as synonyms is a precondition for Radford's morphology of theories. A consequence of this conceptualisation is that "theory" is implicitly distinguished from "theoretical framework", which does not automatically involve a methodology. The same goes for "theoretical approach" versus "theoretical perspective" and I suggest a terminological clarification of the latter pair (Wedege, in press): A *theoretical approach* is based on a system of basic theoretical principles combined with a methodology, as defined by Radford (2008), hence, guiding and directing thinking and action. A *theoretical perspective* is a filter for looking at the world based on theoretical principles, thus with consequences for the construction of the subject and problem field in research; that is the field to be studied (cf. Wedege, 2006). Cobb (2007) uses the metaphor "conceptual tools" for theoretical perspectives. Hence his understanding of theoretical perspectives matches my definition where perspective is distinguished from theoretical approach, which also includes a methodology. In the literature, by the way, reference is often made to sociocultural perspectives on mathematics education, simply meaning that social and cultural aspects of the educational phenomena are taken into account in research. Within the suggested terminology, it would not make any sense to talk about sociocultural approaches without a reference to a specific theory, e.g. a sociocultural approach – or problematique – like Engeström's (2001).

Terminology for connecting theories

The background for searching for connecting strategies and developing a relevant terminology can be found in the large diversity of theoretical approaches and perspectives, as mentioned above. In this section, I present the terminology developed by Prediger, Bikner-Ahsbahs and

Arzarello (2008, pp. 170–173), which I connect with Radford's morphology of theories (Radford, 2008):

Theories can be connected in multiple ways and degrees. The term *connecting strategies* is used as the overall notion for all strategies used by researchers to relate theoretical approaches in one way or another. A connection can happen at different levels of the theories: at the level of principles, of methodologies, of research questions or as a combination of these levels. In the terminology, the different connecting strategies are presented as pairs of similar strategies (understanding others / making understandable; contrasting / comparing; combining / coordinating; synthesizing / integrating locally) within a scale of degree of integration from "ignoring other theories" to "unifying globally" (see figure 1). The two poles with extreme strategies, ignoring / unifying, allow distinguishing different degrees of integration. With *ignoring* other theories at one end of the scale, we find at the other end of the scale *unifying globally* which is led by the idea of having a unique theory of mathematics education and hence only serves as a virtual extreme position. The term *networking strategies* is used to conceptualize all connecting strategies in between and which aim at reducing the number of unconnected theoretical approaches while respecting their specificity.

A little more than the laissez-faire of ignoring other theories is *understanding* others' system of basic principles *P* or methodologies *M*. Understanding takes place, for example at international conferences when researchers with different cultural backgrounds and theoretical approaches are determined to try to understand each other. All inter-theoretical communication and in particular all attempts to connect theories must start with understanding and *making understandable* one's own theory. Paired with understanding, this strategy is explicitly included because the articulation of a theory in a research practice is full of implicit aspects. Making understandable is about making explicit the theoretical structures, for example, the paradigmatic research questions Q of the theory. Likewise a successively deeper understanding of theories is always an aim of connecting attempts. This pair of strategies is also in play when researchers collaborate like in the European project TELMA (Technology Enhanced Learning in Mathematics). Here one of the working hypotheses sounds like this:

> [...] the multiplicity and isolated character of most theoretical frames used in technology enhanced learning in mathematics is an obstacle to the exchange and mutualisation of knowledge, and that the development of collaborative work requires better mutual understanding of our respective theoretical frames. (Artigue, 2007, p. 75)

Comparing and contrasting theories is the pair of networking strategies which is mostly used. The two strategies only differ gradually, but *comparing* is finding out similarities and differences, whereas *contrasting* is stressing the differences. Theories for example can be compared regarding the role of selected implicit or explicit aspects in the theoretical structures; e.g. in the principles as conceptualization and role of the individual, of social interaction and of mathematical knowledge. They can also be compared with respect to a priori defined criteria for the quality of theories; e.g. their potential contribution to the practice of mathematics education.

While the strategies of comparing and contrasting are mostly used for better understanding specific aspects of a theory or for offering a rational base for the choice of theoretical approach, the strategies of coordinating and combining theories – or conceptual frameworks – are usually used for a networked understanding of an empirical phenomenon or a piece of data. The term *coordinating* is used when a conceptual framework is built by well fitting elements from different theories: elements, e.g. from the basic principles *P*, are chosen and put together in a more or less harmonious way to investigate a certain research problem. This can only be done by theories with compatible cores, which include the theories' accepted ground rules and norms. The term *combining* is used when theoretical approaches are only juxtaposed. The chosen elements do not necessarily show coherence which is needed in coordinating. Nor does combining require complementarities or compatibility. Even theories based on conflicting principles can be combined. However, whereas all theories can be compared or contrasted, the combination of theories – or theoretical elements – might become difficult when the theories are not compatible.

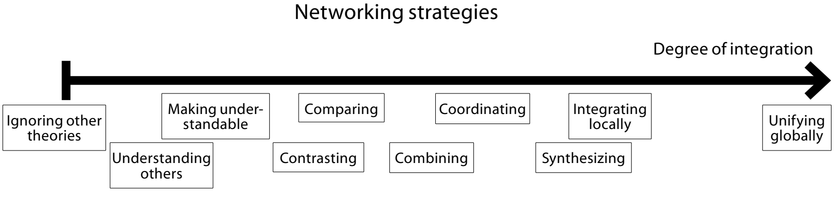

Figure 1. *A landscape for connecting theoretical approaches* (Prediger et al., 2008, p. 170).

When theoretical approaches are coordinated, it can be the starting point of a theorising process that goes further than the better understanding of a specific phenomenon towards the development of a new piece of synthesized or integrated theory. The aim of the two connecting strategies locally integrating and synthesizing is the development of theories. The term *synthesizing* is used when two or more equally established theories are connected in a way that a new theory evolves. The term *integrating* is used when the theories connected are not symmetric in scope and degree of development and some elements from one theoretical structure are integrated into a more elaborated theory. As this is not globally unifying, the term here is "integrating locally". Synthesising and integrating have stronger preconditions than the other networking strategies. It is, for example, important not to synthesize different parts of theories with contradictory cores into arbitrary patchwork-theories.

Bricolage

The term is borrowed from the French word "bricolage". It is used in several disciplines for example in the visual arts and literature to refer to the construction or creation of a work from a diverse range of things which happen to be available. The everyday meaning of the French word "bricoleur" is in English "tinker" or "handyman", i.e. a person who is clever at doing household repairs etc. (Danish: altmuligmand). In his article on coping with multiple theoretical perspectives, Cobb (2007) suggests that the researcher acts as a bricoleur by adapting and modifying ideas from a range of theoretical sources. As an example of bricolage taken from his own work, Cobb chooses the coordination of a social perspective on classroom activity drawing on sociocultural theory and a cognitive perspective drawing on both cognitive psychology and distributed accounts of cognition. This coordination resulted in an interpretive framework with the key concepts of mathematical, socio-mathematical and social norms. He indicates that "the pragmatic spirit of the bricolage metaphor indicates that the goal in doing so is to fashion conceptual tools that are useful for our purposes as mathematics educators" (p. 30). Lester (2005, p. 460) also employs the metaphor of bricolage when he proposes that "we view the conceptual frameworks we adopt for our research as sources of ideas that we can appropriate and modify for our purposes as mathematics educators". Both authors employ the metaphor with a reference to Gravemeijer (1994), who was the first to use it in mathematics education in relation to instructional design and did so with inspiration from Lévi-Strauss.

Gellert (2010) has examined the notion of "bricolage" as a strategy for coordinating theories in mathematics education research. He does this with a reference to its origin in anthropology where Lévi-Strauss (1962) introduced the "bricoleur" as opposed to the professional. Gellert goes back to the meaning of "bricoleur" in the work of Lévi-Strauss as it is interpreted by Gravemeijer (1994). He shows that the distinction between the bricoleur's pragmatic solutions and those chosen by the professional still exists in Gravemeijer. Gellert claims that "bricoleur" as a metaphor imported from anthropology, is not open for any interpretation and it cannot simply be exchanged by "handyman". Nevertheless, as he argues, this is what Cobb (2007) and Lester (2005) have done when they suggest that researchers act as bricoleurs when they adapt ideas from a series of theoretical sources. In his book "La Pensée Sauvage", Levi-Strauss (1962) confronts bricolage and science where the bricoleur approximates the savage mind and the engineer approximates the scientific mind. The bricoleur is competent at solving many tasks and at putting things together in new ways. But he is working with whatever is at hand and his universe of aids is closed. The engineer deals with projects in their entirety, taking into account the availability of materials and tools required. His universe is open in that he is able to create new tools and materials (p. 27). However, according to Lévi-Strauss both operate within a limited reality. The engineer has to consider a "toolbox" of existing theories and methods, in a way like the bricoleur who choses among the tools that are personally available. In the interpretation of Gravemeijer (1994), the scientist alias the engineer has precisely become a "technician" whereas Gellert contrasts bricolage with science: "The bricoleur takes whatever tool is at hand; the researcher constructs the optimal tool for the very research purpose. The criterion of optimality is precisely what is at stake when quality of research is evaluated" (p. 5).

However, this presentation of the engineer, who pictures the professional in Lévi-Strauss's work, as a technician with appropriate and targeted tools, has lead me to Schön's (1983) critique of the dominant technical rationality model of professional knowledge and to his concept of reflective practitioner (Wedege, 2010). According to him technical rationality is inadequate both as a prescription for – and as a description of – professional practice:

> Let us search, instead, for an epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict. (Schön, 1983, p.49)

Schön is concerned with developing an epistemology of professional creativity characterised by "reflection-in-action" and "reflection-on-action". Eraut (1994) argues that it is helpful to view Schön's work on professional knowledge as a theory of meta-cognition during deliberative processes. However, Gellert (2010) considering research quality states that

”Bricolage as a way of theorizing abdicates the theorizer from her scientific responsibility as it extracts the research from principled evaluation” (p. 539). As a criterion for quality of the research report explicitness is vital. In relation to the issue of theory, the paper must explain and present its own problematique within mathematics education and its research method and design must be clearly stated and described (Wedege, 2009). Thus, I see the work for developing a terminology – or a meta-language – for connecting theories in mathematics education as a step from bricolage to professionalism in research.

Professionalism

The morphology and the terminology presented above provide a conceptual tool for connecting and distinguishing theories. In order to clarify this, I have set up a matrix combining the six types of connecting strategies with the three levels of the theoretical structure (see table 1). Any connection of two or more theories will depend on the theoretical structures involved (i.e. their basic principles, methodology and paradigmatic research questions), and the goal of the connection. The main purposes of connecting theories are to understand better the theories involved, to understand better a specific empirical phenomenon or to create a new theory. A successively deeper understanding of theories is always an aim of connecting attempts. When the only aim is better understanding of specific aspects of a theory (basic principles, methodology, or research questions) the strategies understanding or making understandable (2) or contrasting and comparing (3) are used. Whereas combining and coordinating theories (4) are usually used for a networked understanding of an empirical phenomenon or a piece of data. With the aim of development of theories, the two connecting strategies locally integrating and synthesizing (5) are used.

The aim of networking is always to reduce the number of unconnected theories while respecting their identity. Radford (2008) claims that a networking space rotates around two complementary themes: differentiation and integration. These themes are latent in his discussion though he does not reconsider them later in the article. In the first column of the matrix, I have located the two themes in either part of the scale from ignoring other theories to globally synthesising theories. However, the two strategies in the middle of the scale, comparing and combining theories, both have the potential of evoking the complementary theme: comparing might lead to integration in the next step and the reason for combining might be precisely the differences between the theories.

Table 1. *Matrix of connecting theories: strategies and levels*

	Theoretical level / **Connecting strategy**	Principles *P*	Methodology *M*	Questions *Q*
Differentiate	1) Ignoring			
	2a) Understanding			
	2b) Making understandable			
	3a) Contrasting 3b) Comparing	Bergsten (2008)	Bergsten (2008)	Bergsten (2008)
Integrate	4a) Combining	Alrø et al. (2009)		
	4b) Coordinating	Wedege (1999)		Wedege (1999)
	5a) Integrating locally	Gellert (2010)	Gellert (2010)	
	5b) Synthesizing			
	6) Unifying globally			

The references in table 1 are papers and articles based on research which involves networking of theories. In Bergsten (2008), three theoretical approaches the APOS theory based on Piaget's constructivism, Reasoning and beliefs, and the Antropological theory of didactics are compared/contrasted at all levels (*P*, *M*, Q) in a study on students' learning limits of functions. Alrø, Skovsmose and Valero (2009) combine nine theoretical perspectives at level *P* in the notion of landscapes of learning as a tool to capture and structure part of the complexity in the multicultural mathematics classroom. Wedege (1999) coordinates the theory of situated learning with the sociological theory of habitus at two levels (*P*, Q) to better understand the role of mathematics in a woman's life (see below). Gellert (2010) integrates locally a structuralist and a semiotic theoretical approach at two levels (*P*, *M*), with the result of a deepened and more balanced understanding of the role of explicitness in mathematics classrooms.

Quality criteria

The conceptual tool as presented with the terminology in table 1 opens for communication around theory connection. One of the general criteria for a study to be scientific research – in the sense of disciplined inquiry – is that the study is public and verifiable (in the meaning that the research procedures are checkable). The researcher makes decisions at many steps of the research process: the choice of the problem, of the theory, of methods etc. These decisions are influenced by the researcher's epistemology, beliefs and values. Thus, there is a need to make these aspects explicit, in order to allow communication (Zan, 2004).

At a symposium in Denmark on criteria for scientific quality and relevance in "the didactics of mathematics", Dörfler (1993), former editor of *Journal für Matematikdidaktik* and of *Educational Studies in Mathematics*, presented a list of eight requirements or demands, which he used to obtain a rather formal assessment of a research paper. In the majority of the points, the criterion of explicitness is visible. Here follows my summary of these five statements:

1 There should be an explicitly formulated rationale for the presented research: What are the goals? What is the motivation? The central research questions?

2 The research paradigm, the background philosophy should be made explicit and recognizable.

3 The employed research method and research design should be clearly stated and described; especially when it is about empirical research.

6 A general requirement is for a reasonable embedding in existing research and literature. Research is a social process and this should be reflected in every single paper to a certain extent.

7 The author should make plausible to the reader the relevance of the research to mathematics education. Not that the results could necessarily be applied in the classroom the next day, but in some way the paper should be concerned with teaching/learning mathematics.

(from Dörfler, 1993, pp. 85–87)

These criteria are relevant to all kinds of mathematics education research. However, only one of the requirements (7) is specific to mathematics teaching and learning. In (1) Dörfler claims the importance of making the research interest and questions visible. In (2) he talks about the "research paradigm" (or "background" philosophy) which also has to be explicit and in (6) about methodology. These two points concern explicitness around two levels of the theoretical structure: basic principles and methodology. In (7), he states that the problems and the results have to be relevant to mathematics education and that the relevance should be explicitly argued in the paper. In keeping with the issue of connecting theories, I suggest that another point is added to this list of quality criteria concerning explicitness when reporting research based on theory networking:

– The author should make explicit which levels of the theoretical structures are connected, what is the networking strategy and why the theories are connected.

Coordinating – an example

As an example of a report of coordinating theoretical perspectives, I shall use the conceptual tool to present the analysis of a life history interview. The aim of this theory connection was networked understanding of a piece of data. In the narrative of a 75 year old woman, Ruth, about mathematics in her life, there was a type of contradiction which is well known in adult education: many students show resistance against learning mathematics in formal settings while they are mathematically competent in their everyday life. This particular woman, who had really bad experiences with mathematics in secondary school, went to a technical school to be a draughtsman at the age of 50 and she got the top grades in mathematics. But her dispositions towards having to do with mathematics did not change neither did her beliefs about herself and mathematics. In order to explain this incident, I attempted to coordinate Lave and Wenger's (1991) concept of situated learning with Bourdieu's (1980) sociological concept of *habitus*, i.e. systems of durable, transposable dispositions as principles of generating and structuring practices and representations (Wedege, 1999).

Lave and Wenger (1991) see learning as a social practice and the context of their analysis of learning processes is the current community of practice. The theory of *situated learning* is about learning as a goal-oriented process described as a sequence from legitimate peripheral participation to full participation. Throughout her life Ruth has participated in a number of different communities of practice (family, school, work, etc.). In her mathematics lessons, she learned that she was stupid at mathematics, that she was not interested in it, and that in any case mathematics had no relevance for her life. She was confirmed in this by never having failed in practical situations due to a lack of mathematics knowledge. When, much later in her life, Ruth got the highest grade in the subject of mathematics this did not change her idea of mathematics, the world around her, or herself. But the theory of situated learning does not present the possibility of explaining why her perception of herself had not changed in the new educational context, and why she never had any appreciation of mathematics.

Ruth's motivation to become a draughtsman made her overcome her blocks, but not her resistance to learning mathematics. Her intentions had changed but not her dispositions towards mathematics, incorporated through her lived life. According to the theory of Bourdieu, the habitus of a girl born 1922 in a provincial town as a saddler's daughter, of a pupil in a school where arithmetic and mathematics were two different subjects, at a time where it was "OK for a girl not to know mathematics", and the habitus of a wife and mother staying home with her two daughters is a basis of actions (and non-actions) and perceptions. Habitus undergoes transformations but durability is the main characteristic.

Elements from the systems of basic principles of the two theories are connected in this analysis. I have argued that the concept of habitus, developed and belonging in a sociological problematique as a concept of socialisation, can be coordinated with Lave and Wenger's concept of situated learning in a problematique of mathematics education (Wedege, 1999). In the first place, Bourdieu emphasises that the theory of habitus is not "a grand theory", but merely a theory of action or practice (Bourdieu, 1994). The habitus theory has to do with why we act and think as we do. It does not answer the question of how the system of dispositions is created, and how habitus could be changed in a (pedagogical) practice. This means that the concept of habitus can be used in a descriptive analysis of the conditions for adults' learning. Lave and Wenger's theory of situated learning is also a partial theory, a theory of learning as an integral part of social practice. They are precisely trying to find an answer to the question of how people's dispositions are created and changed through legitimate peripheral participation (Lave & Wenger, 1991). Bourdieu and Lave/Wenger both aim at challenging the dichotomies of subject-object and actor-structure. Both are critical of phenomenology and structuralism while simultaneously having social relations as the focus of their subject areas. Bourdieu sets himself the task of constructing a theory of action as social practice and Lave and Wenger a theory of learning as an integral part of social practice.

A common core – or basic principle – in both theories is the understanding of learning as a social practice. Besides, the two theories reject the idea of internalisation of knowledge, attitudes and norms. They mention instead active incorporation. I have argued that the two theories are compatible and that the concept of habitus, which is developed and belongs in a sociological problematique, can be imported into an educational problematique about adults' learning mathematics together with the concept of situated learning. Thus, in this case, coordinating theories can be the starting point for local integration and development of a new theory.

Conclusion

Diversity of theoretical approaches and perspectives is a challenge in mathematics education research. Inter-disciplinarity is also a significant feature of this field where theories and theoretical frameworks are imported and restructured. However, the researchers often import concepts or other theoretical elements from other disciplines, like psychology, sociology and anthropology, without any critical reflections on the process of import, integration and restructuration of the framework. Hence, there is a need for strategies for connecting theories from within mathematics education or from other disciplines. Missing terminology is a related problem and I see the work on developing terminology in parallel with strategies as very important in terms of research quality (Gellert, 2010; Prediger et al., 2008; Radford, 2008, Wedege, 2010). This article presents and discusses strategies and terminology for networking theories and suggests resulting quality criteria for scientific papers and reports from research based on connecting theoretical approaches or perspectives. These criteria are about explicitness, and I have contrasted bricolage with professionalism in mathematics education research arguing that a meta-language is needed for connecting theories. I do this with a reference to Schön's (1983) "reflective practitioner" and to Gellert's (2008) calling attention to the researcher's scientific responsibility of opening for principled evaluation of her/his research.

Any criterion of quality – like any standard for research – implies a risk of technocracy and of reducing professional creativity. There are however reasons for trying to verbalize principles of evaluation:

> The existence of criteria, no matter how provisional or incomplete, allows researchers to assess the quality of their work or the work of others, and it allows the field to see what progress, if any, is being made. [...] the criteria are lenses through which the research landscape can be viewed. (Kilpatrick, 1993, p. 31)

This article deals only with criteria for quality when reporting research, and not with principles related to the research itself. Yet, the suggested criteria for explicitness about the networking of theories can also guide ongoing processes of design in mathematics education studies where theories are differentiated or integrated.

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Notes

1 Apart from the two – mainly conceptualizing – articles which I build on in this article, this issue of ZDM – *The International Journal on Mathematics Education*, 40(2), 2008, contains a series of articles with examples of networking theories and debate about theory connection. So does the report from Group 9, *Different theoretical perspectives/approaches in research in mathematics education*, in the proceedings from the *Sixth Conference of the European Society for Research in Mathematics Education*, Lyon, 2009 (in press).

2 In the context of the discussion group 8, *The quality and relevance in mathematics education*, at ICME 10, 2004, where Zan's paper was presented, theory is not given a common definition.

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