

Chapter 4

An Introduction to Grounded Theory with a Special Focus on Axial Coding and the Coding Paradigm



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Abstract In this chapter we introduce grounded theory methodology and methods. In particular we clarify which research questions are appropriate for a grounded theory study and give an overview of the main techniques and procedures, such as the coding procedures, theoretical sensitivity, theoretical sampling, and theoretical saturation. We further discuss the role of theory within grounded theory and provide examples of studies in which the coding paradigm of grounded theory has been altered in order to be better suitable for applications in mathematics education. In our exposition we mainly refer to grounded theory techniques and procedures according to Strauss and Corbin (*Basics of qualitative research: Grounded theory procedures and techniques*, Sage Publications, Thousand Oaks, 1990), but also include other approaches in the discussion in order to point out the particularities of the approach by Strauss and Corbin.

Keywords Grounded theory · Coding procedures · Coding paradigm · Coding families · Theoretical sensitivity

4.1 Introduction

In 1967, sociologists Barney Glaser and Anselm Strauss published their seminal book “The discovery of grounded theory: Strategies for qualitative research” (Glaser and Strauss 1967), which lays the foundation for one of the most prominent and influential qualitative research methodologies in the social sciences and beyond. With their focus on theory development, they dissociate themselves from mere theory verification and the concomitant separation of the context of theory

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discovery and the context of theory justification, which was the prominent scientific method at that time. With their approach to qualitative research, they also go beyond the mere description of phenomena. Originally, the book was written as a book for young researchers. One of its main intentions was to legitimate qualitative research (Mey and Mruck 2011).

Quite soon after their joint publication in 1967, Glaser and Strauss developed grounded theory in different directions and started to argue their own understanding of grounded theory methodology and methods apart from each other in different ways, Glaser primarily on his own, Strauss also together with Juliet Corbin (Glaser 1978; Strauss 1987; Strauss and Corbin 1990). Later, students of Glaser and Strauss further developed the different interpretations of grounded theory methodology so that today there is a second generation of grounded theory researchers, namely Juliet Corbin, Adele E. Clarke, and Kathy Charmaz (Morse et al. 2009). As those further developments of grounded theory resulted in different research methodologies, it has been suggested to talk about grounded theory methodologies in plural or at least to acknowledge that there are numerous *modi operandi* involving grounded theory methods in different fields of research as well as different national traditions (Mey and Mruck 2011). In Germany, for instance, it is still most common to work with the grounded theory methodology version that was published by Strauss and Corbin in 1990 (German translation from 1996). The second generation's developments are still hardly noticed.

As this chapter is an introduction to grounded theory methodology and methods, our aim is to outline the common core of the different approaches to grounded theory. Therefore, we give a short introduction to grounded theory as a methodology (Sect. 4.2) and its techniques and procedures (Sect. 4.3). We further discuss an issue that lies at the heart of grounded theory, namely the role of theory within the methodology (Sect. 4.4). There, we also describe some examples of studies that used grounded theory as the main methodology, but took a specific stance to theory development in using the methodology.

4.2 A Short Positioning of Grounded Theory

This section provides a short overview of grounded theory as a methodology. We aim to answer two questions: 1. What is a grounded theory? 2. What kind of research questions are appropriate for a grounded theory study?

4.2.1 What Is Grounded Theory?

There is no simple answer to this question as the term *grounded theory* adheres to different research elements. In the first place, grounded theory is a methodology, which is characterized by the iterative process and the interrelatedness of planning,

data collection, data analysis, and theory development. Grounded theory further provides a particular set of systematic methods, which support abstraction from the data in order to develop a theory that is grounded in the empirical data. These methods include different coding procedures, which are based on the method of constant comparison. New data are gathered continuously and new cases are included in the analysis based on their potential contribution to the further development and refinement of the evolving theory. This sampling method is called *theoretical sampling*. The iterative process of data collection according to theoretical sampling, data analysis, and theory development is continued until new data do not contribute any longer to a substantial development of the theory, i.e. until *theoretical saturation* is achieved. The theory that is the product of this process is also referred to as *grounded theory*. The quality of a grounded theory is not evaluated according to the standard criteria of test theory, i.e. objectivity, reliability and validity, but according to criteria such as credibility, plausibility, and trustworthiness.

4.2.2 What Kind of Research Questions Are Appropriate for a Grounded Theory Study?

According to the usual scientific procedure, the research question is at the outset of any scientific endeavour. It is the essence of what the researcher wants to know. The overall purpose of the study is to find an answer to the research question. Methodology and related methods are but a vehicle to find the (possibly best) answer to the research question. Ideally, it should be the research question that determines the methodology and not vice versa. Thus, it is important to ask what kind of research questions are appropriate for a grounded theory study. The character of the research question will influence the methodology and the choice of methods. We will try to characterize the kind of questions to which grounded theory could probably provide a good answer.

The overarching goal of grounded theory is to develop theory. Therefore, grounded theory studies may be carried out related to research phenomena or objects, which lack a (sufficient) theoretical foundation. It may be, that no theory exists for the phenomena under study or that the existing theories are insufficient in that

- they lack important concepts;
- the relationships among the concepts are not elaborated enough;
- the relevance of the concepts and their relationships has not been corroborated for the population or the context under study.

Due to the origins of grounded theory in the social sciences, the main epistemological interest lies in predicting and explaining behavior in social interaction. Thus, Strauss and Corbin (1990) stress the orientation towards action and processes of grounded theory research questions.

4.3 A Short Introduction to the Methods and Techniques of Grounded Theory

The methods and techniques of grounded theory make use of different elements: some relate to the collection, some to the evaluation of data, and some refer to the research process. The following section gives a short introduction to the most important methods and techniques to make the start of working with grounded theory easier for a newcomer to this vast field. A more detailed description of the procedures and techniques can be found in the original literature describing grounded theory (e.g., Glaser 1978; Strauss 1987; Strauss and Corbin 1990). Note that technical terms and procedures may differ (slightly) when adhering to literature from different traditions of grounded theory. Even within one tradition of grounded theory, the methodology may also change over time (see Sect. 4.3.3.2 for an example with relation to the coding paradigm proposed by Strauss and Corbin 1990 and Corbin and Strauss 2015 respectively). To gain a more practical idea about the application of grounded theory, we suggest looking at Vollstedt (2015) for an example of the application of grounded theory methods in an international comparative study in mathematics education carried out in Germany and Hong Kong.

4.3.1 *Theoretical Sensitivity and Sensitizing Concepts*

When starting to work with grounded theory, there is no fixed theory at hand with which to evaluate the data. On the contrary, the researcher moves into an open field of study with many unclear aspects. As described above, important concepts are missing, and/or their relationship is not elaborated enough. The longer the researcher will have worked in this field, the clearer those unclear aspects will (hopefully) become. In order to make sense of the data, an important ability of the researcher is theoretical sensitivity. The notion of theoretical sensitivity is closely linked to grounded theory and Glaser (1978) even devoted a whole book to this issue. Corbin and Strauss (2015) describe sensitivity as “having insights as well as being tuned into and being able to pick up on relevant issues, events, and happenings during collection and analysis of the data” (p. 78). According to Glaser with the assistance of Holton (2004) the essence of theoretical sensitivity is the “ability to generate concepts from data and to relate them according to normal models of theory in general” (para. 43). They further sum up a number of single abilities that characterize the theoretical sensitivity of a researcher. These are “the personal and temperamental bent to maintain analytic distance, tolerate confusion and regression while remaining open, trusting to preconscious processing and to conceptual emergence [...] the ability to develop theoretical insight into the area of research combined with the ability to make something of these insights [...] the ability to conceptualize and organize, make abstract connections, visualize and think multivariately” (para. 43).

The opinions about how a researcher might develop theoretical sensitivity differ between the two founders of grounded theory and are in fact one of the main differences between their approaches. While Glaser (with the assistance of Holton 2004) suggests that the “first step in gaining theoretical sensitivity is to enter the research setting with as few predetermined ideas as possible” (para. 43), Strauss and Corbin (1990) name different sources of theoretical sensitivity: these are respective literature, the professional and personal experience of the researcher as well as the analytical process itself. However, the researcher is not supposed to follow the beaten track of the literature or his/her personal experience, but to question these and go beyond in order to get novel theoretical insight. In “Basics of qualitative research” Strauss and Corbin (1990) describe techniques to foster theoretical sensitivity. These are questioning, analyzing single words, phrases or sentences, and comparing, thus techniques, which pervade grounded theory in general.

4.3.2 Interdependence of Data Collection, Analysis, and Development of Theory

One characteristic of grounded theory is that data collection, data analysis, and theory development are not successive steps in the research procedure but are intertwined and interdependent. Thus, action in terms of data collection and reflexion in terms of data analysis and theory development always alternate. Data collection and analysis initialize the process of theory development. Further cycles of data collection and analysis are guided by theoretical sampling and serve to specify the research focus on the one hand, and to develop hypotheses and theory on the other. Theoretical sampling denotes a cumulative sampling method, in which the selection of new cases that are to be included in the analysis is guided by the unfolding theory. In this context “cases” does not necessarily mean “people”. Corbin and Strauss (2015) point out that “it is concepts and not people, per se, that are sampled” (p. 135). The authors point out that the goal of theoretical sampling might vary throughout the process of theory development. In the beginning of the process, cases are selected, because they are likely to enable the discovery of new relevant concepts. Later on, cases are selected because they are likely to contribute to the differentiation, elaboration, consolidation, and validation of categories in terms of their properties, their dimensions, or their interrelations (see the next section for the development of concepts and categories).

Theoretical sampling and the development of theory are continued until *theoretical saturation* is achieved, i.e., new data do not seem to contribute any longer to the elaboration of categories. The relations between the categories are well developed and validated (Strauss and Corbin 1990).

4.3.3 Data Analysis

The overarching goal of data analysis in the grounded theory methodology is theory development. In order to achieve this goal, the collected data are evaluated by applying different ways of coding as the core process. Coding in grounded theory methodology is a process of conceptual abstraction by assigning general concepts (codes) to singular incidences in the data.

After having collected some (not necessarily all) data, the evaluation process may begin. Depending on which line of grounded theory methodology one follows, the different kinds of coding that are applied may vary in nomenclature as well as procedures (Glaser 1978; Mey and Mruck 2011; Strauss and Corbin 1990; Teppo 2015). Glaser (1978) discriminates between substantive coding, which consists of open and selective coding, and theoretical coding. In contrast, Strauss and Corbin (1990) differentiate between three kinds of coding procedures that are needed to develop a grounded theory from the data: open, axial, and selective coding. These procedures are not to be misunderstood as being precise procedures that are easily distinguishable. On the contrary, the procedures are neither clear-cut, nor do they easily define phases that chronologically come one after the other. They embody rather different ways of working with the data that can be combined with each other and between which the researcher can move back and forth if needed (Mey and Mruck 2011).

The following sections give a brief overview of open, axial, and selective coding following Strauss and Corbin (1990). Section 4.4 then focusses on the role of theory in grounded theory with a special focus on axial coding and the coding paradigm.

4.3.3.1 Open Coding

Although the different procedures of coding do not occur in a strict sequence, open coding is usually the first approach to the data. Core elements of open coding are posing sensitizing questions and constantly comparing data and codes.

Open coding is the part of data analysis that focuses on the conceptualisation and categorisation of phenomena through an intensive analysis of the data. In this first step of open coding, the data are broken up into smaller parts that are deeply analysed. The aim of this analysis is to grasp the core idea of each part and to develop a code to describe it. Open codes can be either developed *in vivo*, i.e. directly from the data using descriptions that also are derived from or close to the data, or with reference to technical literature referring, e.g., to theories from mathematics education, educational psychology, or other relevant areas of study.

In a second step then, these smaller analytical parts are compared with respect to similarities and differences. Similar parts can be labelled with the same code. Strauss and Corbin (1990) use the terms *concept* and *category* to denote a phenomenon that is categorized and conceptualized by assigning it to one code (*concept*) or concepts of higher order (*category*). This means that the concepts

developed are then related to other concepts so that categories of a higher order emerge so that different dimensions of the category can be described. During the process of developing the dimensions of categories, theoretically relevant characteristics of every category are determined and explicated in the code descriptions (Mey and Mruck 2011).

The overall goal of open coding is to develop a wealth of codes with which to describe the data. To reach this goal, sensitizing questions are posed regarding the data when they are being analysed. This finally leads to new discoveries (Strauss and Corbin 1990). The following list shows some of the questions that offer rich answers for the interpretation of the data (Böhm 2004; Mey and Mruck 2011; Strauss and Corbin 1990):

- What?—Which phenomenon is described?
- Who?—Which people are involved? Which roles do they embody, or which ones are assigned to them?
- How?—Which aspects of the phenomenon are dealt with? Which are left out?
- When? How long? Where?—In what way is the spatiotemporal dimension biographically relevant or important for single actions?
- Why?—Which justifications are given or deducible?
- Whereby?—Which strategies are used?
- What for?—Which consequences are anticipated?

To pose those sensitizing questions, the researcher uses his/her personal and professional experience as well as knowledge that was gained from the relevant literature. All those resources are used in a creative manner of free association (Strauss and Corbin 1990) to interpret the data and to develop codes to describe the interpretation found. Thus, the researcher's own and other people's presuppositions in relation to the phenomenon are questioned and investigated.

4.3.3.2 Axial Coding

To develop a grounded theory, the emerging relationships between the elaborated concepts need to be integrated into an overarching framework with one core category. Glaser (1978) calls this process *theoretical coding*; Strauss and Corbin (1990) differentiate between *axial coding* and *selective coding*, but themselves emphasize that there is not much of a difference, except at the level of abstraction.

According to Strauss and Corbin (1990), axial coding is needed to investigate the relationships between concepts and categories that have been developed in the open coding process. As people act and interact with other people, they possess different strategies to handle their interpretations of the situations in which they are involved. Their acting as well as the pursuit of their strategies have consequences. Explanations contain conditions that have an impact on one's actions and interaction as well as the consequences that result from these (Strauss and Corbin 1990). To work out the relations between the categories, Strauss and Corbin (1990) suggest examining the data and the codes based on a coding paradigm that focuses on

and relates causal conditions, context, intervening conditions, action/interaction strategies, and consequences. These perspectives on the data help to detect relations between concepts and categories in order to relate them on a meta level. Strauss and Corbin (1990) perceive the coding paradigm as an obligatory element of a grounded theory: if the coding paradigm was not used in theory development, the theory would miss density and precision.

One of the most difficult questions for a researcher new to the field of grounded theory is as follows: How does the coding paradigm work? After having broken up the data in the process of open coding, they are joined together in a new way in the process of axial coding as links are worked out between a category and its sub-categories. The focus of axial coding is on a category (the phenomenon) in relation to the following aspects. First, causal conditions specify the phenomenon with respect to incidents or occurrences that result in appearance or development of a phenomenon. Second, the context is the specific set of characteristics in which the phenomenon is embedded. Simultaneously, the context also characterizes the special set of conditions in which action/interaction strategies take place to overcome, handle or react to a certain phenomenon. Third, intervening strategies are the broad and general conditions that influence action/interaction strategies. These comprise, for instance, time, space, culture, socioeconomic status, technological status, career, history, and individual biography. Fourth, action or interaction strategies are directed towards the phenomenon. No matter whether the research is about individuals, groups or collectives, there is always action or interaction that is directed towards the phenomenon, to handle or to overcome it, to perform it, or to react to it. The phenomenon always appears in a certain context or under specific circumstances. The interactional component is related to the self of the acting person as well as to other interactions. And finally, action and interaction that are performed or—on the contrary—are not performed as an answer to or to overcome a phenomenon, lead to results and consequences. These are neither always predictable nor intended, and also the default of an action/interaction leads to results and consequences. Consequences can be real or hypothetical in the present or in the future. In addition, consequences can change their frame of reference as in one point of time they can be consequences of an action/interaction, whereas at a later point of time, they can be part of causal conditions for another phenomenon. Note that in the fourth edition of the “Basics of qualitative research”, Corbin and Strauss (2015) reduced the coding paradigm to the three main features “conditions”, “actions-interactions”, and “consequences or outcomes”.

As Glaser, Strauss, and his colleagues were social scientists, the aspects chosen for their coding paradigm do not necessarily meet the necessities for educational research. Thus, there have been researchers who have changed the procedure of axial coding such that they in general followed the idea to look for relations between the phenomena described in the categories that were developed in the process of open coding but changed the aspects in the coding paradigm to look for those relations. We take a deeper look at the coding paradigm and its possibilities of amendment in Sect. 4.4.

4.3.3.3 Selective Coding

The goal of selective coding is to integrate the different categories that have been developed, elaborated, and mutually related during axial coding into one cohesive theory. To reach this goal, the results from axial coding are further elaborated, integrated, and validated. Thus, selective coding is quite similar to axial coding, but it is carried out on a more abstract level. The categories are theoretically integrated into a consistent overarching theory as they are subsumed under a core category that is linked to all other categories that were established in axial coding. As Teppo (2015, with reference to Corbin and Strauss 2008, p. 14) points out, the questions that have to be answered are “what is the research all about?” and “what seems to be going on here?”. Thus, selective coding is the process of choosing the core category and relating it with the other categories from axial coding. In addition, these relations need to be validated and some categories might need to be refined and further elaborated. The core category described “the central phenomenon around which all the other categories are integrated” (Strauss and Corbin 1990, p. 116). If the core category is found, the story line of the research is set or, as Vollstedt (2015) writes, the path is detected that leads the way through all the trees so that the wood can finally be seen. Having detected the core category, the researcher knows the central phenomenon of his/her research and can finally answer the research question. The product of this research process finally appears: the grounded theory that arose from the data.

4.3.3.4 Memos and Diagrams

A further central rule of grounded theory methodology is to interrupt the coding process again and again to write down memos: “Stop coding and record a memo on your ideas”, as Glaser and Strauss (1967, p. 113) put it. In general, memos are very special types of written notes as they keep track of the analytical process and the directions for the analyst. Thus, they not only describe the phenomena they are about, but move on a meta level by being analytical and conceptual and help the researcher to step back from the material to see it from an analytical distance (Strauss and Corbin 1990). Glaser (with the assistance of Holton 2004, para. 61) writes: “Memos are theoretical notes about the data and the conceptual connections between categories. The writing of theoretical memos is the core stage in the process of generating theory. If the analyst skips this stage by going directly to sorting or writing up, after coding, he/she is not doing GT” [i.e., grounded theory].

There are different kinds of memos like memos on methodical decisions, planning steps, case selection, or interpretative team sessions. The most important variant for the development of a grounded theory is writing memos that contain code notes and theoretical notes. In the process of data analysis, codes can be elaborated so that code notes can be further developed into theoretical notes (see Strauss and Corbin 1990 for a detailed description). Although it is tempting not to write memos in the analytical process, “writing memos and doing diagrams are

important elements of analysis and never should be considered superfluous, regardless of how pressed for time the analyst might be” (Strauss and Corbin 1998, p. 218). Thus, writing memos should accompany the whole analytical process from the development of the first code to the final grounded theory. Memos are written only for the analyst in order to keep track of the analytical “process, thoughts, feelings, and directions of the research and researcher—in fact, the entire gestalt of the research process” (Strauss and Corbin 1998, p. 218). Hence, they are hardly seen by people other than the researchers involved, but are nevertheless of high importance, also from the perspective of quality criteria. As mentioned above, the quality of a grounded theory can be judged—among other criteria—with reference to credibility, plausibility, and trustworthiness. Memos are needed to argue and prove the development of the grounded theory from the data and are thus a crucial aspect to draw back to when writing down the theory. In addition, Strauss and Corbin also warn “if memos and diagrams are sparsely done, then the final product theory might lack conceptual density and integration. At the end, it is impossible for the analyst to reconstruct the details of the research without memos” (Strauss and Corbin 1998, p. 218).

Supplementary to written memos, diagrams also help the researcher to find relations between concepts and develop the grounded theory from the data. Strauss and Corbin (1998) define diagrams as “visual devices that depict the relationships among concepts” (p. 217). Thus, diagrams are needed to link concepts graphically, which is especially helpful for instance to illustrate the relations between the different elements of the coding paradigm (cf. Vollstedt 2015 for a concrete example).

4.4 The Role of Theory Within Grounded Theory and the Coding Paradigm

From its origins, there has been a conflict inherent in the grounded theory methodology, which relates to the role of theory. The main idea of grounded theory and one of its hallmarks is that categories, concepts, and finally theory ‘emerge’ from the data. In “The discovery of grounded theory” the researcher is therefore advised to “ignore the literature of theory and fact on the area under study, in order to assure that the emergence of categories will not be contaminated” (Glaser and Strauss 1967, p. 37). However, Glaser and Strauss also admit that “of course, the researcher does not approach reality as a *tabula rasa*. He must have a perspective that will help him see relevant data and abstract significant categories from his scrutiny of the data” (Glaser and Strauss 1967, p. 3). Thus, they acknowledge that in modern epistemology it is taken for granted that the world is always perceived through theoretical lenses and related conceptual networks, and empirical observation therefore is always influenced by the theoretical and conceptual knowledge of the observer. Thus, the inherent conflict in terms of the role of theory in grounded theory is, if it is possible that theory only “emerges” from the data or if

theory is actually “forced” on the data. This has in fact been a major issue of debate between the two founders of grounded theory—Glaser and Strauss—which finally led to their separation and constitutes the fundamental difference between the two approaches to grounded theory today (Kelle 2005).

In order to resolve this conflict between an unbiased emerging of theory and the inevitably theory-laden perspective of the researcher, Glaser and Strauss introduce the notion of *theoretical sensitivity*. In later works, the *coding families* (Glaser 1978) and the *coding paradigm* (Strauss and Corbin 1990) can also be seen as answers to the same problem.

The coding families (Glaser 1978) are sets of general sociological concepts organized into loosely connected frameworks, which are supposed to foster the theoretical sensitivity of the researcher in order to support the development of theory from the data. Some illustrative examples of coding families are provided in Table 4.1. Glaser’s (1978) original list is much more detailed and extensive.

Strauss and Corbin (1990) offer a general model, which they denote as “coding paradigm”, and which is supposed to provide a general frame for analyzing relationships between the categories and concepts. The coding paradigm has already been described in more detail in Sect. 4.3.3.2.

Although the coding families and the coding paradigm are only very general and widely accepted perspectives on social reality, it is important to be aware that the coding families and the coding paradigm are themselves theoretical framings or orientations, which are utilized within grounded theory in order to develop theory. Thus, the development of theory is not independent, but is structured by the theoretical assumptions and relations provided by the coding families and the coding paradigm. Both encompass a particular perspective on social reality.

Due to the sociological background of Glaser and Strauss, the epistemological interest of grounded theory lies in predicting and explaining behavior and social processes. Accordingly, the coding paradigm focuses on action and interaction in social contexts and related strategies (Tiefel 2005). The causal assumptions that are

Table 4.1 Some examples from Glaser’s (1978, pp. 73–82) coding families

Families	Examples
The Six C’s	Causes (sources, reasons, explanations, accountings or anticipated consequences), Context or Ambiance, Contingencies, Consequences (outcomes, efforts, functions, predictions, anticipated/unanticipated), Covariances, Conditions or Qualifiers
Process	Stage, Staging, Phases, Phasing, Progressions etc.
Degree	Limit, Range, Intensity, Extent, Amount, Polarity, Extreme, Boundary, Rank, Grades, Continuum, Probability, Possibility, etc.
Dimension	Dimensions, Elements, Divisions, Piece of, Properties of, etc.
Identity-Self	Self-image, Self-concept, Self-worth, Self-evaluation, Identity, etc.
Means-goal	End, Purpose, Goal, Anticipated consequences, Products
Cultural	Social norms, Social values, Social belief, Social Sentiments
Theoretical	Parsimony, Scope, Integration, Density, Conceptual level, Relationship to data, Relationship to other theory, Clarity, Fit, Relevance, Modifiability, etc.

inherent in the coding paradigm structure the development of theory as a whole. Accordingly, Kelle (2005) advises researchers, which “may feel that this approach goes contrary to their requirements and would be well advised to construct an own coding paradigm rooted in their own theoretical tradition” (para. 21). Tiefel (2005) also argues that especially in educational research, the coding paradigm of grounded theory is not universally applicable. She even goes one step further and suggests an alternated coding paradigm, which captures dimensions of individual construction of meaning in the dialectic between the individual and the social context (see Sect. 4.4.1.1). In mathematics education research, there are also studies that are based on a grounded theory methodology, but which altered the coding paradigm according to their needs. Two examples are presented in Sects. 4.4.1.2 and 4.4.1.3.

4.4.1 Examples from Studies in Which the Coding Paradigm Was Changed

The following section provides a little insight into three studies in which the coding paradigm was altered. Tiefel (2005, cf. Sect. 4.4.1.1) offers an amendment for learning and educational science; Vollstedt (2011, cf. Sect. 4.4.1.2) and Rezat (2009, cf. Sect. 4.4.1.3) are studies from mathematics education.

4.4.1.1 A Modification of the Coding Paradigm from the Perspective of Learning and Educational Theory

As Tiefel (2005) explicates, Strauss and Corbin offer with their coding procedures a technique that relates structures, actions, and subjectivity with each other. A special focus is put on the processes involved. Being sociologists, their spotlight is primarily on the prediction and explanation of (social) action and (societal) processes. The phenomena that they are especially interested in are, thus, closely linked to a pragmatic understanding of an activist significance of objects, which is raised by people’s action or work and which can be changed by interaction and over time. Thus, in this disciplinary context, theories that are grounded in data aim at the explanation of conditions, meanings and significances, as well as procedures that influence people in different situations and areas of their active construction of the world.

Tiefel (2005) continues that educational science also defines the analysis of interdependencies between biographic and structural processes by means of selected contexts and situations. Nevertheless, its cognitive interest focuses rather on the desire to understand individual decisions and actions. Thus, research in educational science also concentrates rather on the reconstruction of biographical processes in their interdependence with social relativities. Thus, in her research on processes of learning and education as well as the professional biography of an

educational consultant, Tiefel (2005) developed a coding paradigm for processes of learning and education with a special focus on questions of understanding. She proposes the following three perspectives:

- Perspective of meaning (especially referring to the reconstruction of the self-perception): How does the informant present him-/herself? What does the person say about him-/herself? What is not mentioned? Which orientations (norms, values, sciences, commonplaces etc.) are relevant for the informant?
- Perspective of structure (especially referring to the reconstruction of the world view): Which conditions are shown as important or relevant for the possibilities and the spheres of action of the self? Which ideas, positions, and assumptions give orientation? Which social relations, institutional or social/historical connections are marked as being important for the self?
- Courses of action: Which activities/interactions does the informant describe? Which options are noticed and how are they dealt with? Are the strategies rather active or passive, target-oriented or tentative seeking?

Tiefel's (2005) suggestion for the modification of the coding paradigm with respect to learning and educational sciences is probably closer to the needs of many researchers in mathematics education than Strauss and Corbin's (1990) coding paradigm. However, there are still areas where it does not provide the structure needed to grasp the relevant information to answer the research questions. Therefore, the following two sections provide insight into two studies that further adapted the coding paradigms to their needs to be able to develop a dense grounded theory.

4.4.1.2 Personal Meaning When Dealing with Mathematics in a School Context

The claim for meaning in education has been raised for many years and meaningful learning is assumed to be a central impetus (Biller 1991) as well as one of the major goals (Vinner 2007) of education. Hence, one of the challenges of education in general as well as of mathematics education in particular is to find convincing answers to the quest for meaning. Subsequently, to make learning meaningful for the students, we need to ask the students what is meaningful to them rather than imposing some kind of meaning that might be meaningful from a normative perspective, but can hardly be related to the students' biography (Meyer 2008). Howson (2005) therefore distinguishes between two different aspects of meaning, "namely, those relating to relevance and personal significance (e.g., 'What is the point of this for me?') and those referring to the objective sense intended (i.e., signification and referents)" (p. 18). Hence, "even if students have constructed a certain meaning of a concept, that concept may still not yet be 'meaningful' for him or her in the sense of relevance to his/her life in general" (Kilpatrick et al. 2005, p. 14). In her research, Vollstedt (2011) therefore took the students' perspective when she was interested in the aspects of the learning process that make learning

mathematics meaningful for them. To emphasize the focus on the learner's perspective, the term *personal meaning* was coined to designate those aspects that are personally relevant for the students, i.e., the first aspect of meaning that was described by Howson above (cf. also Vollstedt and Duchhardt, in press).

One aim of the study was to develop a grounded theory about what personal meanings students construct when they are involved with mathematical contents in a school context. A second aim was to put a special focus on the role of the cultural background of the classroom situation. Therefore, the interview study was conducted in Germany and in Hong Kong. The two places were chosen as examples of a Western and a Confucian Heritage Culture (CHC, cf. Leung et al. 2006) to make sure to have quite distinct cultural backgrounds for teaching and learning mathematics.

Data gathered for the study comprised video recordings of three mathematics classrooms (9th and 10th grade) for one week in each place together with field notes taken by the researcher. The videos were used for a sequence of stimulated recall (Gass and Mackey 2000) at the beginning of each interview with volunteers from the classes (see Vollstedt 2011 or 2015 for further details).

In the process of axial coding it turned out that neither Strauss and Corbin's (1990) nor Tiefel's (2005) coding paradigm really fitted the data and the research questions. Therefore, the coding paradigm was also adapted to the individual needs of Vollstedt's study in the following way: At first, there was a long and intense discussion with fellow researchers from the *Graduate Research Group on Educational Experience and Learner Development* at the University of Hamburg about how personal meaning might be constructed, and which aspects seemed to be relevant for its construction. In the final model it is assumed that there is an individual in a certain situation in which he/she is dealing with mathematics in a school context, e.g., the student Johanna is studying mathematics at home. The situational context, i.e., the context of the learning situation in terms of topic as well as classroom situation/home, is a crucial factor for the construction of personal meaning and of particular importance in this study as there was a special focus on cultural background of the teaching and learning situation. In this situation, there are certain preliminaries that are part of Johanna, such as her personal background, i.e., aspects that cannot be influenced by herself, including her socio-economic or migration background. In addition, personal traits, i.e., aspects that concern her self, are relevant. They comprise concepts that are discussed in various scientific fields such as educational psychology (self-concept, self-efficacy), mathematics education (beliefs), and educational science (developmental tasks). Based on these preliminaries, Johanna then constructs personal meaning with relation to the learning content and context. Depending on the result of this construction, different consequences can occur. Johanna might for instance appraise the situation with respect to her personal goals so that different actions might follow, e.g., she might not understand the contents she is dealing with and will therefore ask her neighbour for help. Or she might think that mathematics is not as important as spending time with her friends so that she will stop working on her tasks.

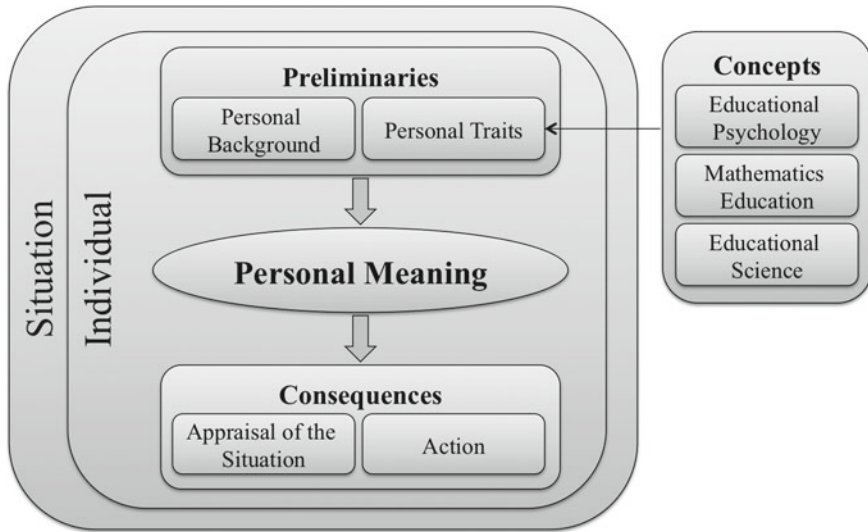


Fig. 4.1 Relational framework of personal meaning (cf. Vollstedt 2011)

The relational framework given in Fig. 4.1 shows the diagram of how the aspects described above might be interrelated to describe the construction of personal meaning. It provided the basis for the coding paradigm used by Vollstedt (2011). For each category that was developed throughout the coding process, it was attempted to fit it in this model and relate it with other relevant concepts. Thus, finally, it was possible to describe preliminaries and consequences for each core category, i.e., personal meaning, that was developed in this study (see Vollstedt 2011, 2015).

Taking a closer look at this coding paradigm, reveals that there are relations to both versions of coding paradigms provided by either Strauss and Corbin (1990) or Tiefel (2005). Vollstedt's (2011) *situation* embraces aspects from Strauss and Corbin's (1990) *context* and *intervening strategies*, whereas some aspects of the latter are also part of Vollstedt's *preliminaries*. *Consequences* are similar in both paradigms. Strauss and Corbin's *causal conditions* and *action/interaction strategies* were not found to be relevant in Vollstedt's study as they are directed towards the phenomenon, i.e., a kind of personal meaning. In Vollstedt's theory, *consequences* occur after the individual has constructed a personal meaning, so that *actions* from her framework—being part of the *consequences*—are something different than *action/interaction strategies* from Strauss and Corbin. With respect to Tiefel's (2005) aspects, on the one hand the *perspective of meaning* is similar to aspects that are described in the *preliminaries* like *personal background* and/or *personal traits*. The *perspective of structure* and the *courses of action* on the other hand relate to *situation* and *preliminaries*, and *consequences* respectively. Nevertheless, although nearly all aspects are somehow integrated in Vollstedt's (2011) coding paradigm,

neither Strauss and Corbin's (1990) nor Tiefel's (2005) coding paradigm would have grasped the particularities of the phenomenon under study. It is interesting to see, though, that Vollstedt's approach is very close to the modifications made by Corbin and Strauss (2015) in the fourth edition of "Basics of qualitative research". There, they reduced the aspects of the coding paradigm to *conditions*, *actions-interactions*, and *consequences or outcomes*. Still, having a sociological perspective, the focus is on actions and interactions whereas in Vollstedt's research, educational processes are the focus. But nevertheless, as her coding paradigm also primarily looks at *preliminaries* and *consequences* from the context and individual's perspective, the similarities of the two approaches cannot be overlooked.

4.4.1.3 Learning Mathematics with Textbooks

Rezat (2009) developed a grounded theory on how students learn mathematics autonomously with their mathematics textbooks. Theory development is grounded in data on the specific parts that students used on their own in their textbooks, and on students' explanations of why they used these parts. He further conducted interviews with selected students in order to better understand how they proceeded when learning mathematics with their textbooks. Finally, he observed the mathematics lessons for the period of the study and took field notes (Rezat 2008).

The grounded theory comprises activities, in which students utilize their mathematics textbooks and students' utilization schemes of the textbook within these activities. Rezat (2009) finds that students refer to their mathematics textbook related to four activities:

- (1) solving tasks and problems in order to get assistance from the textbook,
- (2) consolidation activities in order to use the contents of the book for practicing and consolidation,
- (3) acquiring mathematical knowledge that has not been a matter in class, and
- (4) activities associated with interest in mathematics.

These activities clarify the causal conditions under which textbook use occurs as well as attributes of the context of the investigated phenomenon, *autonomous learning mathematics with the textbook*. In terms of activity 1, this means that the causal condition for using the textbook is that students are working on a task or a problem (that might originate from the textbook or some other source) and they need assistance for solving it. The causal condition for textbook use related to activity 2 is students' aspiration to practice and consolidate their mathematical knowledge/competencies. The inclination to acquire new mathematical knowledge or competencies is the causal condition for textbook use related to activity 3 and students' interest in mathematics motivates textbook use related to activity 4.

Although the coding paradigm of grounded theory according to Strauss and Corbin (1990) allows for a general analysis of students' actions and interactional strategies with their textbooks associated with the four activities, Rezat (2009) argues that the instrumental approach (Rabardel 2002) provides theoretical concepts

and relations that grasp students' interactions with their textbook better than the general focus on actions and interactional strategies of the coding paradigm in grounded theory. Therefore, he enhances the coding paradigm by including the instrumental approach (Rabardel 2002). Instead of analyzing actions and interactional strategies he analyses students' "instrumentalization" and "instrumentation" (Rabardel 2002) of the mathematics textbook within the different learning activities. While the analysis of the instrumentalization of the mathematics textbook relates to functions that users attribute to the textbook within the activities, the analysis of instrumentation relates to the development of utilization schemes. The latter are characterized by "1. goals and anticipations; 2. rules of action, information seeking, and control; 3. operational invariants; 4. possibilities of inference" (Vergnaud 1998, p. 173). Based on this conceptualization of schemes, Rezat reconstructs different utilization schemes of students using their textbook within the different activities. For example, he finds three different utilization schemes related to consolidation activities: (1) *position-dependent practicing*; (2) *block-dependent practicing*; and (3) *salience depended practicing* (Rezat 2013). The three schemes differ in particular in terms of their operational invariants. Position-dependent practicing is based on the operational invariant that contents of the textbook that is useful for practicing can be found at a certain relative position to other contents in the textbook, e.g. tasks that are appropriate for practicing are adjacent to tasks that the teacher explicitly asked the students to work on. On the contrary, block-dependent practicing is based on the selection of a specific structural element of the textbook such as tasks, rules (in a box) or worked examples for practicing. Finally, salience-dependent practicing is based on an operational invariant that takes salient visual features of the contents as the main criteria for selection of contents from the textbook.

On the one hand, the instrumental approach and the notion of utilization schemes is included in the study as a means to increase theoretical sensitivity and to describe the cognitive aspects of students' actions and interactions with their textbooks. On the other hand, the concepts of the instrumental approach provide a language, which can be used to describe students' actions and interactions with their textbooks from a cognitive perspective as exemplified in the three utilization schemes related to students' consolidation activities with mathematics textbooks.

In the study by Rezat (2009), parts of the very general coding paradigm are substituted by a well elaborated theory. Consequently, the question has to be raised if this is actually still a grounded theory study or if a well-developed theory already existed before. However, a well-developed theory about the phenomenon under study, namely students' autonomous learning of mathematics with their textbooks, had not existed before the study. Therefore, grounded theory appears to be an adequate overall methodology of the study. In order to grasp specific aspects of the phenomenon under study in more detail, Rezat (2009) refers to existing and more general theory, which is not solely linked to the phenomenon under study. While Rabardel's (2002) theory conceptualizes human interactions with (technological) artefacts in general, Rezat (2009) develops a theory of students' learning of mathematics with their textbooks. Therefore, his approach seems to reconcile

theory development and building on existing theory. While the overall goal of the study is to develop a grounded theory related to a particular phenomenon, theory development builds on more general existing theories, which seems to be a helpful approach in order to focus and describe particular elements of the developing theory. Thus, existing theory seems to be included in the grounded theory wherever it appears to be useful in the developing theory.

4.5 Concluding Remarks

In this chapter, we gave a cursory introduction to grounded theory methodology and methods. We briefly described the coding procedures, the notions of *theoretical sensitivity*, *theoretical sampling*, and *theoretical saturation* and how these components serve the main aim of grounded theory, namely to develop a theory that is empirically grounded in the data. We recommend that the (early career) researcher, who has become curious and wants to start developing grounded theory, also refers to the original sources. These describe the techniques and procedures of grounded theory in much more detail. As already pointed out at the beginning of this chapter, some of them were even written for early career researchers.

Our chapter might support the early career researcher in becoming aware of differences between the two main schools of grounded theory—grounded theory in the tradition following the foundations of Glaser or of Strauss, respectively. These differences are mainly rooted in the role of theory within grounded theory. We pointed out that the role of theory is actually an inherent epistemological issue in grounded theory methodology. We further provided examples of studies that challenge this issue by adjusting the coding paradigm according to the needs of the phenomenon under study. However, in these cases, the researcher has to justify whether the study remains a grounded theory study. We see this as just another challenge to the theoretical sensitivity of the researcher. And theoretical sensitivity is the core ability a researcher has to bring to, cultivate within, and gain from the endeavor of developing a grounded theory.

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