

Chapter 2

To See the Wood for the Trees: The Development of Theory from Empirical Interview Data Using Grounded Theory

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Abstract The way from empirical interview data to the development of theory is illustrated with reference to an intercultural study. This study was located in the field of mathematics education and focused on the development of a theory of personal meaning. Starting from only a rough understanding of what personal meaning might be, interviews were conducted with students from lower secondary level in Germany and Hong Kong. Due to the setting of the study in two cultures, a pragmatic interpretation of theoretical sampling had to be taken so that as much data as possible was collected to choose from throughout the analytical process. Data analysis followed grounded theory according to Strauss and Corbin (Basics of qualitative research: Grounded theory procedures and techniques . Newbury Park: Sage, Grounded theory: Grundlagen qualitativer Sozialforschung [Basics of qualitative research: Grounded theory procedures and techniques]. Weinheim: Beltz; see also Chap. 1). Therefore, different types of codes (in-vivo, empirically developed, and conceptual) as well as different types of coding (open, axial, and selected) were the result of constant comparison and writing memos. By comparing codes and using a coding paradigm, categories and concepts were developed so that the theory of personal meaning started to evolve from the data. The results of the analyzing process were an empirically grounded theory of personal meaning consisting of 17 different kinds of personal meaning on the one hand and an underlying theoretical framework that describes the surrounding conditions of the construction of personal meaning on the other hand.

Keywords Grounded theory • Personal meaning

In the previous chapter, Teppo gives an introduction to grounded theory and its development into different specifications of the grounded theory methods. In the first section she especially focuses on the four different lines of development of the

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theory of grounded theory in the different schools following the two founders Strauss and Glaser respectively. The prevalent form of grounded theory used in Germany is the one elaborated by Strauss and his disciple Corbin as presented in their 1990 book *Basics of Qualitative Research*. Hence, I also followed their approach in my study so, accordingly, this article provides an example of the application of grounded theory to mathematics educational research following Strauss and Corbin (1990). As I actually worked with the German translation from 1996 of their 1990 book, I will always give both references throughout this text.

The empirical interview study presented here was carried out in Germany and Hong Kong (see Vollstedt 2011b). The aim was to find out and describe what is personally meaningful for the students when they learn mathematics or engage in mathematical problems in a school context and, thus, develop a theory of personal meaning (German: *Sinnkonstruktion*). The resulting theory about personal meaning was supposed to be laid out by different kinds of personal meaning. In the process of data analysis, I followed grounded theory methods according to Strauss and Corbin (1990, 1996). Hence, I also adopted their guidelines for the research process as well as their terminology.

When starting an empirical (interview) study, data often look very confusing and seemingly unrelated. One usually cannot see the wood for the trees at the beginning of data analysis. Therefore, we need a tool to detect a structure in the data that can be further worked out. Following grounded theory is a good possibility to finally see the wood for the trees—i.e. to develop an empirically grounded theory—as it combines methodological as well as methodical aspects (see Chap. 1) that provide guidelines throughout the research process.

This article may in some places diverge from Teppo's (see Chap. 1) description and terminology as she gives a review of the different streams of grounded theory in its different seminal forms. In contrast, I concentrate on one specific line of grounded theory. Nonetheless, it is recommended to read this illustrative chapter of the part alongside the previous chapter of this book as I will often draw back on the methodological basis laid out by Teppo.

2.1 Background and Focus of the Study

The study presented here was embedded in the Graduate Research Group on Educational Experience and Learner Development (German: *Bildungsgangforschung*) at the University of Hamburg, financed by the German Research Foundation DFG. The group's research focused on the question how children, adolescents and young adults act in situations of learning and instruction, how they interpret their learning tasks, and what can be done to encourage their educational development. Hence, in a school context, research on Educational Experience and Learner Development is primarily (empirical) research in teaching and instruction. The emphasis is placed on the perspective of the learners and their development. At the time I was member of the Graduate Research Group, we were especially investigating the role of meaning for learning and educational development.

Vinner (2007, p. 6) points out that humans have a “need for meaning” and that meaningful life and meaningful learning might have the same origin although they seem to be different concepts. If meaningful learning is a special case of “man’s search for meaning” (ibid.), this specific human attitude does not disappear before entering the classroom. Meaning is also sought inside the classroom when students engage in learning and dealing with subject contents. Therefore, the question of meaning is posed time and again by students when they are learning mathematics. The demand for meaning in (mathematics) education has been detected for many years. Hence, meaningful learning has been identified as one of the major goals of education (ibid.). Consequently, one of the challenges posed also—if not especially—for mathematics education is to find convincing answers to the questions of meaning. In addition, if the aim is to make the learning of mathematics meaningful for the students, we need to ask what is meaningful to them rather than to impose some kind of meaning on them, which might be meaningful from a normative perspective but does not prove to be personally meaningful.

There is no commonly accepted interpretation of the term *meaning* in the field of mathematics education. The diversity of concepts is due to a mixture of philosophical and non-philosophical interpretations as the collection of articles of the BACOMET-group shows (Kilpatrick et al. 2005). Howson (2005, p. 18) convincingly 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)”. Hence, “[e]ven 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). Here, the mathematical meaning is obviously not interchangeable with the philosophical kind of meaning the student relates to his/her life.

As my study was embedded in the Graduate Research Group, I focused on the student’s perspective. I therefore concentrated on Howson’s first aspect of meaning and asked for the kinds of meaning that relate to the individual’s relevance in the context of learning mathematics. To emphasize the focus of the learner’s perspective over the, as Howson terms it, objective sense, I picked the term “personal meaning” instead of “sense-making” to denote the concept. By doing so I am also aware that subject-inherent sense-making sometimes also may be personally meaningful for the students. Accordingly, I did not look at what might be meaningful from a normative or domain-specific perspective, but—on the contrary—I investigated the aspects the students judge to be meaningful for them. As Kilpatrick, Hoyles and Skovsmose pointed out (see above), these do not necessarily have to (but may) be the same.

2.2 Realization of the Study

At the beginning of a study following grounded theory, there is no completed theory but—on the contrary—an open field of study whose relevant aspects become clearer and clearer throughout the research process. This was similar in my study. Prior to

it, there was neither a developed theory about what personal meaning in a school context is, nor any empirical results about how personal meaning is constructed in a school context, nor any different kinds or types of personal meaning. The field of research was untilld except for a very rough understanding of personal meaning as described above. Therefore, the decision for reconstructive methods was reasonable—especially as the concerns of reconstructive studies are to understand a certain phenomenon better and to generate new theory that is empirically grounded (Jungwirth 2003).

To get a clearer glance at what is meaningful for the students in their learning processes, I conducted my study in two different learning cultures, Germany and Hong Kong. This decision offered the possibility of getting a sharper view on my own learning culture by being contrasted with a different setting I was not acquainted with. Stigler and Perry (1988, p. 199) describe this with respect to teaching practices as follows:

Cross cultural comparison [...] leads researchers and educators to a more explicit understanding of their own implicit theories about how children learn mathematics. Without comparison, we tend not to question our own traditional teaching practices and we may not even be aware of the choices we have made in constructing the educational process.

Similar to the teaching practices, we do not question our own beliefs and about teaching and learning when we do not reflect them against the background of another culture. Looking at another teaching and learning culture, thus, offers the possibility to reflect aspects that have been taken for granted beforehand and so to get a clearer picture of one's own culture, too. Hence, conducting a comparative study in two different cultures gives us a deeper understanding of our own teaching and learning culture (Jablonka 2006; Kaiser et al. 2006). Accordingly, it is a methodological tool to see the characteristics of both cultures more clearly. My study was conducted in Germany and Hong Kong being representatives of the Western and the Confucian Heritage Culture.¹

One aim of the study was to develop a theory of personal meaning from empirical interview data. The theory is elaborated by means of the reconstruction of different kinds of personal meaning in the context of academic learning of mathematics.

The study is based on 34 guided interviews conducted in Germany and Hong Kong with students from lower secondary level. At the time they were interviewed, the students were 15 or 16 years old respectively. Seventeen students from each country participated in the study; all attended the highest school type in the respective educational system. In Hong Kong, I collaborated with schools that use English as medium of instruction. It was, thus, possible to conduct the interviews in English. The guided interviews lasted for about 35–45 min and began with a sequence of stimulated recall (Gass and Mackey 2000). This means that the students watched a five- to ten-minute video sequence of the last lesson they attended. Their task was

¹I also investigated the role of the students' cultural background for the construction of personal meaning by comparing the results of the students from Germany and Hong Kong. As this part of the project is not related to the application of grounded theory, it will not be reported in this chapter in detail (for further information see Vollstedt 2011b).

to reflect on and verbalize the thoughts they had during the lesson. The subsequent interviews then tackled various topics that were assumed to be related to our understanding of personal meaning (see below). This understanding was at that time quite broad and not yet focused. The intention was to come as close as possible to the aspects related to learning mathematics which are personally meaningful for the students in a school context. Students were for instance asked about their associations of the words *mathematics* and *mathematics lessons* and about the characteristics of a good lesson. They were interrogated about their beliefs with relation to mathematics, mathematics lessons and their learning of mathematics as well as about their feelings, their learning strategies, their goals etc. In addition, they were asked about their preferred learning conditions and the reasons why they learn mathematics, whether they see a relation between mathematics and their lives, and whether they might need mathematics for their dream job. All these questions were supposed to give information about aspects that might be relevant for the construction of personal meaning.

The decision to analyze the data in a coding process is made for methodological reasons as well as for reasons of content. From the methodological perspective, coding is a core element for the development of a theory which is grounded in empirical data. To break up and to continuously compare the data is equally constitutional for the development of a grounded theory as well as for the development of codes throughout the analytical process. Thus, relations between phenomena can be detected in the data; phenomena can be distinguished and sharpened. Thereby, the aim of this comparative analysis is to use descriptive categories to come to analytical concepts so that the relations between phenomena can be explored and clarified (Tiefel 2005; see Chap. 1).

Additionally, in my study, there was also a content argument for the coding analysis as personal meaning can be understood as an individual psychological construct. It can be revealed by character traits and individual attitudes from which one can draw conclusions on the kinds of personal meaning preferred by the interviewed students. Thereby, it is of no importance at which time in the interview the utterance was made as long as the incidents mentioned were considered to be relevant for the development of the theory. Therefore, the sequentiality of the interviews can be neglected so that I chose a coding procedure instead of a sequential analysis method for this study. Coding thereby is characterized as a process of continuous comparison of phenomena, codes and categories with the aim of reaching analytical concepts which explore and clarify relationships between phenomena via descriptive categories (Tiefel 2005; see Chap. 1).

As the data of this study were collected to develop an empirically grounded theory, I decided to use grounded theory following Strauss and Corbin (1990, 1996). I chose their approach because they offer the most concrete guide to the grounded theory method that was available in Germany at the time the study was carried out. The authors point out that their outline of this method is not to be adhered to rigidly but it can be used rather as guidance for the research process (ibid.). Yet, this may not be understood as the permission for undirected interpretations. The guidelines given are more than just an enumeration

of recommendations as they mark some operations as obligatory. A coding procedure and the writing of analytical memos for instance are among these (Strauss 1987; Strübing 2004; see also Chap. 1).

The following passages give a more detailed introduction to the different decisions made throughout the research process with concrete examples from my study. The main focus thereby lies on the different ways of coding.

2.3 Theoretical Sensitivity and Sensitizing Concepts

In a study following grounded theory, there are no hypotheses to be tested nor is there a fully developed theory of the research field. In return, grounded theory postulates a high level of theoretical sensitivity of the researcher. According to Strauss and Corbin (1990, p. 42), only this “attribute of having insight, the ability to give meaning to data, the capacity to understand, and capability to separate the pertinent from that which isn’t [...] allows one to develop a theory that is grounded, conceptually dense, and well integrated”. To come nearer to our object of research, we need sensitizing concepts (Flick 2005) which are influenced by theoretical prior knowledge. Hence, researchers do not enter the field of study as *tabula rasa* as the approach of grounded theory is often misunderstood (Strübing 2004; see also Chap. 1, Sects. 1.2 and 1.5.1, for the place of literature review in grounded theory).

Strauss and Corbin (1990, 1996) explicitly mention literature, particularly technical literature, as one source of theoretical sensitivity. Other sources are professional and personal experience as well as the intensive interaction with the data throughout the analytical process. In my case, it seemed reasonable that personal meaning is somehow related to or influenced by concepts from educational psychology like the basic needs for autonomy, competence and social relatedness (Ryan and Deci 2002), personal or situational interest (Krapp 2002), concepts from mathematics education like mathematical beliefs (Op’t Eynde et al. 2002) or mathematical thinking styles (Borromeo Ferri 2004), and concepts from educational experience and learner development like developmental tasks (Havighurst 1972; Trautmann 2004). These concepts therefore were taken as sensitizing concepts into the analytical process. As Teppo (Chap. 1) points out, a review of related literature can also provide links to which the newly developed theory can be adhered.

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

According to Strauss and Corbin (1990, 1996), a grounded theory is developed from the study of phenomena occurring in the respective field of research. The data collected need to be analyzed systematically to discover, develop, and verify the theory.

Therefore, data collection, analysis, and theory stand in reciprocal relationship with each other. One does not begin with a theory, then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge. (Strauss and Corbin 1990, p. 23)

Strübing (2004) describes this close interdependence of data collection and analysis as functionally dependent and chronologically parallel. None of these processes is thereby understood as final; even the theory developed at the end of the researching process is characterized by tentativeness as it can be further developed in future research projects. The research process in the course of developing an empirically grounded theory then is iterative and circular (Strübing 2004; see Chap. 1). Please note that the procedure is repetitive and circular—but not the theory which is developed in this process.

This close interaction of data collection, analysis, and development of theory is also reflected in the procedure of data collection and selection of cases that are to be analyzed. The strategy used in grounded theory for this procedure is called *theoretical sampling* (see Chap. 1, Sects. 1.4 and 1.6.1). This term should not be confused with representative sampling as it is used in studies with large sample sizes opting to test hypotheses. According to Strauss and Corbin (1990, p. 177), theoretical sampling is “sampling on the basis of concepts that have proven theoretical relevance to the evolving theory”. This means that the concepts are relevant with respect to the developing theory as they repeatedly occur in the data, or, on the contrary, are notably absent when comparing the incidents (ibid). In order to note which concepts are relevant, theoretical sensitivity is needed, i.e. sensitivity to recognize relevant indicators in the data. As sensitivity increases over time, it is possible that previously analyzed data must be recoded with the additional knowledge gathered in the analytical process (ibid.; Chap. 1, Sect. 1.6.1). Therefore, two aspects characterize theoretical sampling: chronological parallelism of data collection, analysis, and development of theory on the one hand, and a certain influence of the developing theory on the data collection on the other hand.

Chronological parallelism of data collection, analysis, and development of theory is difficult to realize in a study that is carried out in two cultures. If the demand for chronological parallelism is, however, applied not to the collection of new data but to the choice of which cases are to be analyzed from an assorted pool of data, it still can be satisfied. This is also in line with the argumentation of Strauss and Corbin (1990, p. 181, original emphasis), who argue that “*one can sample from previously collected data, as well as from data yet to be gathered*”. Following this interpretation of theoretical sampling, I collected as much data as possible in both countries by having interviewed every student who volunteered. By this means, I generated a data set of 17 interviews per country. In addition, I kept the videotapes of all lessons I attended as well as the teaching materials used. Although I was interested in the personal view of the students on their learning process of mathematics, I wanted to be able to draw back on these materials if necessary throughout the analytical process. Further, at the time of data collection, I took field notes. The field notes concentrated on my experiences within the foreign culture, kept track of my understanding of the Hong Kong school system as well as the information I got about the teachers, and noted down

Example 2.1 Field note taken on April 4, 2006 in Hong Kong**Wah Yan College, class 4D/4C, Mr. Ng (approx. mid-thirties)**

- 12 years of teaching experience
- School is in fact CMI (Chinese as Medium of Instruction), but from Secondary level on, 3 subjects are taught in English → all are natural sciences!
- Headmaster is one of the authors of the schoolbook that is used in class
- Filmed lesson
- Immediately, several students volunteered for the interviews! (It probably helped that I had my fingers crossed?!)
- School was founded in 1999, hence everything is quite new
- Class is better performing than average
- Today directly interview with Camryn (she was addressed by Mr. Ng before class; he said she does not like his way of teaching so talking to her might be interesting for my study. She denies this. We'll see.
- Sequence of stimulated recall: Introduction to direct variations (more or less ex-cathedra teaching)
- Got a copy of the teacher's version of the book together with a seating plan
- The teacher's version of the book could theoretically be read out in class exactly the way it is; Mr. Ng does not do this
- Solutions are printed in red next to the question (lighter shade of grey in the copy)
- The students' version of the book is similar to the teacher's but with solutions at the end of the book

some experiences from the interviews. Example 2.1 above gives an idea about what these notes looked like. As the analysis proceeded, it turned out to be not necessary to come back to the additional material as the interviews proved to be a very rich source with respect to the focus of my study.

After having collected so much data, one might be overwhelmed by it and it is a challenge to decide where to start the analysis. What should I begin with to find a way through the material? Or, with reference to the title of this chapter: I see a large conglomerate of bigger and smaller plants in front of me that I'd like to explore. But I can't walk through them to understand them—there is too much thicket, bushes and fern. Where and how should I start to find a way through them?

I chose to start with the analysis of interviews according to certain considerations. When listening to the mp3-files after the data collection, I wrote recapitulatory memos that summed up the topics that were talked about in the interviews. I always tried to keep the formulations as close as possible to the ones used by the interviewees. These memos were the first step towards a detailed transcription and also served as its basis. Therefore, I also stuck to the grammatical mistakes. As a whole recapitulatory memo is too long to be presented here, Example 2.2 below gives an excerpt from the interview with William, a student from Hong Kong to

Example 2.2 Excerpt from the recapitulatory memo of William's interview

Time	Main aspects
[...]	[...]
27:12	<p><i>Anything of special interest in lesson?</i></p> <p>Not much, only doing the exercises. It's quite fun, solving the formula. Discuss with my classmate, knowing what is [quarter].^a</p>
29:58	<p><i>Anything interesting in topic?</i></p> <p>Drawing a graph to find the median is quite fun. Because drawing a graph, although it's complicated, but the graph is very beautiful and it's very easy to find some information. So, it's very interesting and attracts me.</p>
31:53	<p><i>Associations math?</i></p> <ul style="list-style-type: none"> - Receipts: I like to calculate whether it's correct. It's very interesting. - Sudoku: It's about numbers and logical thinking. - Triangles: Calculating angles is fun and interesting. - Economy: It's always about math. - Computers: Are a calculator. - Time: When I listen to music, it's counting the time; when I sleep I calculate whether I can sleep how long; prepare my timetable. - Volume: Bathing—I like to turn on the tub and to [...] the volume, although it's very difficult.
35:31	<p><i>Like math?</i></p> <p>Most certainly. It's interesting; the logical thinking lets me feel excited. I feel happy after having finished calculating a formula. I like math lessons very much because it's the place, the time I can interact with the math very much. The knowledge of math is very wide. Sometimes it's difficult, but I'm keen on that. Because if I understand that, I get more things in the mind and brain and I feel great at that time. I don't like using a calculator. Using a calculator is fast, but there isn't a feeling of success, so I like calculating by myself.</p> <p><i>Do you also do it in class?</i></p> <p>Yes, I try. If there're too many numbers, I use the calculator. But if there are less numbers, I do it by myself.</p>
38:52	<p><i>Associations math lessons?</i></p> <p>Math teacher: She is funny, enjoyable because everything is new.</p> <p>Happy: We can freely talk: In some other lessons teachers don't like us to talk, but in math we can discuss.</p> <p>Interesting, enjoyable: No need to remember things, not like history, geography: just calculating, observation of the graph. It's easier, interesting. If you listen clearly, you can do your exercises easily. You only need to remember the formula.</p> <p>Most of math lessons is recess. After I go out of math lessons, I feel very happy and have [...] confidence, maybe because of the logical thinking I do for the questions.</p>
42:50	<p><i>Like math lessons?</i></p> <p>Yes, I like it very much. One reason is: Ms. Ting is very funny, interesting. Her talking to us is sometimes some jokes. Imagine, I solve a formula, I can [...] confidence, increase myself.</p>
[...]	[...]

^aExpressions in square brackets were not perfectly understandable

illustrate what these memos looked like. The sequence is taken from the beginning of the guided interview following the stimulated recall. We shall have a more detailed look at the mid part of this excerpt below.

The interviews were selected for analysis with reference to these recapitulatory memos. The first interview was chosen due to the personal characteristics of the student; the successive interviews then were chosen either in minimal or maximal contrast to the students analyzed beforehand with respect to the characteristic under consideration. To be more precise, I started the analytical process with William, a very high-performing student from Hong Kong, who wanted to be challenged in his mathematics lessons (see above). The interview with William was exceptional as it was very long compared to the other interviews and, judging from the first impression deduced from the recapitulatory memo, it was very detailed and provided lots of examples William used to undermine his thoughts. Due to this richness, I felt confident that it was a good interview to start with.

William's classmate Vincent was similar with respect to his wish to be challenged in a mathematics lesson so that I analyzed his interview secondly. By this minimal contrast, it was possible to sharpen the concepts that were developed so far and get some more ideas about how they are conceptualized. In addition, new concepts that were not present in William's interview could be developed.

The third analysis dealt with Alban's interview, a low-performing student from Hong Kong who was afraid to fail and to lose his face. This case formed a maximal contrast to the first two with respect to the level of the students' achievement. Hence, the concepts could be deepened again concerning their scope and new concepts were developed. Following this procedure, I first analyzed all interviews from Hong Kong before I proceeded with the German interviews. By this means, I could guarantee utmost sensitivity to the data as I did not apply concepts that were developed from a person with Western cultural background in the context of Western lessons to ways of learning in a Confucian heritage culture. Rather, the concepts were developed from Confucian heritage data and later refined with Western data.

Throughout the analytical process, the sensitivity towards the concepts under consideration grows as more and more concepts are developed (see Chap. 1, Sect. 1.3). To ensure that also concepts could be applied to interviews that were analyzed at the beginning of the analytical process, some of the interviews were coded again. By doing so I was able to tag codes to phenomena that otherwise would have been overlooked, as I was not sensitive enough for them in the first coding cycle.

Finally, theoretical saturation was reached (see Chap. 1, Sect. 1.6.1): In the course of the analytical process of the last two interviews, no new categories were developed and the relationship between the categories seemed well established and validated (Strauss and Corbin 1990, 1996). Hence, I did not collect more data but decided to write down the theory as it was developed up to this point. As mentioned above, this does not mean that the theory is unchangeable—on the contrary: Although the theory of personal meaning may be corroborated by future research, it may well be the case that it can also be elaborated or extended further.

2.5 Data Analysis

When we think about our data as the thick and indistinguishable conglomerate of trees, thicket and bushes again, the coding procedure in grounded theory is our tool to bushwhack deeper and deeper into it. To be more precise, we can distinguish between different kinds of coding steps. Teppo (Chap. 1, Sects. 1.3 and 1.5, with reference to Birks and Mills 2011) differentiates between open and intermediate coding. Strauss and Corbin (1990, 1996) on the other hand discriminate three different types of coding: open, axial, and selective coding.² They also state that the decision for different types of coding is artificial and can hardly be made transparent in a coding process. Due to the circular design of the research process (ibid), coding is not necessarily linear. It alternates in particular between open and axial coding (ibid). Accordingly, the analytical process is marked by inductive and deductive thinking: The continuous interplay between deductive assumptions concerning the relationship between phenomena and the attempt to verify it with reference to the data is constitutive for the groundedness of the theory in empirical data (ibid).

This oscillating process is supported by analytical memos and diagrams. They reflect the analytical process and the relationships between the concepts in written analysis protocols or graphical representations respectively (ibid). Abstract thoughts about concrete data can be recorded so that they are prepared for verification or falsification respectively in relation to the material. In line with constant comparison of passages and concepts or categories while coding the data, the production of memos and diagrams is another essential element for the development of an empirically grounded theory (see Corbin and Strauss 1990; see Chap. 1, Sects. 1.1.1 and 1.4). In this study, I wrote recapitulatory memos for every person to keep a synopsis of every interview (see above) and analytical memos for every code to refine the description more and more over time (see below). In addition, I attached memos to certain passages from the interviews that brought up questions that I thought might be answered later on in the coding process. Diagrams were developed to graphically represent the relationships between different levels of codes in the process of axial coding (see below).

Several people were involved in the coding process. Primarily, I worked together with research students. Thus, we were able to develop codes consensually as well as independently. The codes that were developed individually or collaboratively could therefore be discussed intensively. At the beginning of the coding process, there was no code system that could have been applied. Therefore, the first codes were generated consensually. To achieve this, some interviews were analyzed collaboratively so that the developed concepts could intensively be discussed in little sections. We started in very great detail so that soon a great number of concepts was developed. Subsequently, the following interviews were analyzed independently so that the results were compared afterwards. The findings showed that basically we tagged the same contents with codes so that the same phenomena were labeled as categories.

²Teppo (see Chap. 1, Sect. 5) groups axial and selective coding under the term intermediate coding.

However, differences occurred whether the respective phenomenon rather belonged to the realm of personal meaning or whether it described a precondition that influences the construction of a personal meaning. This discussion led to a more precise description of the categories as well as a stronger awareness that we have to make the distinction between personal meaning in contrast to its preliminaries. Please note that categories were developed with respect to several interviews, i.e. categories do not describe phenomena that are special for a certain student.

Due to reasons of efficiency and scarce resources, I had to code the majority of the interviews on my own. However, when I came to sections in the interviews that seemed to be not straight forward, I sought the discussion with people who have been involved in the project for some time. Also, the progress of the analytical process was discussed time and again with my colleagues in research colloquia where the whole working group attended, or smaller meetings with my supervisor or just a few colleagues.

From the technical side, the study was carried out with the help of the software MAXQDA (1989–2013). The program can be downloaded from <http://www.maxqda.com/>. The full version is subject to licensing, the demo version can be tried out for 30 days for free. MAXQDA has been developed specifically to analyze qualitative data and offers a wide range of methods for analysis. Among other features, codes can be organized into a hierarchy and complex inquiries can be made about the coded data to work out connections and differences between the codes.

2.5.1 Open Coding

The data that were analyzed in this study consisted of two different groups of texts: the transcribed interviews with students from Germany and from Hong Kong. I started the analysis with the interviews from the Hong Kong data set to encounter them as unbiased as possible and with a great theoretical sensitivity (see above). Hence, the category system was developed with reference to the Hong Kong interviews and it was adapted and further developed with the help of the German data. I tried to keep the influence of the Western perspective on the Hong Kong data as little as possible.

Although the three different types of coding do not occur sequentially (see above), open coding usually is the first approach to the data. Sensitizing questions and constant comparison are core elements of this coding step (See Chap. 1, Sect. 1.3, for a detailed description of open coding). Strauss and Corbin (1990, 1996) use the terms *concept* and *category* to denote a phenomenon that is categorized and conceptualized by assigning it to one code on the one hand and, on the other hand, concepts of higher order, i.e. concepts that are subsequently compared again so that they can be grouped to more abstract concepts.

The name of codes, concepts, and categories can be derived in different ways. Firstly, there are codes that are developed *in vivo* (Strauss and Corbin 1990, 1996). These codes get their names directly or with only little variation from the data.

The concepts are directly mentioned and named by the interviewee. Secondly, there are codes which are also developed from the data and which are named by the researcher in the course of the analytical process. Thirdly, codes can be related to technical literature applied to enhance theoretical sensitivity (ibid). In this case, theoretical concepts that are relevant for the research question and, hence, that are part of the theoretical background of the study are assigned to the data. Their names are taken over; these names mark the relevance of the theoretical concept for the theory. These codes are called *conceptual codes*. The denomination of codes, concepts, and categories is preliminary at first and may be changed in the course or further analyses. Examples of the three different kinds of coding are presented in the illustrative part of this section below.

With reference to our forest metaphor, open coding helps us to name the different kinds of plants and maybe animals we come across on our way through the conglomerate of trees and thicket. The result is that they are not so indistinguishable anymore. We begin to understand what we are exploring.

2.5.2 Axial Coding

In her overview on intermediate coding, Teppo (see Chap. 1, Sect. 1.5) gives some introduction to axial coding as well as the use of a coding paradigm. She also describes selective coding according to Glaser (2004) in this subsection as a way to focus the researcher's attention on this part of intermediate coding. Strauss and Corbin (1990, 1996), on the other hand, differentiate more strongly between axial and selective coding as separate steps in the analytical process. Therefore, this section will discuss the application of axial coding, whereas selective coding is presented below.

Following Strauss and Corbin (1990, 1996), axial coding is the second step in the coding process. They suggest investigating the following elements to work out the relations between the categories with the help of a coding paradigm (see Chap. 1, Sect. 1.5): causal conditions, context, intervening conditions, action/interaction strategies, and consequences. Strauss and Corbin perceive the coding paradigm as obligatory element of a grounded theory in contrast to the elements used. Therefore, Tiefel (2005) for instance adapted the coding paradigm to her study with respect to a theoretical framework of learning and education. Both versions, i.e. the one by Strauss and Corbin as well as the one by Tiefel, however, seemed of little use for my study so that I also adapted the coding paradigm to come to one that matches my study better. I assumed that there are certain personal preliminaries like the student's personal traits or his/her personal background that might influence the construction of personal meaning. In addition, the kind of personal meaning constructed by the student might influence the student's actions or judgments. Therefore, I analyzed the phenomena with respect to their preliminaries and consequences in the course of axial coding. The results were recorded in theoretical memos and diagrams. Thus, the different kinds of personal meaning, which were developed as main categories, could be theoretically refined and contextually condensed.

The development of main categories from categories works differently than the development of categories from concepts in the course of open coding. In open coding, concepts were related with reference to their content. Similar phenomena were collected in categories of different levels of abstraction. In axial coding, we look for relations between categories and concepts that are proposed by the interviewees themselves. Hence, relations are established between a category (the main category) and other categories or concepts (the subcategories). The differentiation between main categories and subcategories therefore lies on another analytical level than the relation between categories and concepts.

When thinking about our trees metaphor, with axial coding we now begin to understand the relationship between the different plants and trees. Anemones, for instance, are little flowers that widely grow in the undergrowth and underneath trees. They only blossom in springtime when the trees do not yet have strong leaves as they are in the need of much light. The “structure” of the trees and other plants becomes clearer and clearer—especially concerning their relations.

2.5.3 Exemplary Illustration of Open and Axial Coding Using Memos and Diagrams

Before I continue with selective coding, I illustrate the open and axial coding processes with the help of an extract from the interview with William, the student from Hong Kong we already met above in the illustration of the recapitulatory memo. I also show how memos and diagrams can help in the analytical process and how they were used in the course of the analysis. Please note that my interpretation is just one possible interpretation and that other interpretations may also be valid. Especially with a focus on another research question, one might come up with quite different concepts and categories.

To understand the section chosen a bit more easily, consider the following information: The extract quoted below was preceded by the stimulated recall about a section of his last mathematics lesson in which the class learned about the median. In the part of the interview from which the section was taken, the questions dealt with the student’s attitude towards mathematics and mathematics lessons. In the interview with William, I started with the question about his associations with the word “mathematics”, which was followed by the section below. Questions about his associations with the word “mathematics lesson” and whether he liked mathematics lessons then succeeded (see above). It could be reconstructed from these and other parts of the interview that William liked mathematics lessons very much and he was eager for mathematical knowledge. He therefore wanted his teacher, Ms. Ting, to arrive more quickly at the classroom after the bell rang so that the lesson could start earlier and that they could learn more in a lesson.

1. Interviewer: Do you like mathematics?
2. William: Oh, certainly.
3. Interviewer: Ya?

4. William: Because ... I say it's interesting, the logical thinking is ... let me feel ... exciting
5. ... becau- ... I feel successful after I finish ... calculating a ... formula ... also feel ... (3 sec)
6. happy, happy because it's quite ... (5 sec) I feel successful also ... (2 sec) when I'm
7. ... (3 sec) I like the mathematics lesson very much because ... this the ... the place, the
8. time I can interact with the mathematics very much (2 sec) becau- I don't know ... the
9. ... knowledge of the mathematics is very wide so ... learning it is ... although is, maybe
10. sometimes is difficult but ... I'm keen on that because ... if I understand that ... what is
11. that thing about ... (14 sec) I get ... I get more more more things in the mind and in the
12. brain, so ... (3 sec) I don't know that word is in English but ... maybe I try to use another
13. word to explain to you, ... the knowledge come into your brain and you feel more, you
14. get more information and get more knowledge and feel great at that time ... (3 sec) I
15. don't know that word, sorry.

The excerpt presented starts with the question whether William likes mathematics. He confirms this question and stresses it explicitly with “certainly” (1–2³). From this utterance, we can reconstruct a positive attitude towards mathematics. Therefore we can generate the code *positive attitude towards mathematics* and so develop our first concept. To remember later on in the coding process which incidents we wanted to denote with this code, we should write a code memo containing a description of the phenomenon labeled with this code and possibly give an example of an utterance which might stand exemplarily for this code. Although it often seemed straightforward what the code was about judging by its name, it later on frequently turned out wrong in my study. One day I was really sure about what concept I wanted to denote with a certain code and thought that writing a memo would take too much time. Then, a couple of days later I was cross with myself for not having written a memo. It is often difficult to draw the lines between two codes when in doubt whether to add a new interview line to an existing code or whether to create a new one. When you cannot refer back to a definition in a memo, things turn out even worse.

³In the original interview, the transcript lines were numbered differently. There, every speech act was labeled with one number, i.e. this section was enumerated with 132–135. To make it as easy as possible to follow the coding process, I chose here to number every line as presented above in order to find the different bits labeled with codes more easily.

Code memos should be kept up to date. They will become more and more explicit over time when we come across similar incidents, which also belong to a certain concept, or—even more precisely—when we detect utterances in the data that just do not belong to the code. It is also helpful to expand the information collected in the code memo and make notes about these concepts that are close to the one explained. Therefore, memos get more and more detailed over time. With reference to the code developed above (*positive attitude towards mathematics*), at first, I just noted down that the interviewee mentions something positive about his or her attitude towards mathematics. The illustrative line taken from the interview helps to get a better understanding of the code when referred back to later on in the analytical process. When more and more passages were coded, the information was enriched, and more illustrative examples were added. For instance, students did not only generally talk about liking mathematics or certain fields of mathematics (e.g. geometry) but they also like mathematics for its difficulty and because they are challenged by it. I also noted down that the concepts labeled with this code referred to mathematics and not to the activity of doing mathematics (like problem solving) or to mathematics lessons. These instances belonged to other codes.

After William's short answer, the interviewer replies with a confirmative "Ya?" (3) and William elaborates more on his attitude towards mathematics. He relates it at first to his interest in mathematics: "I say it's interesting" (4). Here, we can use a code from our sensitizing concepts that we read about in technical literature: We can link this utterance to the concept of personal interest (e.g. Krapp 2002). Again, we develop a code (*personal interest in mathematics*) and write a code memo as explained above. Due to the succeeding utterance ("the logical thinking is ... let me feel exciting", 4), one can argue whether William's interest results at least partly from his excitement to think logically. Therefore, in the code memo of *personal interest in mathematics* we can add this idea so that later on in the coding process, we can check whether this relation is made more explicit by other interviewees or whether we can find other incidents which suggest this relation. In addition, we can attach an analytical memo directly to this incident in the interview (i.e. next to the transcript line) with the idea that there might be a relation between William's personal interest in mathematics and his excitement about logical thinking. These ideas and codes about a relation between personal interest of the student and a positive attitude towards mathematics are very first ideas of axial coding as we think about the relation of two concepts that lie apart from the grouping of similar concepts in one bigger category. Thus, we can see that the discrimination of the three different types of coding is artificial as at least open and axial coding interact to quite some extent.

William's excitement about logical thinking, however, seems to be another phenomenon. It shows that William enjoys when he can think logically. We can develop a new code *enjoyment of logical thinking* and write a code memo respectively. The name of the code is partly inspired by the interviewee's formulation, i.e. it is partly coded *in vivo*. William then links the enjoyment of logical thinking to the feeling of success after having finished his calculation and the application of a formula (5). At this instance, again, we can generate a code (and write a corresponding memo) that

comes from a sensitizing concept, i.e. the experience of competence as formulated in self-determination theory by Deci and Ryan (2002). We call our code *experience of competence by successful calculation*. Then, William tells the interviewer that he also feels happy when he is successful with the calculation (5–6). Hence, William also links the experience of competence due to his successful calculation with enjoyment so that we get another code: *enjoyment of experience of competence*. Now we realize that we had a similar code beforehand, the *enjoyment of logical thinking*. Thus, we can now generate a broader code that embraces two codes: the category *enjoyment* with the two subcategories or concepts *enjoyment of successful calculation* and *enjoyment of logical thinking*.

After some stammering containing half sentences which cannot be clearly linked or interpreted (“... (5 sec) I feel successful also ... (2 sec) when I’m ... (3 sec)” (6–7), William further elaborates on his attitude towards mathematics lessons. He explains that he likes his mathematics lessons very much as they provide the time when and the place where to interact with mathematical contents (7–8). William therefore shows a *positive attitude towards mathematics lessons*. Again, we can combine two concepts in a category: *positive attitude towards mathematics lessons* and *positive attitude towards mathematics* can be interpreted as two subcategories of *positive attitude*. In addition, William seems to enjoy interacting with the mathematics (8), i.e. we have our third subcategory of *enjoyment: enjoyment of active engagement with tasks*.

Then, William goes on and states that “the knowledge of the mathematics is very wide so ... learning it is ... although is, maybe sometimes is difficult but ... I’m keen on that” (8–9). So, although it is sometimes difficult to understand, William likes to learn more about mathematics. Hence, he does not shy away from difficult topics; on the contrary, it seems that he likes to be challenged by mathematics (“I’m keen on that”, 10). Thus, we can develop a new code together with its memo: *enjoyment of challenge by difficult mathematics*.

In William’s last longer utterance he obviously has problems in formulating his thoughts. We can tell this from the long pause of 14 seconds in line 11, as well as the fact that he addresses his formulation problems. Still, his thoughts are understandable so that we can interpret them. In this section he makes a connection between understanding and knowledge: “if I understand that ... what is that thing about ... (14 sec) I get ... I get more more more things in the mind and in the brain, so [...] the knowledge come into your brain and [...] you get more information and get more knowledge and feel great at that time” (10–14). In William’s opinion, understanding of the topics seems to be a precondition for education and for knowing more, probably even for becoming more intelligent. He seems to value the broadness of the mathematical body of knowledge and it is his aim to get more knowledge. In addition, he also feels great when he learns more (13–14). Therefore we can generate the codes *eagerness for knowledge* and *enjoyment of knowledge* (again as a subcategory of *enjoyment*) together with their memos.

Another instance of *enjoyment of knowledge* can be reconstructed from William’s utterance that he feels great when he gets more information and when “the knowledge come into your brain” (13). William’s eagerness to know more combined with

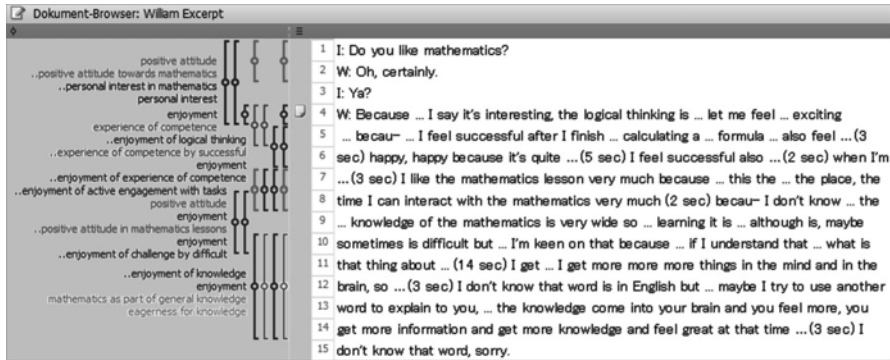


Fig. 2.1 Coded excerpt from William's interview (Screenshot taken from MAXQDA)

his emphasis of the broadness of mathematics suggests that he values mathematics as a part of general knowledge that is to be aspired. Thus, a new code can be *mathematics as part of general knowledge*.

When applying these codes and the analytical memo about the connection between logical thinking and personal interest in mathematics to this section using the software MAXQDA the coded passage looks as presented in Fig. 2.1 above.

To recapitulate, in this interview excerpt we learn something about William's personal attitudes as well as instances that are important for him in the context of learning mathematics. He shows the belief that mathematics may sometimes be difficult and that mathematics lessons provide the conditions in which he can actively engage with mathematical contents. He has a positive attitude towards mathematics and he is interested in the subject as well as the contents. He likes to think logically and to be challenged by difficult topics. Finally, he is eager to learn and wants to develop himself.

Correspondingly, when we subsume our findings from this interview excerpt, we come up with the following (preliminary) list of codes as presented in Fig. 2.2 (given in alphabetical order).

For axial coding we now need to relate categories and concepts on a different level. As described above, I made changes in the coding paradigm, as the elements proposed by Strauss and Corbin (1990, 1996) did not match my research question. To elaborate the different kinds of personal meaning, we need to relate those aspects that are personally meaningful with those which are preconditions and consequences.

When we have a closer look at the categories developed so far in the course of the analytical process, we realize that *eagerness for knowledge*, *personal interest in mathematics*, as well as *positive attitude towards mathematics* or *mathematics lessons* denote elements of William's character. They signify features belonging to his personal traits. Therefore, they are elements of the preliminaries William brings to the process of constructing personal meaning. On the other hand, a closer look to the categories grouped beneath *enjoyment* shows us that we need to distinguish

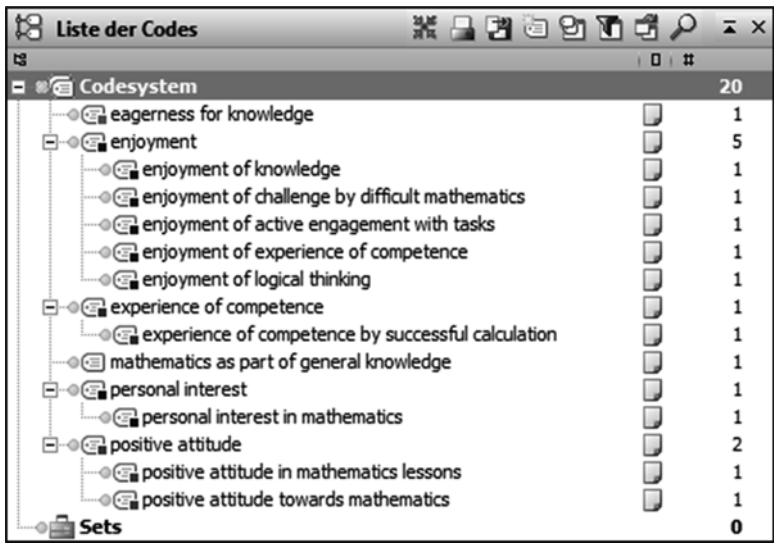


Fig. 2.2 List of codes in alphabetical order (Screenshot taken from MAXQDA)

between the enjoyment itself and the source from which the enjoyment origins. Consequently, the sources are manifold, but they all share the same consequence: the experience of enjoyment. In other words: The phenomena described by the source of enjoyment are personally meaningful for William—provided that he is able to realize them. He then enjoys the learning of mathematics or dealing with mathematical contents.

We can deduce two main statements from these findings: The first one is that the theoretical framework, which relates personal meaning to the surrounding conditions of its construction, becomes clearer and clearer. We now know that we need to distinguish between preliminaries, elements that relate to personal relevance, and consequences. In the course of the analytical process, this model was again refined until the theoretical framework as presented in Fig. 2.3 was developed. With respect to preliminaries, we distinguish between personal background (e.g. cultural and socio-economic background, age, and gender) and personal traits. The latter can be specified in more detail with the help of concepts that are determined in educational psychology (e.g. interest, motivation, and self-efficacy), mathematics education (e.g. mathematical beliefs and thinking styles) or concepts from the didactics of Educational Experience and Learner Development (denoted as *Bildungsgangdidactics* in Fig. 2.3) like developmental tasks.

The second statement is that the sources of enjoyment detected seem to play a decisive role for the development of a theory of personal meaning, as they are elements that are meaningful to William. Hence, they are the first elements that give us an idea about different kinds of personal meaning. In the course of the further analytical process, the different sources of enjoyment show varying degrees of

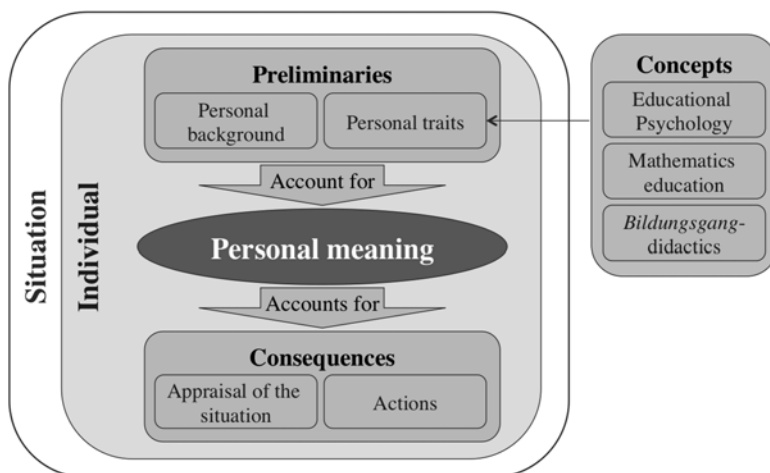


Fig. 2.3 Theoretical framework of personal meaning as developed in the course of the analytical process

relevance for different kinds of personal meaning. One source thereby might be decisive for one kind of personal meaning and also relevant but not central for other kinds. To illustrate this with a more concrete example, let us investigate the idea of *challenge by difficult mathematics* in more detail: At the end of the analyses, this phenomenon that students want to be challenged by difficult topics or tasks proves to be important for the kind of personal meaning *experience of competence* in which it is relevant for the students to experience themselves as competent and successful (see also the need for competence as described in Self-Determination Theory according to Deci and Ryan 2002). One of the personal traits considered as relevant for the construction of this kind of personal meaning is that the student likes to be challenged by difficult mathematics as these contents especially bear the possibility of experiencing competence after they have been successfully solved. The second kind of personal meaning to which *challenge by difficult mathematics* was central is *cognitive challenge*, for which it is the defining element. The final coding paradigm is shown in Fig. 2.4 below. Relevant preliminaries for this kind of personal meaning were a wish for cognitive challenge and that difficult tasks were provided in the lesson so that it was possible for the student to engage with them. Some of the students also are very ambitious and they like competitions with their classmates. Consequences that derive from *cognitive challenge* are for instance that the student can improve his/her achievement and that he/she enjoys the challenge. Hence, the student can experience competence and success. Here, again, the close relationship between some kinds of personal meaning becomes evident.

As only a short excerpt could be shown, it is difficult to clarify the steps of constant comparison in the latter coding process. Hence, from this article it hardly becomes clear how categories become more and more complex and how the ‘big idea’ of every category arises while the analytical process is proceeding. To cushion this, let me add some general ideas about working with grounded theory. When we

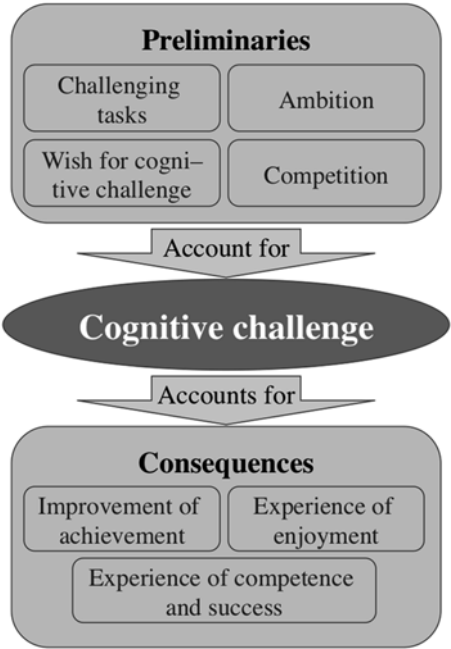


Fig. 2.4 Completed coding paradigm for Cognitive challenge

use the grounded theory method to develop theory from empirical data, our general aim is to discover elements of a theory about our research question in these data. The difficulty is to decide which elements are relevant and how to combine them in such a way that a consistent theory arises. The first thing is that we constantly have to ask ourselves about the more general idea behind what the interviewees say. This means that we have to generalize from the concrete expressions to deduce the more general idea that is relevant for our research question. So, what is behind what the interviewee (or the data in general) tells me? Throughout the research process, these ideas can be linked with each other or—equally or even more interesting—not linked. On the one hand, concepts can be grouped as they denote similar phenomena (subcategories in a category of higher order). On the other hand, concepts can be linked although they do not denote a similar idea. Then, the connection is usually suggested by the interviewees, who combine them in their expressions (axial coding). Here we have to pay attention to the links that can be developed in the analysis and those that cannot be established. Lots of questions arise: Why is that so? Do the categories describe different ‘big ideas’? Or do my categories denote facets of an overarching ‘bigger idea’? Why can’t I put them in one main category? What is missing? And why is it missing? Do I need more (other?) data to answer this question? So here, again, we have to look for the more general idea on category level.

On this level of analysis, we usually keep writing memos over memos to remember all our ideas about combinations of categories and also about links between categories that are not possible and why they are not possible. We formulate hypotheses

about them and try to find more evidence or counterevidence with the help of new data or sometimes even data that have been analyzed beforehand. After some time and after the analysis of more data, some links between categories become more and more established as they occur time and again in the data; other links cannot be verified with new data so that we have to dismiss them. You can see that, slowly, a closely-knit net of combinations of categories arises from the data.

2.5.4 *Selective Coding*

Selective coding describes a procedure similar to axial coding but it is carried out on a more abstract level. The aim is theoretical integration of the developed categories into a consistent overarching theory (see Chap. 1, Sect. 1.7). This means that we are looking for a core category, which is related to all other main categories that were established in axial coding.

Following Strauss and Corbin (1990, 1996), selective coding is the third step in the coding procedure. As Teppo (Chap. 1, Sect. 1.7, with reference to Corbin and Strauss 2008) points out, the questions that have to be answered are “what is the research all about” and “what seems to be going on here”. The aim in this analytic step is to find the common thread that runs through the study. Or—in our trees and anemones metaphor—to detect paths that lead the way through all the trees and plants. We finally get to the point of realizing that we are investigating a complex conglomerate of trees, which finally turns out to be a beautiful forest.

When the analytical process in my study came to an end, 17 main categories were developed, that could be described with reference to several subcategories. The main categories cover a broad range from the fulfillment of duty and the wish for cognitive challenge when dealing with mathematics to the experience of social relatedness. So what is their combining element? All these instances are in some way or another important for the students when they are dealing with mathematics. In other words: All phenomena describe aspects or phenomena in the context of learning mathematics at school that are personally relevant for the individual. This relevance makes the phenomena personally meaningful for the students. Hence, when asking the sensitizing questions of selective coding, I decided in favor of the core category *personal relevance*. The different kinds of personal meaning can be characterized as those incidents that are dealt with in the context of learning and dealing with mathematics at school which are personally relevant for the students. With reference to the codes that were developed in the course of the analytical process of the study, this means that the main categories worked out in axial coding describe the different kinds of personal meaning.

Strauss and Corbin (1990, p. 116) define the core category, which is to be developed in this step, as the “central phenomenon around which all the other categories are integrated”. It might have been developed in the course of axial coding or it might as well arise in selective coding. The phenomenon being central for selective

coding may in some research even be contained in the formulation of the research question (Böhm 2005).

Personal relevance fulfills the assessment factors for a core category suggested by Strauss (1987⁴). The core category *personal relevance* is the central element of the developed theory and can easily be interwoven with the main categories in a close network. This is due to the fact that every main category developed in axial coding describes another kind of personal meaning. Each of these categories therefore categorizes another specification of personal relevance. Every main category, i.e. the different kinds of personal meaning, together with its subcategories describes indicators for the core phenomenon, which frequently occur in the data and form a pattern.

2.6 Going Beyond Grounded Theory

Having reached this point, I came up with a dense grounded theory about personal meaning based on the construction of 15- to 16-year-old students from Germany and Hong Kong when they learn mathematics. I was able to describe 17 different kinds in rich detail. I could have stopped here—and actually the application of grounded theory methods ends here. Moreover, I was interested in the relationship between the different kinds of personal meaning, i.e. the main categories of my theory. Is there some axis they all refer to and according to which they can be ordered? Is there a basic underlying, subject-independent dimension which can be used to work out guidelines or more general criteria to think about personal meaning across different subjects? To answer these questions, I had to think about the different kinds of personal meaning I had worked out from a more general perspective. By doing so, I followed the methods laid out by Kelle and Kluge (1999). The two dimensions I finally came up with were the relatedness towards the individual and the relatedness towards subject contents, i.e. mathematics. I was able to arrange all kinds of personal meaning with reference to these two dimensions. Then, seven different types of personal meaning could be deduced from the arrangement (see *ibid*). As the typology is not reported here in detail, see Vollstedt 2011a or 2011b for more detail.

The analytical elaboration of the categories finally resulted in a decisive advancement of the theory, which gained more explicitness and density. Furthermore, it is possible to integrate maximum variation of the specifications of the core category *personal relevance* into the theory as can be seen in the development of the typology. By writing down the theory that has been developed from our interview data, we give other people the possibility of also understanding and referring to the theory we worked out.

⁴At the time of writing his introduction to *Qualitative analysis for social sciences*, Strauss (1987) used the term *key category* instead of *core category*. They denote, however, the same kind of category.

2.7 Conclusion

The aim of this chapter was to trace the analytical process of an empirical interview study using grounded theory. To achieve this, an excerpt from one interview with a student from Hong Kong was analyzed and the analytical process was shown in as much detail as possible. It is, of course, not possible to illustrate every little step of the highly complex analytical process with such a short excerpt. Still, I tried to give insight into the different levels of coding as well as to provide examples for the decisions that have to be made throughout the analysis.

To conclude, the basic idea of the development of theory using grounded theory is to get the main ideas behind what the interviewees say (or our data provide), to formulate hypotheses about links between these ideas, and to try to establish or dismiss these links. To finally come to a dense theory that is empirically grounded, a very detailed analysis of the data is necessary. The ideas discovered have to be knit together tightly with the help of empirical evidence. Eventually, we see in the data not only manifold expressions or phenomena but concepts and categories that are strongly interwoven to form a theory about our research question in focus.

In other words: We started our journey with an indistinctive conglomerate of plants, began with a categorization of trees, bushes and animals and finally reached a good understanding of our forest with all its paths, bigger ways and shortcuts through the undergrowth. Having laid out the theory now also puts up signposts to enable other people to enjoy a day in the forest without being lost, and to come back once in a while. Thus, in the end, it is possible to see the wood despite—or precisely because of—all the trees.

References

- Birks, M., & Mills, J. (2011). *Grounded theory: A practical guide*. Los Angeles: Sage.
- Böhm, A. (2005). Theoretisches Codieren: Textanalyse in der Grounded Theory [Theoretical coding: Text analysis with grounded theory]. In U. Flick (Ed.), *Qualitative Forschung. Ein Handbuch* (4th ed., pp. 475–485). Reinbek: Rowohlt.
- Borromeo Ferri, R. (2004). *Mathematische Denkstile: Ergebnisse einer empirischen Studie* [Mathematical thinking styles: Results of an empirical study]. Hildesheim: Franzbecker.
- Corbin, J., & Strauss, A. L. (1990). Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift für Soziologie*, 19(6), 418–427.
- Corbin, J., & Strauss, A. (2008). *Basics of qualitative research* (3rd ed.). Los Angeles: Sage.
- Deci, E. L., & Ryan, R. M. (Eds.). (2002). *Handbook of self-determination research*. Rochester: University of Rochester Press.
- Flick, U. (2005). *Qualitative Sozialforschung: Eine Einführung* [Qualitative social research: An introduction] (3rd ed.). Reinbek: Rowohlt.
- Gass, S. M., & Mackey, A. (2000). *Stimulated recall methodology in second language research*. Mahwah, NJ: Lawrence Erlbaum.
- Glaser, B. G. with the assistance of Holton, J. (2004). Remodeling grounded theory. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, 5(2), 80 paragraphs, Retrieved from <http://nbn-resolving.de/urn:nbn:de:0114-fqs040245>. Accessed 25 July 2013.

- Havighurst, R. J. (1972). *Developmental tasks and education* (3rd ed.). New York: Longman.
- Howson, A. G. (2005). "Meaning" and school mathematics. In J. Kilpatrick, C. Hoyles, & O. Skovsmose (Eds.), *Meaning in mathematics education* (pp. 17–38). New York: Springer.
- Jablonka, E. (2006). Student(s) at the front: Forms and functions in six classrooms from Germany, Hong Kong and the United States. In D. Clarke, J. Emanuelsson, E. Jablonka, & I. A.-C. Mok (Eds.), *Making connections: Comparing mathematics classrooms around the world* (pp. 107–126). Rotterdam: Sense.
- Jungwirth, H. (2003). Interpretative Forschung in der Mathematikdidaktik: Ein Überblick für Irrgäste, Teilzieher und Standvögel [Interpretative research in the didactics of mathematics: An overview for vagrants, partial migrants and sedentary birds]. *Zentralblatt für Didaktik der Mathematik*, 35(5), 189–200.
- Kaiser, G., Hino, K., & Knipping, C. (2006). Proposal for a framework to analyse mathematics education in Eastern and Western traditions: looking at England, France, Germany and Japan. In F. K. S. Leung, K.-D. Graf, & F. J. Lopez-Real (Eds.), *Mathematics education in different cultural traditions. A comparative study of East Asia and the West* (pp. 319–351). New York: Springer.
- Kelle, U., & Kluge, S. (1999). *Vom Einzelfall zum Typus. Fallvergleiche und Fallkontrastierung in der qualitativen Sozialforschung* [From single case to type. Comparison and contrasting of cases in qualitative social research]. Opladen: Leske + Budrich.
- Kilpatrick, J., Hoyles, C., & Skovsmose, O. (2005). Meanings of 'Meaning of Mathematics'. In J. Kilpatrick, C. Hoyles, & O. Skovsmose (Eds.), *Meaning in mathematics education* (pp. 9–16). New York: Springer.
- Krapp, A. (2002). An educational-psychological theory of interest and its relation to SDT. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 405–427). Rochester: University of Rochester Press.
- MAXQDA (Software for qualitative data analysis). (1989–2013). Berlin: VERBI Software, Consult, Sozialforschung GmbH. Retrieved from www.maxqda.com. Accessed 25 July 2013.
- Op't Eynde, P., de Corte, E., & Verschaffel, L. (2002). Framing student's mathematics-related beliefs: A quest for conceptual clarity and a comprehensive categorization. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 13–37). Dordrecht/Boston: Kluwer.
- Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: an organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3–33). Rochester: University of Rochester Press.
- Stigler, J. S., & Perry, M. (1988). Cross-cultural studies of mathematics teaching and learning: Recent findings and new directions. In D. A. Grouws & T. J. Cooney (Eds.), *Perspectives on research on effective mathematics teaching* (pp. 194–223). Reston: Lawrence Erlbaum.
- Strauss, A. L. (1987). *Qualitative analysis for social scientists*. Cambridge: Cambridge University Press.
- Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park: Sage.
- Strauss, A. L., & Corbin, J. M. (1996). *Grounded theory: Grundlagen qualitativer Sozialforschung* [Basics of qualitative research: Grounded theory procedures and techniques]. Weinheim: Beltz.
- Strübing, J. (2004). *Grounded theory: Zur sozialtheoretischen und epistemologischen Fundierung des Verfahrens der empirisch begründeten Theoriebildung* [Grounded theory: Its social-theoretical and epistemological foundation]. Wiesbaden: VS Verlag für Sozialwissenschaften.
- Tiefel, S. (2005). Kodierung nach der Grounded Theory lern- und bildungstheoretisch modifiziert: Kodierungsleitlinien für die Analyse biographischen Lernens [Coding in terms of grounded theory: Modifying coding guidelines for the analysis of biographical learning within a theoretical framework of learning and education]. *Zeitschrift für qualitative Bildungs-, Beratungs- und Sozialforschung*, 6(1), 65–84.

- Trautmann, M. (Ed.). (2004). *Entwicklungsaufgaben im Bildungsgang* [Developmental tasks in the context of educational experience and learner development]. Wiesbaden: VS Verlag für Sozialwissenschaften.
- Vinner, S. (2007). Mathematics education: Procedures, rituals and man's search for meaning. *Journal of Mathematical Behaviour*, 26(1), 1–10.
- Vollstedt, M. (2011a). On the classification of personal meaning: Theory-governed typology vs. empiricism-based clusters. In B. Ubuz (Ed.), *Proceedings of the 35th conference of the international group for the psychology of mathematics education* (Vol. 4, pp. 321–328). Ankara: PME.
- Vollstedt, M. (2011b). *Sinnkonstruktion und Mathematiklernen in Deutschland und Hongkong: Eine rekonstruktiv-empirische Studie* [The construction of personal meaning and the learning of mathematics in Germany and Hong Kong: A reconstructive-empirical study]. Wiesbaden: Vieweg+Teubner.

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