VIDEOCODING – A METHODOLOGICAL RESEARCH APPROACH TO MATHEMATICAL ACTIVITIES OF KINDERGARTEN CHILDREN

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In this paper a methodological research perspective is taken on the mathematical activities of Kindergarten children in mathematical situations of play and exploration. Videotaped verbal and gestural expressions of children as well as activities with the material are encoded with the help of a coding guideline, which is developed for mathematical activities. So courses of mathematical activities can be traced during a mathematical situation of play and exploration and even over several data collection points. At the same time connections of using different mathematical activities between the participants become clear. The introduced methodology of video coding connects qualitative with quantitative analysis methods.

Keywords: video coding methodology, Kindergarten, example and exemplification

INTRODUCTION

Starting point for the development of an instrument for video coding are videotaped mathematical situations of play and exploration, which occur within the framework of the project ‘erStMaL’ [1]. One overarching aim of ‘erStMaL’ is to trace the development of mathematical thinking of children aged between four and nine years from a mathematics-didactical perspective (cf. Acar Bayraktar, Hümmer, Huth, Münz & Reimann, 2011; Krummheuer, 2011). The mathematical domains numbers & operations, geometry & spatial thinking, measurement, patterns & algebraic thinking and data & probability serve as reference points for the conception and the development of the mathematical situations of play and exploration (cf. Clements & Sarama, 2007). Within the ‘erStMaL’-project the mathematical situations of play and exploration [2] serve as an empirical research instrument (Vogel, in preparation). The developed situations provide a situational framework within children work in tandems and together with a guiding adult on mathematical tasks. The guiding adult has an expert status concerning these mathematical tasks. These situations are designed dialogically and the children’s mathematical activities, which are usually tied to the selected materials (artefacts) of the particular situation, are in the centre of consideration (cf. Wells, 1999; van Oers, 2004). The materials (artefacts) are selected in a way that they on the one hand show a narrative character and on the other hand they provide connection points for mathematical activities. The materials can therefore be seen as ‘culture tools’ (Bodrova & Leong, 2001, p. 9). Overall an ‘overlap situation’ between the world of mathematics and the world of experience is generated by the designed mathematical situations of play and exploration (cf. Prediger 2001; Vogel, in preparation).

THEORETICAL BACKROUND

In terms of a social-constructivist perspective on learning mathematics the situations of play and exploration activate the involved persons ability to negotiate the objects` mathematical meanings. Dealing with the objects and how the objects can be used for the solution process of the mathematical task has to be clarified in a negotiation process by the children (cf. Brandt & Höck, 2011). This theoretical learning approach can be combined with the theoretical development approach of the co-construction, which is discussed primarily for early education processes (cf. Brandt & Höck, 2011). In the context of these interactionist approaches the area of tension "between interaction processes between partners with equal rights" and "interaction processes with a rather disparate role allocation and clear differences" (Brandt & Höck, 2011, p. 249, translated by R. Vogel) must be taken into account between the participants. At the same time the mathematical situations of play and exploration create an area in which knowledge can be expressed situationally (cf. Vosniadou, 2007). With this a further development of mathematical concepts, according to conceptual changes, which does not exclusively exchange concepts but also change perspectives, is integrated (cf. Vogel & Huth, 2010; Vosniadou, 2007).

RESEARCH PERSPECTIVE

Against this theoretical background, it is necessary to develop an analytical tool that enables the reconstruction of the childrens' mathematical activities in the situational processes of negotiation. Through this reconstruction, on the one hand it is possible to track the development of mathematical concepts of children over the course of time. And on the other hand, video sequences, which can be analyzed with other qualitative analysis tools on a micro level in terms of the mathematical concept development, can be identified. Particularly the significance of the interaction of different semiotic resources for the development of mathematical thinking can be worked out (cf. Vogel & Huth, 2010; Givry & Roth, 2006).

VIDEO CODING – THEORETICAL FRAMEWORK AND APPLICATION

The presented method of video analysis combines qualitative and quantitative analysis steps. By using a coding guideline and by determining frequencies of the emerging categories quantitative analysis of the videotaped mathematical situations of play and explorations are carried out. For the development of the coding guideline a qualitative content analysis has been carried out. In this process an offset of deductive and inductive developed categories has been created (cf. Mayring, 2000; 2012). Figure 1 shows an overview of the process of category determination. Several and relevant mathematical concepts from the five mathematical main domains which are the basis of the different situations of play and exploration formed the starting point (cf. Clements & Sarama, 2007). Within the consideration of the video data this first category-system was supplemented and extended inductively trough the mathematical activities that have been expressed by the participating children. Therefore we looked at various videotaped situations of each domain considering the first four data collection points. After determining a constant category system the coding accordance of different persons was checked and the categories have been proved and verified again.

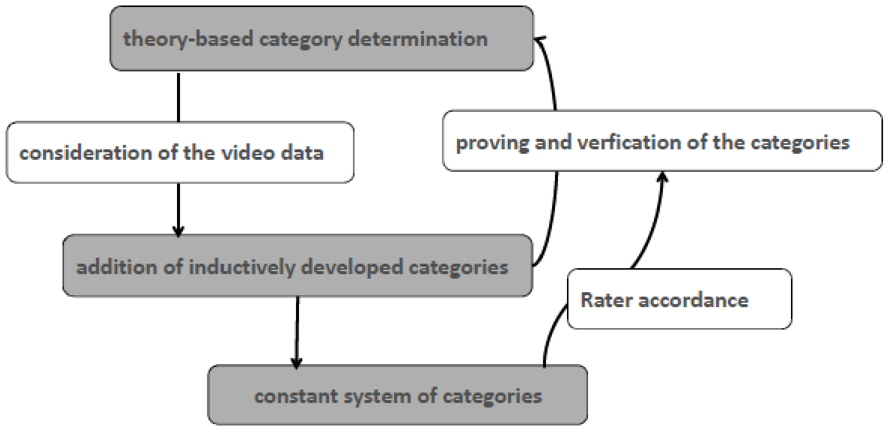

Figure 1 Process of developing the coding guideline

The coding guideline consists of eleven main categories which are divided into several subcategories. The main categories refer to mathematical activities which are attributed to the five mathematical domains already mentioned above. In the following paragraphs the main categories will be presented briefly.

The main category 'determination of quantities – operation (QO)' which is attributed to the domain of 'numbers & operations' will be presented in detail, because of its importance for the selected example. A provided reference to empirical research context is given. It is a domain that is elaborately researched for mathematical early education so far. A distinction is made between counting as a series of numbers (right or wrong) and one to one assignment of numbers and objectives (cf. Fuson, 1988; Gelman & Gallistel, 1978). Additionally the field of subitizing is mentioned. This kind of entry of quantities is often described as a preliminary stage of counting. „Results suggested that spontaneous focus builds subitizing ability, which in turn supported the development of counting and arithmetic skills." (Clements & Sarama, 2007, p. 473). Another subcategory serves to register children's activities and statements in the fields of seriation (cf. Clements & Sarama, 2007). Further subcategories serve to register simple operative activities in the field of addition and subtraction. Subcategories are indicated with numbers after the short cut of the main category (e.g. QO1 for 'Counting', QO2 for 'Determination of quantity without recognizable counting processes').

The main categories 'algebraic structures (AS)' and 'patterns (patterns, bandornaments, parquets) (PA)' are attributed to the domain of 'patterns & structures': The central focus of the main category AS is on constructions of structures in a quantity as well as between several quantities (cf. example of the video coding process). It becomes apparent that the children integrate structures of their every day life into the situations and partially interpret these structures mathematically. In the field of PA geometrical activities with regard to the work with patterns are represented, e.g. bandornaments should be added, continued or should be reinvented by the children. Here it is taken into consideration that children might create patterns, which cannot be interpreted as patterns from a mathematical perspective, but are described as patterns by the children. As a result sequences from the video data can be identified where several patterns of interpretation from within the children's world and the world of mathematic become apparent. Comparable subcategories have been developed for dealing with parquets.

Within the coding guideline activities in the domain of geometry and spatial thinking are determined through three main categories: topological fundamentals and activities (TP), components of spatial thinking (ST) and geometric shapes and 3-D figures - transformation between plane and space (GE). There is a distinction between dealing with closed and open lines and finding ways in narrative contexts e.g. within 'railway-situations' and activities of Euclidian geometry. Components of spatial thinking should also be taken in account in a separated category. The domain of 'measurement & sizes' is represented by the main category 'meas-urement (ME)'. It is proposed that within the subcategories activities of direct or indirect comparison are coded.

The mathematical domain of 'data and probability' is included in three main categories: data (DA), coincident (chance) (CH) and combinatorics (CB). In view of the example the domain data must be emphasized. Focus is on elementary and complex processes of sorting as well as on adequate representations for comparison of quantities.

The process of coding involves mathematical interpretations of verbal and gestural based statements of the children as well as actions with the material according to the coding guideline. The multimodal statements of several persons are coded separately. Therefore a coding unit of 30 seconds is allocated to maximum two subcategories. The following example of transcription [3] reproduces most of the coding units 16 and 17 (cf. Figure 2) and it also shows which subcategories are allocated to the involved persons' statements.

Coding unit 16 (extract from the 30 seconds, start):

<	René	look . one two three four *pointing at the dots of a 'June bug- card' which is in front of him* one two three four *pointing at the dots of the 'June bug-card' in his hand*
<	Marie	**two** *taking a 'June bug- card' with two dots out of the middle and dropping it infront of him on the floor together with the other 'two-dots June bug-cards'*
	B	yes-
	Marie	and three\ do I have a three/ *observing a 'June bug-card' with three dots, which is lying in the middle* and *then looking at a 'June bug-card' which is in a row in front of her on the floor*

	René	*taking the ‘three-*dot *June bug- card’ out of the middle* **he**/ . I have a three\ *dropping the card to the other ‘three-*dot *June bug-card’ in front of him on the floor*

Coding (Subcategories):
René: counting (QO1) & elementary sorting according to one category (DA1)
Marie: recognizing structures within quantities (AS1) & elementary sorting according to one category (DA1)
B (guiding adult): algebraic structures (stimulus) (AS (x))

Coding unit 17 (extract from the 30 seconds, start):

<	René	Mum and Dad\ *pointing at two red ‘four-*dots *June bug-cards’* Brother and Sister\ *taking two red ‘three-*dots *June bug- cards’ in his hand* Mum and Dad\ Brother and Sister\
<	Marie	*pushing all ‘June bug-cards’ lying in front of her on one pillar* mine is a whole kindergarten\...should be a whole kin-
	Marie	that is a whole Kindergarten\
	B	*laughing* a whole Kindergarten/

Coding (Subcategories):
René: recognizing structures within quantities (AS1)
Marie: recognizing structures within quantities (AS1) & determination of quantity without recognizable counting processes (QO2)
B: algebraic structures (AS)

EXAMPLE OF AN ANALYSIS

For this paper the mathematical situation of play and exploration ‘June bugs’ is selected for an exemplary analysis. In the settings the participating children are observed in constant tandem (pairs). In these pair settings the children always attending the same mathematical situation however for each data collection point the mathematical tasks and materials are adapted to the age of the children if necessary. For the current analysis the selected tandem consists of René and Marie. They deal with this situation at three different data collection points. The data collection point T2 is missing due to the research design (situation with the kindergarten teacher). At the data collection point T1 René and Marie were 4;9 years old.

In the ‘June bugs-situation’ the children can differentiate between similar objects, which differ in several attributes. The children work with ‘June bugs-cards’ which differ in colour (red, green, yellow), in number of spots on it (one, two, three, four) and in the shape of the spots (circles, triangles, squares). No ‘June bugs-card’ appears twice. In the first working phase the children are encouraged to sort the ‚June bugs-cards’ according to different criteria and to establish different ‘June bugs-groups’. In the second working phase the member of the research team presents a triplet of big ‘June bugs-cards’. The big ‘June bugs-cards’ also differ in colour, shapes, size and number of spots. The children should decide which of the three cards does not fit.

The results of the analysis are visualised in two different forms. Below first a time course that shows the emerging mathematical activities and its transitions and connections at one data collection point in one situation is presented. Here it is possible to follow the interaction between the participating persons regarding to its influences on the mathematical activities carried out of one person. The second form of representation shows the quantities of the mathematical activities over time. The percentage frequency of main categories or subcategories at different data collection points can be compared and possible transformation become apparent. Children’s preferred mathematical domains can be described through comparing and contrasting their percentages.

Time course

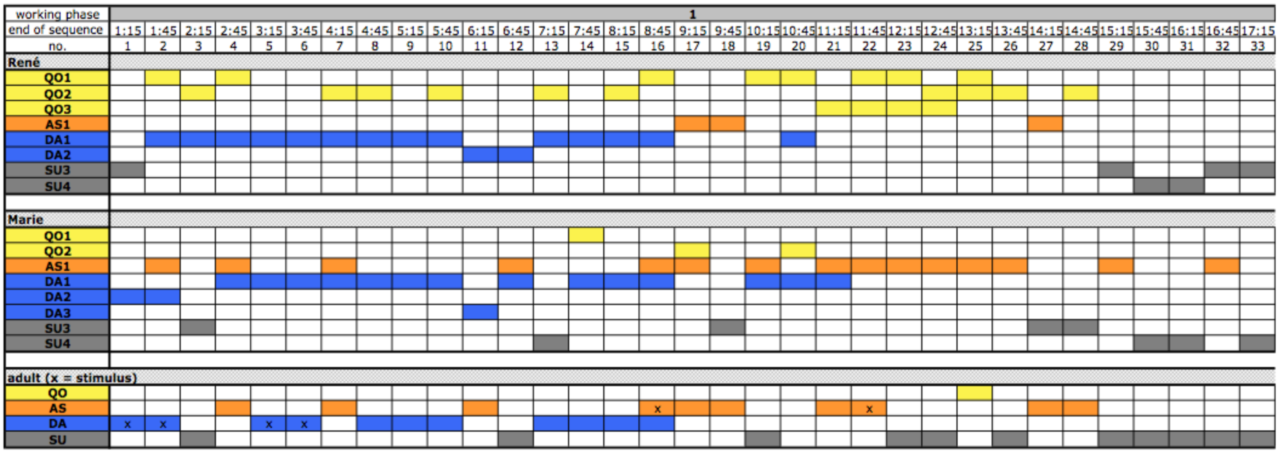

Figure 2: Time course of the first working phase of the ‘June bug-situation’ carried out at the data collection point T3

Figure 2 shows the time course with the coding of the mathematical activity of the two children and the guiding adult in the first working phase of the ‘June bugs-situation’ at the data collection point T3 (Marie and René: 5;10 years). The guiding adult starts with impulses from the domain data (DA), which are picked up by the children. In the sequences from 1-16 the ‘June bugs-cards’ primarily are sorted by one specific criteria (colour, shape, number) (DA1). Marie and René combine the sorting process with other different mathematical activities. René has a particular interest in determining the numbers of spots on the ‘June bugs-cards’. Therefore he uses different strategies: ‘counting (QO1)’ and ‘determination of quantity without recognizable counting processes (QO2)’. Marie is specifically focused on the structural relationships of the objects of different quantities (AS1). She uses the context of family and kindergarten. There is an intensive exchange between the main categories QO, AS and DA to be seen during the coding units 16 and 17. This indicates a so-called ‘dense’ sequence, in which different mathematical concepts within the activities become apparent and are placed in relation to one another (cf. example of the video coding process). After those coding units Marie remains in the domain of algebraic structures until the end of the working phase deepening her idea of structuring the quantities. Rene's mathematical activities can mainly be attributed to the domain 'determination of quantities – operations'. Once he has sorted the 'June bugs-cards' according to colours he starts to bring the cards in an order according to the number of spots upon the back and determines which 'June bugs-group' is the biggest one. Over time it becomes evident that during the span of a mathematical situation of play and exploration sequences can be observed in which the activities of the involved persons cannot be interpreted as mathematical activities. Nevertheless these activities can also be important for the children and the course of the situation. From coding unit 29 until 33 Marie begins with a detailed description of her 'June bugs kindergarten groups' and starts telling of a fictional excursion for the groups. René is sitting next to her, not entirely detached and listening partially. Overall it becomes obvious that the children combine activities from within different mathematical domains and they switch from one domain to another.

Quantities of the mathematical activities

If you compare the percentage frequencies of the emerging major activities of René to the ones of Marie you will get to the point that they remain true to their favourite mathematical activity (Figure 3). The fact that through all the data collection points the domain data remains constant is a result of the situation's and the material's design. Compared to Marie René's obviously preferred activity is out of the domain of determination of quantity - operations.

The courses over time allow the following interpretation: At point T1 from the data collection the children bring up a diversity of mathematical domains. This diversity of different mathematical activities decreases over time. It is possible that this is due to the fact that the children already know the task and the material and that does not require that much testing anymore.

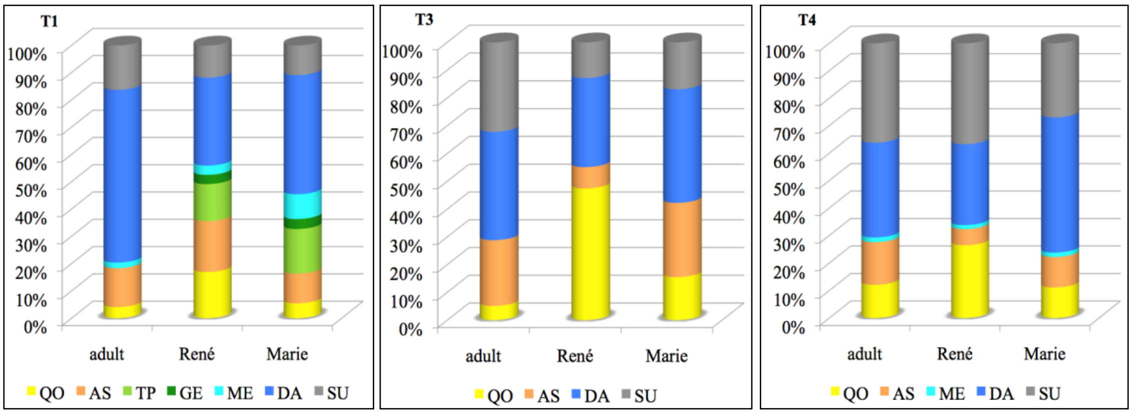

Figure 3 Percentage frequencies of main categories at different data collection points

If you focus solely on the main category there does not appear to be a major change between the data collection points. But when taking the subcategories into account you can notice that there are changes in the mathematical activity over time. Figure 4 shows the subcategories of the main category ‘determination of quantities – operations’. The subcategories are counting (QO1), determination of quantity without recognizable counting processes (QO2), ordering (QO3), operations – addition and subtraction (QO4) and operations – multiplication and division (QO5).

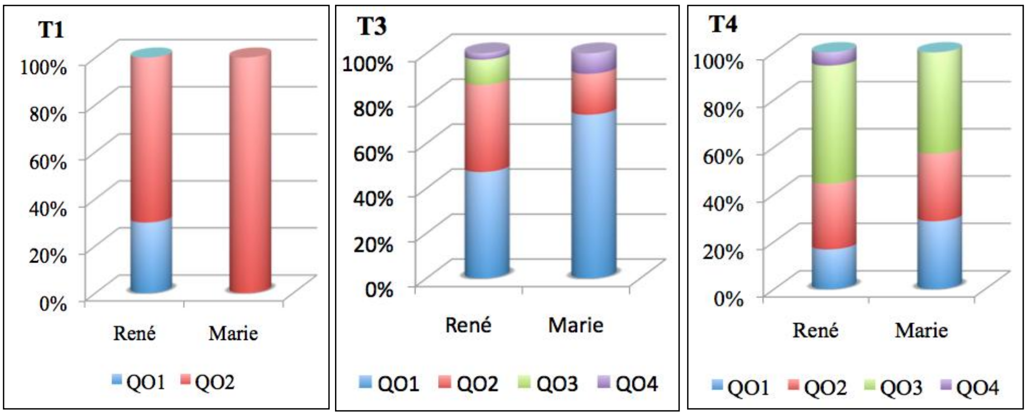

Figure 4 Percentage frequency of the subcategory ‘Determination of quantities – operations’ at different data collection points

At the first data collection point Marie’s activities out of the domain ‘determination of quantities – operations’ can be exclusively assigned to the subcategory determination of quantity without recognizable counting processes (QO2). She distinguishes between less and many ‘June bugs–cards’ however without counting them, whereas René tries to confirm these assumptions with noticeable counting processes. Nearly one year later at the third data collection point the children focus on counting processes. At the data collection point T4 (Marie and René: 6;5 years). the focus of the children is on sorting the ‘June bugs-cards’ in series according to the number of spots and bare counting processes are less frequently realized.

CONCLUSIONS AND FUTURE PROSPECTS

The example already shows the potential of this type of video analysis. The results show that the mathematical main categories remain constant over time, while the subcategories are changing. Therefore the results of the video coding process offer reference points for the reconstruction of the development of mathematical thinking in different mathematical domains. The results of analysis of various mathematical situations of play and exploration and different tandems of children suggest the existing of preferred mathematical domains for particular children during the process of problem solving. This result could be used to examine specific groups of children in their mathematical preferences. In addition the results show that the procedure of video coding enables an identification of sequences with reference points for further analysis regarding mathematical concepts. The coding can also be used as an evaluation of the situations of play and exploration which is necessary for a possible advancement to a diagnostic tool.

NOTES

1. The project ‘erStMaL’ (early Steps in Mathematics Learning) is a longitudinal study, which accompanied the children during their time in kindergarten and primary school. 178 children in 12 day-care centers participate in the study. Data collection takes place twice a year and is carried out in the familiar environment of the day-care-centers. The project is established at the IDeA centre (Individual Development and Adaptive Education of Children at Risk) in the context of the LOEWE-Initiative.
2. All the situations of play and exploration were developed by the research team of the project ‘erStMaL’.
3. Explanation for understanding the transcript: / … lifting the voice, \ … lower the voice, - voice in abeyance, pause in speech: one point according one second, action are in italics, < … happened at the same time.

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