INTEREST-DENSE SITUATIONS AND THEIR MATHEMATICAL VALENCES

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This paper presents part of a data based theory construction about interest fostering situations. It describes how collective value constructions in everyday maths classes support the emergence and stabilisation of these situations. How this is done can be distinguished by the way mathematical valuable ideas are produced. Reconstructions of these production processes lead to the development of four ideal type process characterisations and their potential to initiate interest based actions.

1 Introduction

Empirical studies about interest primarily investigate interest from the perspective of individuals (for a short overview see Bikner-Ahsbahs 2001)[1]. Above all, everyday maths lessons are social events. Whether learning mathematics with interest is possible is not only a question of the students' preferences but also a question of content and social processes as well (Middleton et. al. 2003; Prenzel 1998; Deci 1992; Deci & Ryan 2000). During the last few years interest researchers demand a connection between interest research and research on learning and instruction (Prenzel 1998, p. 362; Krapp 1998, p. 190). Following this the core question of the research project "interest in maths between subject and situation" is about how everyday maths lessons are shaped to further or hinder learning mathematics with interest (Bikner-Ahsbahs 2001, 2003a, 2003c). An interest concept which includes interest quality of situations in maths lessons has led to a situational interest theory that

- tries to bridge the gap between psychological interest research and practice,
- describes and explains how special kinds of interest supporting situations – so called interest-dense situations – are initiated, stabilized or hindered and
- provides a basis to connect the individual and the social view on learning mathematics with interest in school.

The focus of this paper is to give an overview of the construction process of this theory, to present a part of it, and to illustrate some of it through data.

2 Integrating the individual and a collective view of interest

Self-determination theory serves as a background theory for interest concepts. It describes how individual interest develops and how it can be supported. (Deci & Ryan 2000) "To be *self-determined* means to act with a sense of volition and agency, a sense of being autonomous and wholly willing to engage in some activity. It is as if this activity were a expression of who one is. … In contrast, to be controlled means to

[1] An overview of current interest research can be found in Hoffmann et al. (1998).

act with a sense of pressure and demand, with the feeling that you have to do the behaviour because of some interpersonal or intrapsychic force." (Deci 1998, p. 147) Self-determined motivation shapes a continuum which reaches from doing something controlled through the different grades of self-determination to intrinsic motivation. "… *intrinsic motivation* is defined operationally as doing something for its own sake – or, more precisely, for the spontaneous affects and cognitions that accompany the activity – *extrinsic motivation* refers to doing something for a separable consequence, whether that consequence is in the environment or is a specific cognitive "reward" one gives oneself after completing the activity." (Deci 1998, p. 147) Therefore, intrinsic motivation is highly self-determined whereas extrinsic motivation can be externally or internally regulated, i.e. extrinsic motivation can either be controlled or self-determined. It is self-determined if the source of the activity is self-controlled which means a student has the feeling he/she *must* do something for his/her own sake. (Deci & Ryan 2000; Deci 1992, 1998)

In research literature we find different concepts of personal interest (Renninger 2000; U. Schiefele 1996; Krapp 2000, 2002; Rathunde 1998) which all state that *personal interest* is a concept of intrinsic motivation. The interest concept which a lot of current studies refer to is that of Krapp who further developed this concept from the very first ideas presented by H. Schiefele and his colleagues (1979) and connected it to the self-determination theory. Krapp defines personal interest as a person-object relation which is shown through interest-based actions. These actions are driven by the need to get to know more about the object of interest, by experiencing predominantly positive emotion and value while taking a close look at this object (Krapp 2002, 2000). With regard to the self-determination theory interest based actions are driven by a high amount of self-determination and are supported by the experience of three basic needs: experience of competence, of autonomy, and of social relatedness. Environments that are autonomy supportive, competence supporting and relationally supportive foster intrinsic motivation, hence interest development (Deci 1992, 1998; Deci & Ryan 2000). However, a central question remains: How are autonomy supportive, competence supporting and relationally supportive social environments in maths classes shaped, or, more generally, what conditions of social interaction processes in every day maths classes are likely to foster interest development?

In contrast to the concept of personal interest Mitchell developed a concept of *situational interest in mathematics* as a multifaceted conceptual structure. Students bring personal interest with them into the lesson but situational interest is aroused und held throughout situational conditions within lessons. Situational interest can be aroused by group work or by cognitive challenges such as puzzling or solving problems with a computer. Situational interest which is aroused need not necessarily be held. However, it is held if students experience mathematics as meaningful (*meaningfulness*) and if they get deeply involved in mathematical tasks (*involvement*). (Mitchell 1993) Using self-determination theory as a background theory situational interest can be seen as a person-situation-relationship that initiates a fluctuating person-object-relationship which occurs within a situation and ceases after a while.

Personal interest and situational interest are individual interest concepts. However, teachers often describe classes as interested although they know that not all students of the class are individually interested. In doing so, they talk about a special kind of collective interest. What does this collective interest mean? The basic idea of the presented study was to construct a collective concept of interest which emerges within special maths situations. The following concept describes this kind of collective interest in more detail.

Situated collective interest *is a construct, which describes the relationship between a group of students and a mathematical object. It is presented by collective activities during class discussions with three different features*

- *one after the other students get involved in the activity (**involvement**).*
- *one after the other students construct continuously farther-reaching meanings (**dynamic of the epistemic process**)*
- *the value of the situation is concerned with maths (**mathematical valence**)*

*A situation in which situated collective interest emerges is called an **interest-dense situation**.* (Bikner-Ahsbahs 2002, 2003a, 2003c)

Active participants of interest-dense situations need not necessarily be individually interested in mathematics but altogether they construct continuously farther-reaching mathematical meanings. One after the other they get involved in the activity and the importance of the situation is shaped by the mathematical objects and the epistemic process. Students are involved in creating, developing and working on valuable mathematical ideas and not in getting good marks, in pleasing the teacher, in being better than each other or in winning an implicit struggle or contest. Hence, investigations of the emergence of interest-dense situations have to include analyses about the social interaction processes from three perspectives: From the perspective of social interactions which shape the way how the participants get involved, from the perspective of the epistemic processes which give an insight into the process of constructing mathematical knowledge, and from the perspective of value constructions which show why the activity focuses on maths and which show how different conditions add up to the quality of interest.

In interest-dense situations students have the opportunity to try out what it feels like to act in an interest-based way within a social context. Whether or not individual interest emerges depends on individual attributions to one's own experiences as individual interest is a phenomenon that the individual is aware of. This need not be the case in interest-dense situations.

During a lesson three kinds of interest merge into one activity. Actions driven by personal interest are shaped by situations. Actions driven by situational interest are shaped by the mathematical content. Collective actions driven by situated collective interest are shaped by individuals within social interaction processes. (Bikner-

Ahsbahs 2003c) Thus, interest-dense situations can be investigated through the analyses of social interactions.

The concept of interest-dense situations is used as a core concept for the construction of a theory that answers the question how interest-dense situations are generated, stabilised or hindered.

The next section presents a short overview about the methodological assumptions and the methods used in order to construct this theory.

3 Methods supporting the process of theory development

The process of theory construction is based on empirical data – video recordings of all lessons about fractions in a 6th grade class except the lessons which were involved with test taking. The data show 18 interest-dense situations from which transcripts are made. The questions guiding the construction process are: *How do interest-dense situations emerge? How are they stabilized? How could this generating process be supported and how is it limited or hindered?*

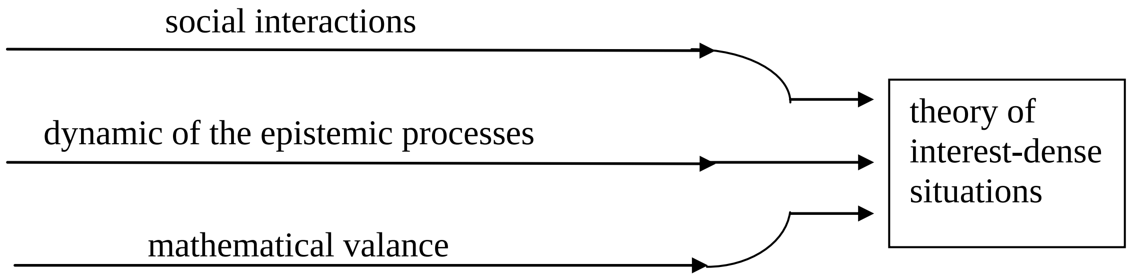

Figure 1: Merging three levels of analyses to construct a theory (Bikner-Ahsbahs 2003c, p. 110)

Guided by the principle of comparing contrasting and similar scenes, three partial theories of interest-dense situations are constructed: one from the perspective of social interactions, a second from the perspective of epistemic processes, and a third from the perspective of mathematical valence. These partial theories are merged in the end to form a theory about interest-dense situations (fig. 1).

Every partial theory is constructed by cycles of analyses consisting of four steps: Initially, the first or next interest-dense scene is reconstructed from the perspective in question and, if necessary, the hypotheses from the analysis cycles before are proved. Next, the interest-dense scenes which were analysed before are compared with additional contrasting scenes. Then typical features of the analysed scene are worked out, and finally hypotheses are formulated.

Deep insight into the condition network can be gained through micro ethnographic interpretative analyses of every scene. Since interest-dense situations are collectively shaped, interaction analysis is used. This kind of analysis assumes on the one hand that people are not able to escape from their own interpretations of the world and on the other hand that individuals orient their actions according to their interpretations of how others act. Action is regarded as behaviour which is aligned with the individual's interpretations. Acting on and interpreting the actions of others cannot be separated. They coevolve during an interaction process and the reasons of an action are shown through the action itself (reflexivity of ethnography) (Krummheuer 1995). Re-constructing a scene through interaction analyses means re-constructing how people act, interpret the action of others, and act on.

Ideal types (see Weber 1921, 1922; Gerhard 1991; Kaiser 1999; Kluge 1999) are core concepts of the theory of interest-dense situations. They comprise of uncovered connections, they structure observed phenomena and in the end are linked and assembled. Building ideal types means grouping all interest-dense scenes according to maximum similarity within a group and maximum differences between the groups. (Bikner-Ahsbahs 2003b) Ideal types are considered to be concepts which are developed by constructing an additional pure case (situation) for each group. Pure cases are constructed through *idealization* of the network of features which characterise the group so that

- the pure case can be included into the set of accepted real cases of the group,
- the pure case can approximately be described by the real cases – so called prototypes – in the set and
- all aspects which disturb consistency are excluded. (Bikner-Ahsbahs 2003b; see also Schreiber 1980).

This paper will now focus on mathematical valence of interest-dense situations. The question posed is in what way value constructions and value assignments contribute to the emergence and stabilisation of interest-dense situations and how mathematical valence of interest-dense situations can be theoretically conceptualised. I will present a prototype scene of the ideal type of a "product check" to illustrate an interest-dense situation. This example will also assist to illustrate the partial theory about mathematical valance of interest-dense situations in more detail.

4 Product check – an ideal type situation

Ina has just presented her idea about the way she would divide fractions: "leave the first fraction and turn the second one round". The class had previously developed a more complex rule for dividing fractions and now they start to test the new one. The students have begun looking for counter examples but even strange examples seemed to confirm Ina's rule. Afterwards, they continue testing the rule at another level, the level of operations: they compare it with the rule for multiplying fractions. The following scene shows that Kira is a bit confused because the new rule of dividing fractions could also be understood as a rule for multiplying fractions.

Testing on an operational level

597 /Kira: yeah but you times it and not divide, don't you
598 /S.: yes but the result Kira
599 /S.: yeeaah but
600 /S.: but

601 /S.: Kira you do it before then with the first thing (.) as well
602 T.: Anji
603 Anji: yes you turn the last fraction ROUND if you don't want to turn it round then you would have to DIVIDE and if you TURN it then you can TIMES it and then you get the same.
604 /S.: I see
605 /S.: yes
606 /S.: Mr. Kramer
607 Kira.: you could turn the first fraction round, too
608 T.: eh are you allowed to turn the FIRST one round'
609 /S(s).: yes
610 /S(s).: no
611 T.: Kira says you could turn the FIRST one round
612 /S.: but that doesn't work
613 /S.: it does
614 /S.: it doesn't work
615 /S.: it does

Transcription key	
S(s), T	student(s), teacher
EXECT	emphasized or with a loud voice
e-x-a-c-t	prolonged
exact.	dropping the voice
exact´	raising the voice
,exact	with a new onset
(.),(..)...	1, 2 ... sec pause
(....)	more than 3sec pause
(*gets up*)	nonverbal activity
/S	interrupts the previous speaker

This transcript shows a scene of an interest-dense situation: All participants are concentrating on the epistemic process and one after the other student presents aspects which further develop (lines 598, 601, 603, 607, 612-615) Kira's contribution (line 597).

Using examples the students' tests have shown that even with critical cases the new division method seems to lead to correct results. Now the new rule is investigated at an operational level. If it is a division method what actually will be the difference between this method and the multiplication method, for "you times it and not divide, don't you" (597)? Anji considers the first method as the division method (603). Ina's way of dividing is more a kind of option: If you are willing to turn the last fraction round then you will be allowed to "times it", if you are not willing to do so then you will have to divide as you did before. The new method is not seen as a further developed way of dividing but as a second option which you are allowed to use if you want to.

This checking process is not finished yet. The division method turns into the object of investigation now (see Cobb & Yackel 1996, p. 476), for "you could turn the first fraction round, too" (607). Obviously, the students do not really agree that this is possible and they do not explain why exactly the last fraction has to be turned round. Using another example the students test whether it is possible to turn the first fraction round instead of the second one before multiplying and what will happen if they do so.

Within an ideal type situation of a product check the difference between multiplying and dividing would have been investigated more deeply but this is not the case during this prototype real situation. The students here just agree commonly that this never would lead to the division of fractions because results would be incorrect. Dividing fractions means turning the second fraction round and not the first one. Thus, they accept Ina's idea.

The episode ends as an evaluation situation. Part of it is presented by the following scene:

Evaluating Ina's Idea

684 Anji: well I would rather take times
685 Caro: yes me too
686 /S.: me too
687 T.: yes
688 Lea: then I would rather reduce (the fraction) there again
689 S.: yes you may take times again then
690 Caro: somehow that is much easier

The collective testing process leads to a collective evaluation process. The students seem to agree that Ina's method is the easier one. Even reducing fractions is accepted. But some uncertainty seems to remain for "somehow that is much easier" (690). It is not just easy but *somehow* easier. It is not really clear in what way it is easier. Probably the students have not thought deeply enough about the reason why the second fraction has to be turned round.

Ideal type characterization of a product check

Right from the beginning the students participate in a product check by constructing and reconstructing Ina's idea. This ensures clarity about the object of the test. While testing Ina's idea from all conceivable perspectives through the use of examples the students struggle with the question whether this idea should be accepted. Consequently, they compare and value the method in question with alternative methods. Hence, during an ideal type situation of a product check a valuable mathematical idea is thoroughly proved before it is accepted. During this process students can present themselves as creative inventors of counter examples or questions, as discoverers of uncertainties (597, 607), as researchers for answers (598, 601, 603), as quality controllers, as evaluators (689, 690), or even as someone who is able to either prove or disprove a statement.

Comparison with the ideal type of an innovatory idea production

In a product check the students do not struggle with the development of a new idea as they would do in the ideal type of an "innovatory idea production". Instead, they test the developed idea. An innovatory idea production begins with contradictory positions which are overcome by a new view, a new concept or a new meaning of a known word. The new view is not simply taken for granted. Students learn to think and speak in a changed way by cautiously using and getting used to the new thing. In the data such a situation emerges when struggling with the German word[2] "Bruchzahl" (which can be translated as *fraction number* meaning a positive rational number represented by fractions). Before, the students have come across different fractions which represent the same positions on the number line. However, numbers have been known as natural numbers and now the question is what kind of numbers "Bruchzahlen" mean. Some students guess these numbers are just (natural) numbers used as nominators and denominators of fractions. Others think "Bruchzahlen" are natural numbers that are fractured and a third group would like to exclude prime numbers from the discussion. After a student has stated that fractions are made of natural numbers the discourse concentrates on the question how fractions can be made of natural numbers. The final idea is that "Bruchzahlen" indicate a new number concept on the number line while the terms "Bruch" (fraction) and "Bruchzahl" (fraction number) have to be distinguished: The "Bruch" (fraction) is just a name of a "Bruchzahl" (fraction number) just like the *person* Kris has the *name* Kris.

In this episode students can position themselves as creative questioners, conceptual thinkers, as defenders of a familiar view or as someone who produces ideas to overcome contradictions or as somebody who is already able to work with the new view.

5 Mathematical valence of interest-dense situations

While recreating processes of constructing values I uncovered a network of conditions which seem to provide the basis of the social genesis of mathematical valence within interest-dense situations in the class. Single cases were analysed first. They show that all interest-dense situations turn into an evaluation situation in the end (lines 684-690). Valuable mathematical ideas are acknowledged and, thus, the performance of the idea producers and vice versa (Ina and her idea). This means acknowledgement of idea products is at the same time acknowledgement of idea producers and vice versa. Hence, there is a value interdependence between idea products and idea producers. The question now is how these concluding effects of value are prepared. Analyses of the preceding processes show that the explicit acknowledgements at the end of interest-dense situations are not the only situations where value is assigned. They are preceded by implicitly uttered or interactively generated value constructions. Most of these interactively generated assignments of value emerge during a process of mutually increasing emotion and value reactions. What conditions lead to these value constructions? How are interaction processes which are initially tied up with concentrating on the creation of valuable mathematical ideas then turned into idea products?

A value complex of producing one's own valuable mathematical ideas is able to tie up und advance collective interactions. The basis for this is an implicit social contract: students produce their own mathematical ideas and the teacher organizes and

[2] It is a particular feature of the German language that "Bruch" and "Bruchzahl" have to be differentiated in maths lessons.

orchestrates the process to enable the students to do so. What are the characteristics of such a process?

Two different types of moderate indistinctiveness are basically accepted during these processes: moderate indistinctiveness of meaning and moderate indistinctiveness of participation which means that the official discourse is accompanied by spontaneous reactions during the process. The acceptance of indistinct meanings (e. g. the interpretations of the term "Bruchzahl") enables students to relate their individual ideas more easily back to preceding contributions and to expect acceptance of their own ideas. In addition, the acceptance of moderate indistinctiveness of participation (see lines 597-601) enables the students to express their emotion and value relationships spontaneously (see 684-690) and to position themselves within the processes concerning mathematical objects (e. g. 603) without any request by the teacher. Parallel to this the official discourse proceeds but takes up spontaneous utterances as well (608). These conditions shape a support network for the development of value specific relationships to mathematical objects, hence, individual interest. Students may express their own ideas spontaneously and without repressions. Therefore they feel encouraged to produce further ideas. They take up, create, develop and build upon other ideas. Thus, they become active participants in the production of valuable und useful mathematical ideas, so called idea products. They experience competence and autonomy within a social context. At this time they have the opportunity to present themselves and their relationship to mathematics in a visible way and to try out what it feels like to act in an interest-based way. The question now is how these relationships are presented and how they are connected to the prevailing situations.

This question was investigated by comparisons of all interest-dense situations in the sample. Based on the extracted results these situations were grouped with regard to minimal differences within the groups and maximum differences between the groups. This grouping process led to four groups each with varying features. The next step was the construction of ideal types for every group. These ideal types (idea contest, innovatory idea production, expert show, product check) – so called production types – describe different kinds of mathematical idea production, different kinds of person-object-relationships and how they offer different opportunities for students to participate within mathematical activities. This means they form different potentials for students to participate in an interest-based way. Mathematical valence can now be seen as the potential of a situation to initiate interest-based actions in mathematics and production types can be regarded as different qualities of mathematical valence. In short, an *idea contest* offers the opportunity to participate in a playful contest of producing mathematical valuable ideas, an *innovatory idea production* offers the opportunity to overcome contradictory views in order to work out und prove new perspectives, in an *expert show* the students prepare themselves according to a special question and meet again as experts and in an *product check* a mathematical idea is thoroughly tested before it is accepted. Thus, production types offer different opportunities for the students' preferences to participate in a mathematical activity.

6 Concluding remarks

Production types describe different qualities of mathematical valence, i. e. different kinds of potential to initiate interest-based relationships. Theoretically, these kinds of potential would be fulfilled if these idealized situations of producing valuable mathematical were made real. This is, however, not normally the case. Nevertheless, the comparison of the ideal type and the real situation enables the researcher or the observing teacher to find out the conditions that hinder fulfilling the potential to initiate interest development. The above prototype situation of a product check approximately fulfils this potential but there is a difference to the ideal type of a product check. This difference is due to the way the teacher avoids to further support this process: The teacher accepts the students' last contributions as sufficient and so ends the process. Thus, the students do not experience the two division rules as being equivalent.

In interest-dense situations production types are generated approximately. That is not the case in non-interest-dense situations: The genesis process of a production type is partly hindered by the unwillingness to accept indistinct meanings. Scenes in the data show that the teacher hinders the emergence of these processes by forcing the students to use precise words before the interaction process may continue. This preciseness of words disturbs the flow of ideas and prevents the students from presenting their own ideas. Thus, students do not contribute as much as they could in the development of an idea product. It seems as if students are either able to focus on the construction of ideas or on a process of stating words more precisely. Therefore teachers can support the emergence of interest-dense situations if they accept indistinct explanations at the beginning of developing mathematical ideas and if they show confidence in the students' abilities to work these ideas out.

Different production types offer different ways to shape the situation and to participate in the production of valuable mathematical ideas. Different production types appeal to different students. Slow but cautious students primarily shape product checks. Creative students who are easily able to create new ideas are likely to participate during an idea contest. Concept oriented students are more involved in innovatory idea productions. And students who think things through in-depth before they come out with their results prefer expert shows. Therefore, lessons which include different ways of producing mathematical valuable ideas foster interest, hence, intrinsic motivation of many students in the class.

Evaluation of the developed theory from the perspective of psychological interest theories suggests that students who participate in interest-dense situations in an active way experience competence, autonomy and social relatedness. Therefore, the students' interest is caught, then held, and, hence, their interest in maths is developed, further developed or stabilised. Nevertheless, the theory about interest-dense situations as it is worked out so far does not answer questions about the impact on individuals who participate in these situations. This has yet to be investigated. Further research should lead to a deeper integration of these individual processes in the theory of interest-dense situations in order to bridge the gap between practical situations and research findings of psychological interest research.

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