TURNING DISINTEREST INTO INTEREST IN CLASS: AN INTERVENTION STUDY

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This paper presents an intervention study in three 11th grade classes on calculus with the aim to overcome the students' amotivation by boosting their situational interest. This was successfully done by teachers implementing interest-dense situations. Data analyses further revealed two different principles of how the teachers transferred the theory on interest-dense situations into practice when arranging the epistemic processes, and two directions of dissemination that the teachers undertook additionally.

INTRODUCTION

Though the contribution of interest to performance in mathematics is not so clear (OECD 2004), implementing learning mathematics with interest in school is relevant for at least two reasons: (1) learning mathematics with interest prevents students becoming amotivated, hence, overcoming a significant obstacle to learning mathematics, and (2) interest can be regarded as the driving force for learning mathematics in self-determined and in-depth ways, since "interest and enjoyment of particular subjects […] affects both the degree and continuity of engagement in learning and the depth of understanding reached" (OECD 2004, p. 117). But what are the didactic tools that teachers can use to plan and implement math lessons that support learning mathematics with interest? This question will be answered by presenting a qualitative intervention study as a case study on how a group of teachers solved motivational problems in their 11th grade classes by the use of the theory of interest-dense situations (briefly expressed as IDS) (Bikner-Ahsbahs & Halverscheid, 2014). Since IDS has not yet proven its applicability as a teaching tool, this intervention study had two aims: to solve the practical problem of increasing learning with interest in math classes and, through that, to prove the applicability of IDS in practice.

THEORETICAL BACKGROUND

Interest in mathematics is a relationship between a person and mathematics (Krapp, 2002) that can appear in two forms. (1) Situational interest is triggered by situational conditions, and may vanish if these conditions dry down. (2) Personal interest is a long lasting kind of interest that, independent of situational conditions, students bring with them into the class. Mitchell (1993) has worked out a concept of situational interest that later Hidi and Renninger (2006) have identified as a step towards the development of personal interest. Personal interest in mathematics is shown by epistemic actions leading to increased knowledge, being accompanied by positive emotions and placing high value on mathematics (cf. Krapp, 2002). Situational interest (Mitchell, 1993) is triggered by the situational conditions. It is relatively easy to catch situational interest in class, but difficult to hold it. Interest can be held if students experience themselves as being *involved in the mathematical activity* which is *meaningful* to them (Mitchell, 1993). Research on Self-Determination Theory (Deci, 1998) has shown that the experience of three basic psychological needs of competence, autonomy and social relatedness support interest development. Thus, fostering learning with interest in class means arranging lessons that support fulfilling these needs. But what do these arrangements look like? Psychological research on interest does not answer this question.

IDS (Bikner-Ahsbahs & Halverscheid, 2014) is a theory of learning mathematics that results from a paradigm shift, merging the concepts of situational and personal interest and turning them into the social-situational concept of interest-dense situations. An interest-dense situation is shaped by social interactions in class. It may appear within an epistemic process of solving a mathematical problem exhibiting three features: The students are deeply involved in the mathematical activity (*involvement*), they construct mathematical meanings in an in-depth way leading to deepened insight (*positive dynamic of the epistemic process*), and they value highly the mathematics at hand (*value attribution*). Research on interest-dense situations has disclosed how these situations may be arranged (Bikner-Ahsbahs & Halverscheid, 2014; Bikner-Ahsbahs, 2004a; 2004b; Stefan, 2009). Some of these conditions are now briefly described:

- *Involvement*: The teacher follows the students' line of thought, the students are focused on their own train of thought.
- *Dynamic of the epistemic process*: The epistemic process comprises three epistemic actions: gathering and connecting mathematical meanings may - if adequately arranged - lead to structure-seeing; for example, this may happen if students first collect examples or ideas (gathering), then relate them to each other (connecting), and finally search for patterns of these relationships (structure-seeing) where a structure is regarded as an entity made of the relations among pieces of knowledge. In every interest-dense situation the epistemic process leads to structure-seeing, i.e. perceiving a new structure or a familiar structure in a new context.
- *Value attribution*: The teacher's and the students' behaviours are based on a didactic contract: the students act as authors producing valuable mathematical ideas, and the teacher acknowledges the students' authorship and fosters such processes, for example assists in finding suitable words, naming mathematical products concerning the original author such "Emma's rule".

Stefan (2009) has researched interest-dense situations concerning how grade 2 students investigate a dice of 1 million cubes. She has identified specific kinds of participation patterns indicating forms of situational interest, such as being interested in theoretical considerations, or being interested in accurately working with dice to build a dice of 1 million.

METHODOLOGICAL CONSIDERATIONS

Applicability, hence, the relevance of IDS, is proven by an intervention study in the math classes of the SINUS-Set teachers in Nordrhein-Westfalen (Germany), who wanted to solve motivational problems in their 11th grade calculus courses. The study was conducted to answer the following questions: a) Do the intervention lessons exhibit interest-dense situations (as described above)? b) How did the teachers organize and conduct the arrangement in class to implement interest-dense situations (i.e. concerning the three features: involvement, dynamic of the epistemic process, value attribution)? c) Did the teachers solve their motivation problem? What kind of indicators can be found? d) Was the experience with IDS disseminated? If yes, how?

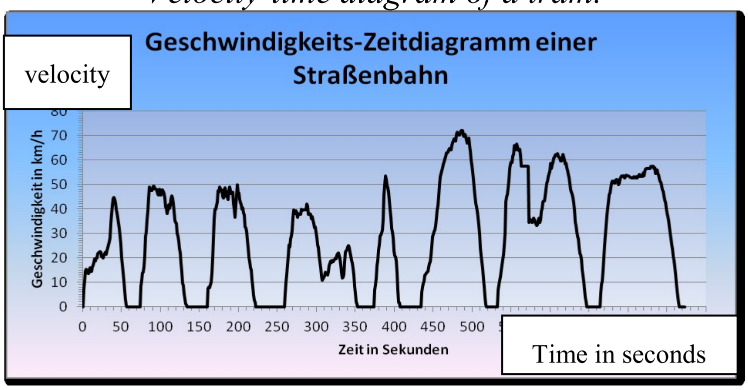
For that, the teachers first were trained in the use of IDS. That was done by a workshop dealing with transcripts of typical interest-dense situations, their specific kinds of social interaction, teacher behaviour and student involvement, the specific epistemic processes and different ways of arranging the epistemic process by means of the epistemic actions model. Moreover, examples of value attribution were presented and discussed (Bikner-Ahsbahs & Halverscheid, 2014). Finally, some mathematical tasks were presented that have the potential to promote a progressive dynamic of epistemic processes. In addition, the SINUS-Set was provided with a summary of the theory of interest-dense situations with some practical advice, such as "interest in the students' learning supports students' interest in learning".

The intervention study comprised three steps:

Preparation: The SINUS-Set commonly planned two lessons for implementing IDS in their 11th grade classes. Two cycles of teacher-planning and researcher-revision were conducted before the teachers implemented the lessons: introduction of the definite integral and finding sufficient conditions on extreme and inflection points.

a) *Introducing the integral concept by application situations*:

Velocity-time diagram of a tram.



1) Find information from the graph and exchange them [in the group].

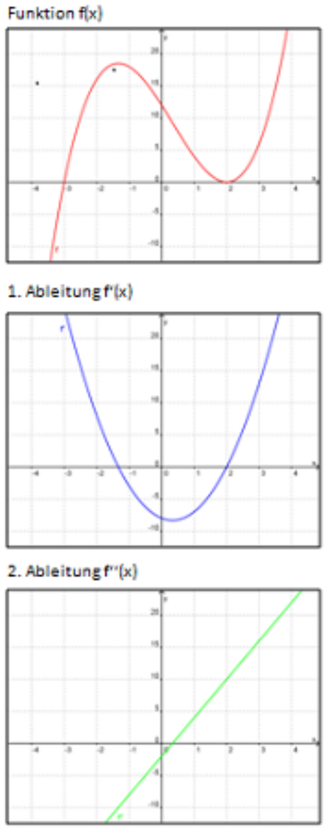
2) How far does the tram approximately drive between 435 sec and 520 sec and between 665 sec and 765 sec? Explain.

3) Prepare a poster presentation with your results. Every member of the group must be able to explain them.

Figure 1: Task example of introducing an integral.

The teachers prepared similar tasks (cf. Figure 1) of seven different application situations which all had the same idea in common: Through converting the area under the graph within an interval into a rectangle, a quantity can be estimated which later is called definite integral.

b) *Particular points of functions*: The teachers prepared the same tasks for seven different functions f (Figure 2), hence, for seven groups of students. Their planning encompassed three phases: Phase 1: Gathering information with the help of graphical representations to create conjectures and some first connections (Figure 2, (1), (2)). Phase 2: connecting mathematical meanings by comparing and contrasting the findings of the groups of students to revise hypotheses (Figure 2, (3)). Phase 3: structure-seeing towards general features of the particular points based on the hypotheses gained.



Task:

(1) Transfer these graphs onto your poster. Use the same colours as the ones in the pictures.

(2) Find correlations among the three graphs. Be aware of the particular points. Formulate these correlations in brief sentences as hypotheses. Find logical substantiations for your hypotheses.

(3) Check your hypotheses by looking at the posters of the other groups. Change and make your sentences more precise if necessary.

(4) Write those sentences that after your revisions seem right and valuable on DIN A4 paper sheets, so that it is well readable by the others.

Figure 2: Example of the tasks about particular points of function graphs.
Legend: f (red), f' (blue), f'' (green)

Implementation and data collection: Two teachers implemented the same lesson on particular points (nulls, extreme and inflection points) of functions (Figure 2) in their calculus ground level courses, and one teacher implemented the lesson of introducing the concept of integral (Figure 1). In order to answer the questions a), b), c), the three lessons were videotaped recording the group work and the whole class situation. To answer the questions c), d), a written interview with the communicator of the SINUS-Set took place.

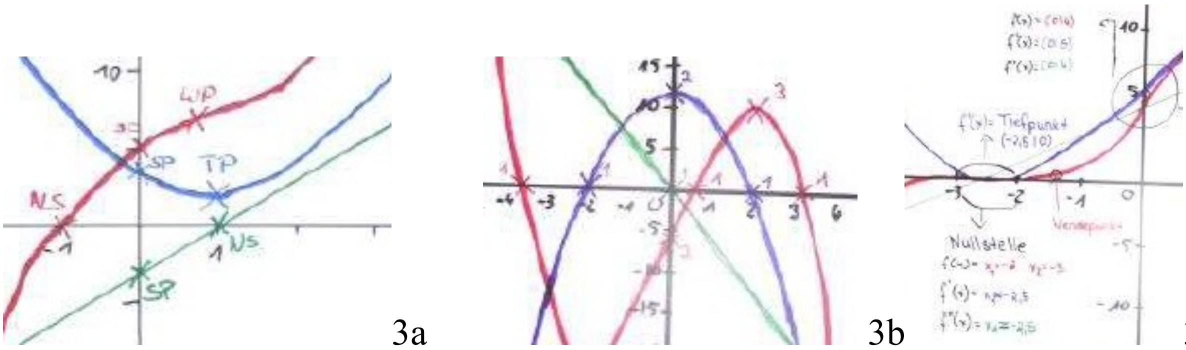
Analyses of the video data: First, the video was reorganized by episodes that were rated according to the features of interest-dense situations. Second, data analyses were carried out observing and interpreting the video episodes several times ac-cording to the tools of IDS. Each time, the researcher decided whether and then reconstructed how the episode shows *deep student involvement, positive dynamic of the epistemic process* and *value attribution*. Third, the epistemic process was analysed according to the epistemic actions model to obtain phase diagrams (Bikner-Ahsbahs, 2004b; Figure 5). Finally, the communicator of the SINUS-Set was interviewed to validate whether the intervention had boosted interest and how the experiences were disseminated.

DATA ANALYSES AND SOME RESULTS

I will now reduce the description of the analyses to the lessons on the particular points of the function graphs and their first and second derivative. The two lessons were arranged in the same way: In groups of four, the students gathered mathematical meanings on their tasks, connected them in order to prepare initial substantiated conjectures and poster presentations thereof (Figure 2. (1), (2)), second revised and improved them (Figure 2, (3)) and third, a class discussion led to structure-seeing.

Involvement: Through the whole process, the students followed their own way of thinking. Within the group work they gathered ideas concerning the given particular points, shared them among the four students and created conjectures about the features of these points. When they compared their group results with those of the other groups written on posters, they systematically contrasted, checked, and revised their hypotheses: The students went to the board, showed their group mates their observations, and improved their findings. After that, the teachers asked the students to present and substantiate their final hypotheses and to hang the paper sheets with their hypotheses on the blackboard. The student audience critically checked and discussed the validity of hypotheses, valuing them as *generally valid, sometimes valid, invalid,* or *just in one case valid.* The teachers' behaviour was steered by the situation, in that they organized the discussion and visualized results on the blackboard but did not intervene.

Dynamic of the epistemic process (Figure 5): During the group work (phase1), initially gathering actions took place leading to building conjectures (connecting). The teachers assisted the groups in organizing and expressing their conjectures. Phase 2 was a connecting phase: The conjectures were checked by comparing them with results shown on the other groups' posters (Figure 3). During this phase the teachers did not intervene and left space for revisions. Each conjecture was finally written on a paper sheet. Phase 3 was that of structure-seeing: The students presented and justified their conjectures to the whole class. The other students checked them. While grouping, the conjectures were hung on the blackboard, though not all the groups found substantial propositions. Figure 3 represents one substantial proposition (4a), a valid but irrelevant one (4b) and a special one (4c). Through a process of collectively reasoning and rearranging the hypotheses, a process of structure-seeing was organized resulting in sufficient conditions for inflection and extreme points of differentiable functions (4a).



3a 3b 3c

Figure 3: Poster presentations of three working groups (WP, Wendepunkt (inflection point), TP, Tiefpunkt (minimum point), Ns, Nullstelle (null))

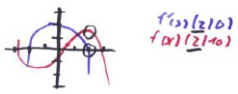
"the maximum point of f(x) is above the null point of f'(x)" Der Hochpunkt von $f(x)$ liegt über der Nullstelle $f'(x)$  4a	"all graphs have an intersection point with the y axis" Alle Graphen haben ein Schnittpunkt mit der der y-Achse 4b	"nulls are at the same time the inflection points" Nullstellen sind gleichzeitig die Wendepunkte 4c

Figure 4: Conjectures: 4a: generally valid, 4b: valid, but irrelevant, 4c: only sometimes valid

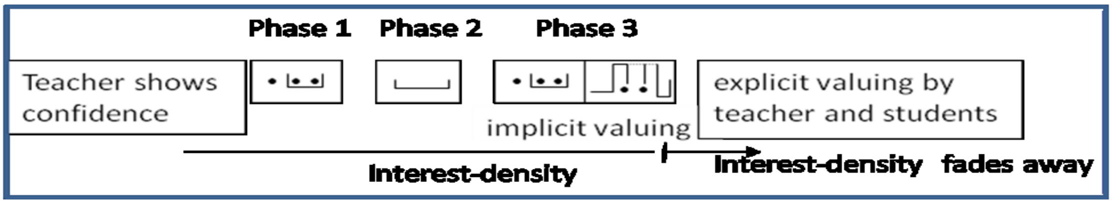


Figure 5: Phase diagram of the epistemic process expressed by pictographs (cf. Bikner-Ahsbahs 2004a; 2004b). Phase1: gathering-connecting, phase 2: connecting, phase 3: gathering-connecting, then structure-seeing

Value attribution (Figure 5): According to value attribution, the two teachers behaved differently towards the creation of valuable ideas. One of them started the lesson showing confidence in the students' capacity to solve the task: "I am curious about the up-and-coming lesson" she said. Her lesson took place in the late afternoon and lasted longer than usual. The students maintained their interest although the bell already had rung. In the end the teacher apologized and thanked them for their engagement. The students reacted by applauding and rapping on the table, hence, they highly valued learning mathematics this way. The other teacher acknowledged the students' engagement in a different way. He clarified the status of all the conjectures by arranging them according to the degree of validity; this way he valued every hypothesis by giving space for it and keeping it on the blackboard. In addition, he acknowledged authorship of valuable ideas. For instance, he asked a student to put his justified conjecture in the right place on the blackboard and finished the sentence by saying: "since you are the discoverer". Figure 5 represents the phase diagram of the epistemic processes including value attribution.

Answers to the three questions

All the three lessons show interest-dense situations. The teachers linked the features of IDS to the topic of their lessons in a substantial way. In the derivative lesson, the core principle was *finding hypotheses and working on them to obtain propositions*. This was done by preparing, revising and collectively checking the validity of conjectures as a three-step-design by means of taking gathering, collecting and structure-seeing as planning tools. The arrangement of the integral lesson was built around the core idea of a definite integral according to the principle of *framing it by different application problems in similar ways*: the estimation of a quantity by calculating an area under the graph of a function. This way, structure-seeing was arranged on two occasions: first, during the group work within each single application context, and second through seeing the same structure underlying other application contexts. (See also Bikner-Ahsbahs & Halverscheid, 2014).

The third question was answered by the interview with the teacher group's communicator. Main points are expressed by the answer to the subsequent questions: Did the concept of interest-dense situations help to solve motivational problems? How? Did you and your colleagues integrate this kind of teaching into other lessons, too? How?

> In all courses in which we tried out our teaching scenarios, all, really all the students be-came actively and very intensively involved in the mathematical activities according to their capacity. We had not expected this. For some students – especially the weak ones – the experience of discovering mathematics themselves within an atmosphere free from fear was an initial ignition. They took this positive experience as motivation with them into the subsequent lessons. In some schools, the developed teaching scenarios have been implemented as a permanent feature of the respective lesson series, slightly adapting them to the specific students, whereby they are thus repeated every year. (Own translation)

This answer indicates the teachers' surprise that they were able to turn amotivation in class into situational interest being held over time. Dissemination of the teachers' experience does not only take place within the teachers' schools, but also by in-service teacher training workshops that one of the teacher is offering: As he wrote:

> [...] That on the base of the concept of interest-dense situation it is possible to develop instruction scenarios leading to an active and markedly motivating lesson for the students independent of the mathematical content and its application, that was a helpful information for the participants of the workshops. Thus, during these workshops such scenarios were developed for further mathematical topics. (Own translation)

CONCLUSIONS

This implementation study has resulted in the new insight that amotivation in a class can successfully turn into learning mathematics with interest by tools extracted from IDS, and that teachers can successfully work with these tools to plan and implement interest supporting lessons. The teachers even have developed suitable transferable principles for the two types of structures to be seen: a concept and a proposition. Since applicability of a theory is an important criterion of the theory's relevance, this implementation study has shown the theory of interest-dense situation is of relevance for practice. However, although the teachers have already practiced some dissemination of IDS and Stefan has applied IDS at primary level (2009), it is not yet clear whether this theory also offers fruitful tools for other school levels or other countries. Larger implementation studies are needed to investigate to what extent the theory of interest-dense situation can be disseminated in practice.

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