EXTERNALIZATION AND INSCRIPTION IN A CHAT-ENVIRONMENT[1]

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Abstract:

Internet chat about mathematical tasks is a mode of problem solving which has not been used very much in schools, yet. In chat situations, the students are confronted with the fundamental issue of presenting their solving-attempts in a written or graphic form. This raises the opportunity to study the use of inscriptions as defined by Roth & McGinn (1998). We present here some results of a pilot study in which primary school students allocated in two separate rooms, solve mathematical problems by means of internet chatting, equipped with computers with touch-screens and the software Microsoft NetMeeting. The project is based on research methods of the Interpretative Classroom Research.

Kurzfassung:

Chatten über mathematische Probleme ist eine im schulischen Kontext bislang kaum genutzte Art der Aufgabenbearbeitung. Es stellt sich für die Schüler hierbei das grundsätzliche Problem der schriftlich-graphischen Darstellung ihrer Lösungsbemühungen. Dies eröffnet Möglichkeiten, mehr über die Verwendung von Inskriptionen im Sinne von Roth & McGinn (1998) zu erfahren. Es werden einige Ergebnisse aus einer laufenden Pilot Studie zum „Mathe-Chat" in der Grundschule präsentiert, in der Schüler in getrennten Räumen an Computern mit Touchscreens und der Software NetMeeting (Microsoft) mathematische Probleme via Chat bearbeitet haben. Zur Auswertung der Chat-Sitzungen werden Methoden der Interpretativen Unterrichtsforschung eingesetzt, die hierbei auch weiterzuentwickeln sind.

1 Introduction

With the advance of computer technology and the Internet new forms of communication have opened up for mathematics education. Internet chatting, one of these new communication forms, has received little attention so far, but it potentially offers new insights in fundamental problems of teaching and learning mathematics. There are several reasons for this:

First, and most important, chats have an *intermediate status* between speech and written text (Koch & Österreicher 1985; Achenbach 2002), the colloquial style of the written interaction is almost blurring the distinction between talking and writing. Second, mathematics seems to depend upon *written* forms of communication more than any other subject (Pimm 1987). Third, in contrast to writing down solutions in a notebook, which usually only the teacher will read, chatting provides students with a

[1] This study is supported by Müller-Reitz-Stiftung T009 12245/02

larger readership: students in another room, potentially another school. Thus there is a real incentive to formulate more clearly one's thoughts and externalize them.

We choose the chat setting to explore the genesis of *"inscriptions"*. Roth & McGinn (1998) describe them as scriptures, pictures, signs, graphs, lists and diagrams embodied in some medium, such as paper or computer monitors (see also Latour & Woolgar 1986). Verbal interaction between the chat partners is not possible, so the demand to externalize questions, hints and the solving attempts in the chat-box or the whiteboard is based on the development of common inscriptions.

More concretely we investigate:
- how pupils use and develop inscriptions for solving mathematical tasks,
- in which way the process of the common problem solving between chat-partners is structured by using these inscriptions,
- and how this structuring fosters the learning process.

Up to now we have focused only on the first issue.

2 Theoretical background

In recent years mathematics educators have advocated the necessity for pupils to fix their thoughts in written form right from the beginning of primary school. This is usually connected to proposals for a general improvement in mathematics teaching. The pedagogic backgrounds for such innovation of the mathematics primary classroom are diverse and they are often not worked out in much detail. They include a *reform-pedagogical* approach ("plan of the week", "journal writing"), a *cognitive psychological* approach, and an *interactionist* approach (written communication).

Most of the mentioned approaches consider writing as part of a *method* of teaching. This specific application is supposed to enhance pupils' production of their own inscriptions on the basis of appropriate mathematical subjects (Selter 1993). Writing constitutes an integral part of mathematical communication. Mathematics educators have argued that students' understanding would benefit if they were asked to fix their solutions in written form and reflect upon them (e.g. Morgan 1998; Pimm 1987). Fixing ideas in a written form changes their status and makes them more explicit and conveyable. One could say, 'private' thoughts are externalized into 'public' ones. According to Bruner 1996 this is called the "externalization tenet" (pp.24-25).

To characterize all these forms of children's writing we take the proposal from Roth & McGinn 1998 and call it "inscriptions" (Latour & Woolgar 1986; Latour 1990). They describe several characteristics of inscriptions:
- Inscriptions are mobile, because they are recorded in materials and can be sent by mail, courier, facsimile, or computer networks.
- They are immutable during the process of moving to different places. Inscriptions remain intact and do not change their properties.

- The fact, that they can be made part of a written text, just after a little cleaning up, is described by Latour (1990) as one of the most important advantages of inscriptions.
- The scale of the inscriptions can be modified without changing internal relations.
- It is possible to superimpose several inscriptions of different origins.
- They can be reproduced and spread at low cost, in an economical, cognitive and temporal sense.
- Inscriptions can be merged with geometry because of the two-dimensional character. Latour (1990) mentions this advantage as the greatest one.
- Inscriptions can be translated into other inscriptions, creating *cascades of inscriptions* (Latour 1990)

Interactionist approaches claim also a possible structural problem with regard to inscriptions arising from the narrative structure of explanation and argumentation of primary students in mathematics (Krummheuer 1997; 2000). The inscriptions of elementary school children do often not represent their narratively structured solving process. Furthermore, there is the question of how to include these own original works into the whole class discourse. Written work is often treated as a finished individual product, rather than as a new starting point that could be further developed during the lesson in a systematic way for the whole class.

From an interactionist view of learning, the emphasis on writing should be foremost on the *process* rather than on the finished *product*. In classrooms, two different processes could be differentiated. First, the *creation* of a text, either done individually or collectively, consists of drafting, editing and polishing up, etc. Second, the *utilization* of the created text at a later stage, where, for example, the text is read out to the whole class, written down on the blackboard, or is inspected by the teacher. Although this second aspect is a frequent feature in language teaching, it is rarely employed in mathematics teaching.

Externalizing one’s thoughts is a special cognitive challenge. The goal of externalization is not to produce a standardized, finished, scientific product, but to encourage children to find their productive forms of written presentation of their thoughts and ideas (Krummheuer 1995). In mathematical problem solving processes this typically includes ways of explaining the results of an investigation in written form.

We would like to stress on some theoretical topics, which have to do with externalization and inscriptions. According to Hughes 1986 one could differentiate the inscriptions that had been accomplished by the pupils of the two examples along the categories "idiosyncratic representation", "pictographic representation", "iconic representation", and "symbolic representation". One also could try to adapt different systems of categorizations, which depart from semiotic studies about inscriptions. In this context we are still looking for appropriate proposals. Specific to our approach is to focus on the process of the genesis of a single inscription: In a chat-based dialogue through their alphanumerical and/or graphic notations pupils externalize parts of their momentary ideas. They get reactions and by this way of interaction their inscriptions turn into conventionalized notations which carry a shared meaning among the internet-chat-participants.

Internet chatting might support the process of *creating* a text, while turning it into an interactive and collective one. The distinction between the writer and the reader evaporates and gets replaced by the process of collaboratively producing a text. As the chat dialogue is already in electronic form, the utilization of the text at a later stage is facilitated. Furthermore, at both stages there is a real readership for students' writing – in contrast to a lot of writing in mathematics classrooms that is only for the sake of the teacher and therefore not necessarily 'purposeful' for students (Morgan 1998).

Our methodological approach grounds on the analysis of interaction as developed in projects by Bauersfeld, Voigt, Krummheuer (see their articles in Cobb & Bauersfeld 1995). This procedure, however, needs to be adapted to the specific features of an internet-chat. Here we are at the very beginning. In this paper we are concerned mainly with the inscriptions of pupils produced on one side of the chat setting, while being involved in a chat conversation. Up to now we paid only few attentions to the interactive aspect of the internet chat.

3 Organizational aspects of the pilot study

In order to provide an appropriate setting for the pupils to communicate via chat, we use two portable computers with touch-screens and wireless connection. Using the software Microsoft NetMeeting the pupils have the possibility to write in the chat dialogue box and to draw in the whiteboard frame. All these activities on both computers are recorded with the software Camtasia – Studio (Tech Smith). Furthermore the communication of the pupils working together on the same computer is saved with an embedded digital voice recorder of the computer.

Within the technical setting we are interested to arrange the following chat-constellations:

Chat constellation	1 pupil ⇔1 pupil	2 pupils ⇔ 2 pupils	1 pup.⇔teacher.-stud.	2 pup.⇔teacher.-stud.
Series I Sept./ Oct. 2002	4 sessions 3rd example	4 sessions	4 sessions	4 sessions 1st example
Series II Jan./ Feb. 2003	4 sessions 2nd example	4 sessions	4 sessions	4 sessions

We cooperate with teachers of different primary schools in Frankfurt. The pupils are nine and ten years old. In a first contact with this field, we conducted some experiments corresponding to the grey colored cells in the table above.

4 First empirical findings

In this section we would like to present some preliminary results in order to demonstrate how the chat dialogues and especially the whiteboard pictures have been created and used. This gives some first insights into the (interactive) genesis of pupils' externalization.

In all the three examples shown below the pupils were given the following task: "*Natalie has 10 animals. They are canary birds and guinea pigs. Together they have 26 legs. How many animals does she have of each kind?*"

In the first example two children are working together on one side of the chat setting. These two pupils appear in the chat dialogue as only one partner called MAXI. They are connected with a second computer via chat, at which a teacher-student is "helping" them by monitoring the process of their externalization on the computer screen. (For the chat setting see table above.)

In several trials the pupils draw animals counting them and counting the legs. They delete animals to reach 26 legs, but so the number of animals does not fit with the task. One pupil comes up with the insight that one reaches more animals while keeping the number of legs when one trades a guinea pig for two birds. Then his partner commences to think aloud about the solution having got this new hint.

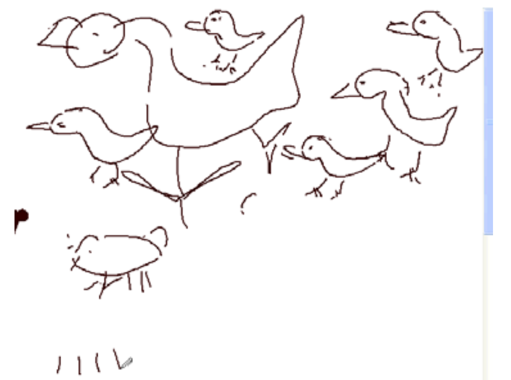

Fig. 1

After a short discussion the pupils decide to start a new drawing in another whiteboard section. They begin to draw birds. After drawing 6 of them, they stop because one of the pupils claims that this might be enough birds and he starts painting guinea pigs. From the second guinea pig on, he changes the procedure of painting these animals. So far, he always started with the painting of the body, now he begins with the legs (Fig. 1). In a kind of trial and error combined with estimations about how many guinea pigs or canary birds they still have to paint, they produce one picture after the other of guinea pigs or canary birds.

Sometimes they seem to lose control about their counting-activities. Possibly it is the unstructured order of animals and legs on the whiteboard that leads to this effect (Fig. 2). They are counting the legs one by one. It is the teacher-student participating all the time in these solving-attempts via chat who points out irregularities in their solution.

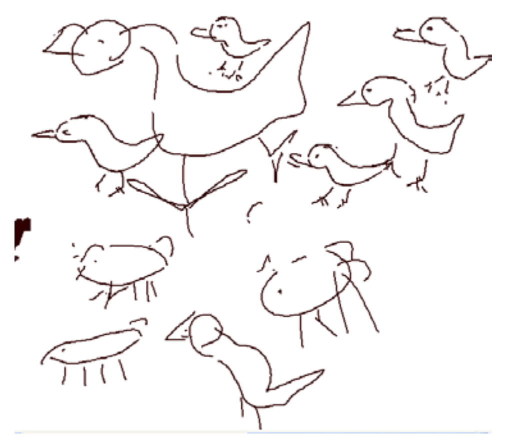

Fig. 2

At last the pupils find the solution, but they need the teacher-student reference to count one more time to discern their solution.

In the second example two pupils, called respectively with their nicknames "MARCO" and "FRITZ", are chatting with each other on separated computers about the same task of animals and legs. (For the chat setting see table above.)

We pay attention here on MARCOs side, because she introduces the manner of problem solving by painting the legs as tally marks and bounding them for animals. She has a few trials yet and after each trial she proposes to go back to the class. It is FRITZ who alludes to the common mistakes, but it is MARCO who goes on with a new attempt. Like in the first example, we start to describe when she begins a new trial in a new whiteboard section.

She is painting first the total amount of 26 legs, putting them together in five groups of 2 tally marks and four groups of 4 tally marks. Then she starts to bound this groups as provided in five 2-leged animals and three 4-leged animals. Counting the animals, she notices that her solution is not right, so she is going on with her trial. MARCO is aware of the right number of legs and the wrong number of animals. Instead of starting a new trial as she did before, she modifies her solution. She is changing a “4-leged animal” into two “2-leged animals” (Fig. 3; top right). So she gets the right number of animals without changing the number of legs. For the observers it was not easy to see this change, but MARCO is keeping track of her inscription. She changes the message on the whiteboard, K. 5/ M. 4 into K. 7/ M. 3 and confirms the solution in the chat box window.

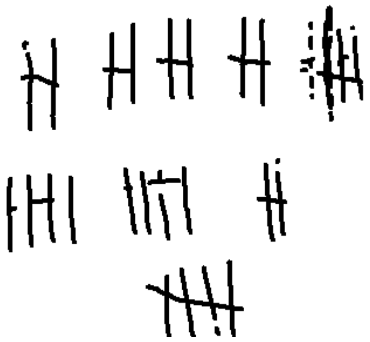

Fig. 3

In the third example two pupils, called respectively with the nicknames "JOJO" and "TIM", are chatting with each other on separated computers about the same task of animals and legs. (For the chat setting see table above.)

We pay attention here on JOJOs side of the chat setting, because he dominates and accelerates the process of solution. Immediately, JOJO tries to find a numerical solution. First he adds the digit 6 a few times as the sum of 2- and 4-legged animals. By this way he finds out that the number of guinea pigs and canary-birds can not be equal. He comes up with the approach of trading 2-legged animals into 4-legged ones. His self-talk is recorded on the hard disk.

In the meanwhile a chat-communication evolves with TIM. JOJO corrects several proposals of his partner. Just as in the first and the second example we will focus on the scene, when JOJO opens up a new whiteboard section.

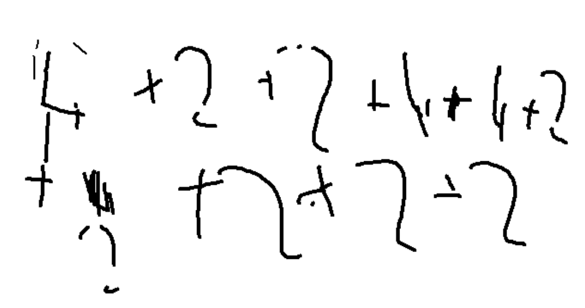

Fig. 4

After a 2-minute-period of thinking aloud, he begins to write down his considerations: he inscribes 2s and 4s in a row as a sum. From the 4th animal on he calculates provisional results. After putting down the 7th number he recognizes that there are too many 4s. As a consequence he substitutes a 4 by a 2 (Fig. 4; bottom left). Already here, before writing the last three digits, he predicts: *"... 20 ... and now ... plus 2, plus 2, plus 2! ... it's 26!"* So he writes the three digits down, and checks his solution by calculating again. He writes below his solution *"7 K. 3 M."* adopting the abbreviations *M.* (Meerschweinchen) for guinea pigs and *K.* (Kanarienvögel) for canary-birds from TIM, who used them in the chat-box before. JOJO comments: *"he has to understand it, too!"*

5 Conclusion

Comparing the reports of the three scenes, first we would like to focus on common aspects. In all cases the pupils first find intuitive approaches to solve the problem. Furthermore, the pupils recognize in each episode, that the relation between animals and legs changes if one trades one type of animal by the other one. They apply this insight productively: they can predict the outcome after putting down the first objects of their evolving inscriptions. So in all cases they end up with the right solution.

From our theoretical interest, we focus on how pupils are using and developing interactively their own inscriptions for solving the task. First we are going to talk about the practice bound to the inscriptions. Then we will stress on the interactional aspects:

MAXIs presentation is context-dependent, each animal is represented by a drawing and they choose a pictographic representation. The inscription is less clearly arranged, so that MAXI loses the overview. They carry out a solving attempt by counting animals and legs, without the advantage of addition or multiplication.

MARCOs presentation is also context-dependent, each leg is represented by a tally mark and the animals are represented by bounding them together. She chooses a graphical representation. The inscription is very clearly arranged and MARCO keeps track with the ongoing activities concerning the inscription. She carries out an arithmetical solving attempt taking advantage of the structure of her inscription.

JOJOs presentation is context-independent. He chooses a numerical (symbolic) representation. The inscription is clearly arranged and JOJO does not loose the overview, albeit he forgot to count the replaced digit. To do an arithmetical solving attempt stands to reason, because of using digits for his inscription.

Applying numerical inscriptions seems to make the specific problem solving process easier. JOJO can recognize easier, that he has to trade an animal by another, here one number by another, to find the solution. This is a decisive advantage to complete the list of animals quickly. JOJO recognizes the solution before writing the last three digits. It seems that JOJO is able to detach from the context and concentrate on the decisive aspects of the task.

Also MARCOs iconic inscription constitutes an advantageous way of solving this task. It is easier to change one animal for another one and it is self evident to avail the structure of the inscription to calculate the solution instead of counting.

MAXIS' pictographic inscription seems less effective to establish an easy way to find out the total amount of legs and kinds of animals. Here the chat dialogue serves in a more explicit way in order to negotiate the meaning of the produced paintings and the correction of the pupils' trials.

In the following we will draw the attention to the relevance of the chat partners on the other side in all episodes. There are differences between the episodes. We consider the different organisation of the chats, namely as pupil ⇔ pupil chat (2nd and 3rd example) in respect to a pupil ⇔ teacher-student chat (1st example), to be one of the reasons for these differences. The communication with the teacher-students is „faster" and often more extensive, which might be caused by their capability of using the keyboard. In all examples, however, it is obvious that the chat partners are perceived as such during the whole chat process.

In our first example it becomes evident for the pupils, that their chat-partners are observing their trials all the time. This was clarified by the teacher-students' feedback signals via chat box even if the pupils do not answer each time in written form. Furthermore MAXI sends their solution via chat to the teacher-students asking for a confirmation.

In the second example MARCO is communicating with her partner many times. They are chatting about details of the task and her partner comments her solutions. After confirming, she casts doubts on the solutions. This motivates MARCO to start new attempts or go on with the last one.

In JOJOS' case the whiteboard is used as a form of „piece of rough paper". He knows that he is communicating with his chat-partner, so he is aware of joining *his* piece of rough paper. He always notices the trials of his partner, especially the messages in the chat-box. It is clear that he is writing *for* someone else when he writes reaffirming the solution of the task below his addition. His message *7 K.* and *3 M.* is for his chat-partner and not a mnemonic for himself. JOJO adopted the abbreviations *M.* (Meerschweinchen) for guinea pigs and *K.* (Kanarienvogel) for canary-birds from TIM, who used them in the chat-box.

Usually the chat participants have to wait for answers a relatively long time: the chat-partners have to read the messages, they have to think about them - sometimes aloud - they have to formulate an answer - often verbally - and finally they have to write it on the keyboard or in the whiteboard frame. Spontaneous verbal reactions do not appear for the chat-partner as it happens in non-virtual working group settings.

Therefore the chat-partners might get the impression that the other one is lurking rather than actively participating. This occurs especially in pupil ⇔ pupil chat settings in the chat-box area. Something different happens with the whiteboard section: the activities of the partners appear simultaneously, so it is evident that the partners are working on the same whiteboard together.

However, when using the whiteboard, the chat participants are depending on each other. Changing the page will often cause a problem because it is not possible to use different pages at the same time. Changes at one side of the chat imply changes at the other side as well.

Our goal is to get a deeper insight into the relationship between the interactive development of inscriptions and the genesis of mathematical meaning. In order to reach this goal, we will attempt to obtain new and better material in other series of chat situations with similar tasks. This will hopefully allow us to make more general statements.

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