The Recontextualization of Inscriptions: an Activity-Theoretical Approach to the Transferability of Abstractions

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The unsolved puzzle of transfer

There is a strong believe today that a person's academic success significantly depends on this person's ability to apply his or her learning acquisitions in a variety of new, often previously unseen situations (see for example Yamnill & McLean, 2001). Connected to this believe there is a widely spread feeling that the growing body of knowledge and the increasing complexity of problems in our modern world makes it impossible to learn individual solutions or responses for a possibly infinite number of specific situations. The cultural evolution calls for strong and flexible learning outcomes that can be easily transferred to a variety of new situations.

Despite the urge for transferability of learning results and frequent manifestations of transfer in everyday life, the mechanisms behind this transfer are still far from clear. Even young children appear to be able to transfer their available vocabulary to new previously unseen situations. A child that is saying "mam" to all new women is transferring one of his or her meanings to new situations. The fact that we take this as a mistake in our culture demonstrates that our culture sets constraints to the acceptability of transfers, but is not a denial of the phenomenon of transfer itself. On the other hand, there are numerous examples that a person cannot or does not use obviously available knowledge in new situations where it would have been quite appropriate to apply it. Take for example the situation that eleven-year-old pupils could calculate the speed of a car, when time and distance are given. On the other hand they couldn't answer the question how many kilometers per hour their hair grows (not even approximately).

There is no doubt that transfer can occur under specific psychological or contextual conditions. So there is no dilemma –as some researchers seem to suggest, see Carraher & Schlieman, 2002- between rejecting or accepting the possibility of transfer. The essential problem is rather why is transfer occurring in some situations, and does not occur in others. Which mechanisms are behind transfer and its occasional non-occurrence?

To date, the phenomenon of transfer is still an unsolved puzzle, despite the many theories that are available for the explanation of transfer. In this article I will argue that many transfer theories to date are insufficient as they focus exclusively on the conditions for transfer and define transfer merely on the basis of result qualities. In most transfer studies it is just a conclusion that transfer has taken place after establishing the use of previously acquired learning outcomes in new situations. This doesn't yield, however, a positive definition of

transfer itself. As an alternative I will address the puzzle of transfer from an activity theoretical point of view and try to demonstrate that transfer is related to the qualities of human action itself.

Transfer and abstract concepts

One of these theories ('the common elements theory', see De Corte, 1999) states that the occurrence of transfer is a function of the number of elements that different situations have in common: if different situations are similar (many common elements) the odds for the occurrence of transfer are high, if the situations are extremely different (low level of common elements), the chances for the occurrence of transfer are low. Recent developments of this point of view have argued that transfer is even better when the communalities between situations consist of structural (rather than superficial) similarities between situations (see Gentner et al, 2003).

A recent elaboration of this theory states that abstractions can positively mediate between situations, as they designate core elements that are shared in a number of situations, and are distanced form specific characteristics (Fuchs et al, 2003). As such abstractions can articulate what different situations have in common, they can mediate between the problem solver and new situations to which the abstractions appear to be applicable. In those cases, abstraction can be said to enhance the transfer of previously learned knowledge or abilities, on the basis of the perceived analogy between situations (Reeves & Weisberg, 1994).

Many studies on transfer and abstraction try to figure out if there is a correlation between learning outcomes through involvement in specific situations (conditions) and the occurrence of specific outcomes in analogical situations (transfer). However, even if there is a positive correlation between the conditions of learning and the occurrence of transfer, there is still no way of knowing how the students did see the analogy between the situations, or how they abstracted the relevant information from the various situations: is it a perceptual process of seeing structural similarities, or affordances? Is it an associative process that triggers the same strategies in the situations encountered? Is it a cognitive process of conceptualizing situations and recognizing structural communalities that call for the same strategies of operating?

One of the candidates for this answer is the theory of transfer through abstraction. This theory, however, runs into serious theoretical problems on closer scrutiny:

- Abstraction through focusing on communalities winds up in serious *epistemological problems*, as the process of abstracting on abstractions finally leads to void categories. As Fuchs et al., (2003, p. 294) formulate: "In formulating an abstraction, an individual deletes details across exemplars, which are irrelevant to the abstract category (…). These abstractions are represented in symbolic form and avoid contextual specifity so they can be applied to other instances or across situations". When accumulating abstractions on abstractions (as happens in science) this must lead to lesser and lesser content in theories. Cassirer (1953) already pointed out that this is inconsistent with the enriching process of abstracting in science (see also Bolton 1978, van Oers, 2001);
- Abstraction is assumed to be related to a process of *decontextualizing* which is supposed to lead to higher-order knowledge that can be applied to several situations; however, decontextualization basically means drawing the context away and this suggests that the outcome of a process of abstraction can exist without context, without relation to human activity, without social interaction or separate from goal directed tool-use. Context is always necessary for the attribution of meaning to all human artifacts; as a consequence decontextualization means reducing the meaningfulness of human artifacts (see van Oers, 1998a ; 1998b). If abstraction were based on decontextualization is does not only lead to void categories (see previous point), but also to meaningless constructs (which is essentially the same conclusion on psychological grounds as the previous logical one).

If transfer is to be based on abstracting processes we need a more detailed view on abstraction as a psychological process.

Substantial abstractions and transfer

In the 1970s Davydov criticized Vygotsky's view on abstraction because of its formal nature. Vygotsky's notion of scientific concepts is grounded in his analysis of the systemic properties of meanings that derive from treating words as decontextualized entities. Vygotsky's view on abstraction thus comes close to the notion of decontextualized knowledge (see for example Wertsch, 1996). According to Davydov (see for example his 1972/1990) abstractions can only be tools for the understanding of the concrete reality if they are substantial, i.e. if they are based on powerful models, drawn from scientific disciplines, which represent relationships between concepts from that domain. Such *substantial abstractions* are not

decontextualized, but infer their meaning from the position in a theoretical framework. The reason that Davydov calls them ‘abstractions’ is that they represent ‘undeveloped’ notions: they are one-sided because they do not represent all details, and have the potential to be unfolded into concrete objects. Particular forms can be inferred in the use of abstract notions (like different particular lines can be inferred from the abstract formula $y = ax + c$). Using such abstract substantial models as a tool for the interpretation of concrete reality is called ‘ascending from the abstract to the concrete’ (Davydov, 1972/1990; Ilyenkov, 1982; Falmagne, 1995). In terms of this theory, transfer in the cognitive domain implies that we ascend from an abstract substantial model to the reconstruction of a new concrete situation in terms of this model. Hence, it is the quality of the tool (e.g. the abstract model) that is used in human activity, that creates the potential for transfer. Only if the tool can be transformed into a variety of particular forms, it will not be rigidly linked to a fixed set of human actions,and will open a range of possible (mental) actions that can be accomplished in different (familiar and new) situations.

A consequence of this point of view is, that teachers should not only provide pupils with the abstract tools, but also teach them how to transform their tools or the related actions, to make them fit for new situations. We may expect that the mere provision of abstract models will not in itself optimize the chances for transfer. In our own research program at the Free University in Amsterdam we conducted a research project in which we tried to test this hypothesis. We compared two groups of students in grade 7 (10-11 year old in The Netherlands, total N = 238, drawn from 10 schools) during a course in which they studied percentages and the use of graphs (see van Dijk, 2002). In one group the students studied percentages from a textbook; the teachers explained the problems to the students, offered them the abstract model (the ones that are commonly used in textbooks), and let them practice with the model and its standard graphic representation. Whole classroom discussions of problem solving processes took place under guidance of the teacher. In the other class students worked in small groups at problems and the teacher encouraged them to construct their own symbolic-graphic models for the solution of percentages problems. In the discussion with the small groups and in the plenary discussions the teacher finally also introduced the standard school model with which the students’ models could be compared. Most students in these groups winded up with adopting the standard model as well among other models Schools in the two groups were matched at the start of the project on

mathematical ability by a standard math performance test. Finally, all students (of both groups) acquired abstract models for solving percentages problems. In the first group: the models were provided, in the second the models were actively co-constructed by the students with the help of the teacher.

The outcomes of the study were remarkable when we compared the students' performances on posttest and especially the transfer items (see van Dijk et al., 2003 a and b). It turned out that the students from the co-construction group outperformed the students of the 'provision group' on both the posttest (in particular the transfer items). On the transfer items the students got new previously unseen problems that differed from the course's problems in terms of content (e.g. instead of percentages they had to calculate with permillages), or in terms of complexity (e.g. comparing different percentages or reasoning with percentages of percentages). The date were analyzed with ANOVA, Regression analysis, and Multi-Level analysis in order to estimate the statistical significance of the differences in relation to different groups and performances on the pretest. The detailed outcomes of these studies will not be discussed here (see van Dijk et al., 2003 a and b). For the present argument it is interesting to note that it was not the model per se that explained the transfer but it was the way the students have produced the model and have learned to use the model in a flexible way.

It is clear, however, that basically this study was also a conditions-transfer study. We could demonstrate that under specific conditions different outcomes are to be expected, especially with regard to transfer. What kind of psychological mechanisms were involved in the transfer was not investigated, neither could the study reveal how the abstract models contributed to the occurrence of transfer. Observations of students' activity in this project and in other research projects, do give us some hints for a theory of abstraction that might give a speculative explanation of abstraction-based transfer. Any theory of abstraction should clarify the process of abstracting itself, and explain how this psychological process of abstracting is related to a variety of concrete situations.

Abstracting as perspective taking

In the summary of the Ilyenkov/Davydon abstraction theory I already pointed out that ascending from the abstract to the concrete is basically related to looking at a concrete situation from a particular theoretical point of view (embodied in the model in use). Already

in the 1920s, the neo-Kantian philosopher Ernst Cassirer described a powerful new approach to abstraction in a fundamental critique on the classical (Aristotelian) theories of abstraction (see van Oers, 2001). He argued that abstracting is essentially a matter of seeing a number of objects as related from a particular viewpoint: abstraction always means that we order a number of (different) objects according to some rule or principle. He writes:

> "Abstraction is no longer a uniform and undifferentiated attention to a given content, but the intelligent accomplishment of the most diversified and mutually independent acts of thought, each of which involves a particular sort of *meaning* of the contents, a special direction of objective reference" (Cassirer, 1923, p. 25; italics by Cassirer).

So an abstraction is not so much an end product of an intellectual act, but is already implied in the intention to look at reality from a specific perspective from which we can see a number of objects as related in a particular way. So the abstract category of triangle is not an end result of seeing the common triangularity in a number of different geometrical figures, but is already implied in our deliberate intention to order objects from the point of view of 'things having three angles'. Similarly we can say that 'blue' is not an inherent quality of objects, waiting to be abstracted, but it is a result of ordering a collection of things from the point of view of a particular color. The color name 'blue' is attributed to objects by an attentively focused observer. Hence, in short, an abstraction is not the recognition of a new, previously unnoticed general characteristic, but it is an attribute **added** to the objects of our thinking from the point of view the observer has taken.

A similar point of view on abstraction was developed by the Russian philosopher Ilyenkov (1967; 1983). For him 'the abstract' is a deliberately impoverished description of reality, originating from a point of view from which the concrete can be seen in its systematicity; it is a point of view that is not yet particularized in all its details, and that is 'uncomplicated by deforming influences' (Ilyenkov, 1983, p. 34). Although Ilyenkov and Cassirer's point of view clearly converge when they both emphasize the importance of the point of view from which the abstractions emerge, Ilyenkov goes beyond Cassiser by assuming that the core element of any abstracting point of view is not just a formal relationship from which all elements in a manifold can be seen as connected. For Ilyenkov , an abstraction can be any conception that integrates a particular situation into one conceivable whole. So a metaphor, a picture, a model can all be basic abstractions from which a particular

object or situation can be understood. So, taking a concretely drawn ellipse (like Kepler did) as a model to organize our planetary system is actually an abstracting act that tries to make the seemingly chaotic movements of the planets in our solar system look similar (i.e. following the same law).

From this point of view, every abstraction is an outcome of an initial act of intentional abstracting. And just like Cassirer already suggested, this process of abstracting supports the attribution of particular meaning to the objects involved. This demonstrates that abstracting is basically also an act of **putting objects in a specific context** that articulates particular meaning in the objects involved. This view conceives of *abstracting as itself a process of contextualization*. Context is essential for all meaningful human activity. Basically, context is a 'meaning-supporting-environment' and all objects and actions need such environment to become meaningful. Abstracting implies a choice for a specific context within which the objects at hand will be viewed, related, and eventually analyzed. So, abstraction has nothing to do with decontextualization (which would mean subtracting specific meaning from the objects observed), but with recontextualization of (symbolic) objects in a new (theoretical) environment (see van Oers, 1998). Hence, theoretical concepts are contextualized as elements of a theory driven activity, which assigns specific meaning to those objects (including the tools of the activity), and makes them distinct from other possible meanings. Problem solving involves a continuous process of abstracting and choosing new contextualizations within current environments.

Activity theoretical elaborations

Elsewhere I rejected the situational interpretation of context. Human action is endowed with meaning through its integration into sociocultural *activity*. Activity is the genuine context of human action. Making a situation into a context for action, means first of all deciding which activity is appropriate in the situation given. Any action can be a part of a variety of activities, and consequently can have a variety of meanings depending on the type of activity in which it is embedded, and on the function of that action within that activity.

The choice to get engaged in a particular type of activity (e.g. 'mathematizing') contextualizes the following actions (and its implied objects, tools, and rules) and, by the same token, sets up an abstracting point of view by predicating the objects and actions in particular (mathematical) ways, and putting them in particular relationships. Take for example

a set of numbers. The decision to view them as a *data set* (rather than a set of fingering instructions for playing a musical instrument, or page references in a book index), is already a contextualization: it contextualizes the next actions as mathematical (rather than musical, rhetorical, historical etc). But it is also an undeveloped starting point for dealing with these numbers. As such it is abstract and it essentially *relates the data with each other* in specific ways. The progress in the process of dealing with the data set depends on a continuous flow of new abstracting viewpoints that help us to approach the goal we have in mind.

As I demonstrated elsewhere (van Oers, 2001), this process was elegantly elaborated by Anna Sfard (e.g. 1998) in her focusing theory of the construction of mathematical objects. In her view, mathematical objects are discursively constructed on the basis of an initial metaphor of a situation that is specified in an ongoing process of focusing. She distinguished three consecutive processes of focusing:

a) Construing a *pronounced focus*: the pronounced focus, according to Sfard, is the entity that is meant to identify the object of one's attention; it is the publicly accessible way of calling attention to some aspect of the (material or cultural) world; pronounced foci materialize in words, symbols, signs, gestures, things). For example: a written list of numbers;
b) Construing an *intended focus*: an intended focus represents the entire collection of experiences – thoughts, emotions, meanings, possible actions, abilities – that are associated with some symbol or object (pronounced focus); the intended focus includes the theoretical content linked to some publicly presented symbol, both the utterances or feelings that are articulated at a particular moment, and the utterances and feelings that are only virtually represented (that could possibly be uttered if required); the intended focus is essentially private and may only be communicated to others by indirect discursive means. For example: all kinds of images, or ideas of how to operate on a list of written numbers, maybe even feelings of disgust or excitement related to lists of written number.
c) Construing an *attended focus:* the attended focus is the public exponent of the intended focus; the attended focus materializes in specific actions on objects in order to achieve some goal, or demonstrate the meanings one has in mind; the attended focus is personal but can be made public by communicative actions (showing, telling, pointing, demonstrating). For example: the scanning procedure one has to perform

with ones eyes in order to establish tendencies in a set of data (represented by a list of written numbers), or the calculation of the mean of the data.

What Sfard aptly describes as a "continuity of focus flow" (Sfard, 1998, p. 13) can also be conceived in activity psychological terms (see Leont'ev, 1975) as a description of the actual evolution of an activity:

(a) The progress of an activity is driven by objects or messages, which are publicly accessible through audible or visible entities ('pronounced foci'). These entities are the materializations of signs or symbols and embody cores of potential meaning. In the modern jargon we would call them *inscriptions* (Latour, 1990). Inscriptions are graphic or acoustic codifications (like maps, signs, symbolic models, instructions, tables etc) that can regulate human actions in concrete situations. The power of inscriptions (such as: $y =\bullet\ x + A)$ is that they are mobile entities: they can be moved from one place to the other, while remaining fairly immutable during transportation, and especially they can be easily integrated into written texts (see also Meira, 2002, p. 88). Graphic representations of abstract concepts ("Models") constitute an important category of inscriptions in the context of learning and problem solving. Inscriptions can be used as means for initiating, maintaining, or regulating human activities. Taking again the list of numbers as an example: the inscription (formula) $\bullet\ \mathbf{x_i/N}$ can be taken out of a book in order to calculate the mean of the set of numbers; by their undeveloped nature inscriptions are essentially abstract;

(b) Inscriptions are always associated with 'intended meanings'; they call forth images, feelings and meanings, i.e. actions (or operations) that can be accomplished with these inscriptions; the meanings can be *direct*, calling forth actions or operations more or less directly, or the meanings can be *generic*, calling forth series of derived actions or operations in relationship with the goals and conditions given; inscriptions support the *orientation* process of an actor in which he or she tries to figure out what should (or could) be done in the given situation, given the available intended focus. The orientation process is one of the most important stages in the evolution of an activity (see Gal'perin, 1976; Davydov, 1972): on the basis of the available tools, action potentials and explicated goals, a plan is worked out. The orientation process connects the available action potentials, thoughts, emotions (in short: intended foci) with the emerging goals and floating conditions of the activity. For example: the situation with the set of numbers also suggests a median or a mode as possible estimates

of the set's descriptor. Through orienting on the details of the problem situation and the goals of the activity the problem solver can finally decide what action to perform.
(c) An outcome of this continuous orientation process is the choice of a specific *action* to be performed, and that makes sense in the given activity, and is meaningful with respect to the goal that was articulated. Finally: the actor can perform the action that came out of the orientation process as the attended focus.
Of course this is just a very brief description of an activity theoretical psychology of human acting and problem solving. Much is to be elaborated for a more substantial clarification. Nevertheless, the main elements for an activity theoretical understanding of transfer through abstracting are now available. I will deal with it in the next section.

Transfer and the recontextualization of inscriptions

In his study on concept formation, Vygotsky (1986) already pointed out that consistently constructing relations among a number of objects is a fundamental action in the formation of abstract concepts. But he also could demonstrate that the use of materialized signs (inscriptions) is essential for this process. In one of his famous experiments on concept formation he used blocks that differed on three dimensions (form, height, and size). The small sized - tall ones, irrespective of form, were called for example called "*MUR"* (a meaningless word for Russians). Other combinations got other names. Through this investigation Vygotsky demonstrated that the use of these names ("inscriptions" in our terminology) eventually produced the ability in students to indicate specific qualities, to focus attention on these qualities and he writes:

> "As already said, concepts are formed through intellectual operations, not through a play of associations. All elementary intellectual functions are involved in special combinations in this process of concept formation. The central moment in this process is the functional use of the word as a means for focusing attention, for abstracting[1], distinguishing characteristics and their synthesis and symbolization with the help of a sign" (Vygotsky, 1934, p. 182)

The sign (or: 'inscription' as we would say today) is essential in the process of abstracting for it contributes new qualities to the topic that is already in our mind, or that is shared by a group

[1] It is important to note that Vygotsky used here abstragirovanie (abstract**ing)** instead of abstracija (abstraction), emphasizing the importance of the process

of communicating people. Psychologically we can interpret this process as a process of *predication*, in which new quality is attributed to an already shared topic. Vygotsky (1934/1982 chapter 7) emphasized the importance of the predication process for the understanding of human thinking. Predication puts the object(s) in a new general category, characterizes the objects for the moment and distinguishes it (them) from other objects (see van Oers, 2000): 'A sign (or symbol) always involves a form of predication, suggesting actions by which the referred-to object obtains its meaning' (p. 149). Calling a constellation of stars a triangle is an abstraction that emerges out of the intentional act of looking at the sky from the perspective of triangles, it adds new quality to our knowledge of these stars (which might be wrong, e.g. from a 3 dimensional perspective), puts them in the general category of triangular configurations, and distinguishes this group from other configurations. Or in another example: calling a set of data 'a normal distribution' emerges out of the intention of looking at these data from the perspective of frequencies. The abstraction ("normal distribution") results from the abstracting act of organizing data in terms of frequencies. In both cases the elaboration of the abstract meanings starts out from predicating the situation with new qualities by the use of specific inscriptions ("terms" like 'triangle' or 'normal distribution'). Hadn't we used these inscriptions in these situations, the development of the abstract conceptualizations of these situations wouldn't have been impossible per se, but extremely more difficult. *Abstracting starts out with taking a* ***perspective*** *followed by further* ***predication*** *(often) with the help of* ***inscriptions***.

With the help of this theory we can now give an explanation of transfer. One of the core problems of transfer always was the explanation of the communality between situations. On the one hand we had the (common elements) theory that assumed communalities intrinsic to the different situations, on the other we had the theory that assumed stable meanings that could be transported from one situation to the other (assuming meanings that could be meta-situational and separated from personal use). Both theories are unacceptable for psychological and epistemological reasons. In our view, transfer is based on the use of inscriptions in different situations that can help solving similar problems that occur in those situations. It is the inscriptions that can be moved from one situation to the other and that can eventually support the occurrence of transfer.

However, the availability of relevant inscriptions is by itself no guarantee that transfer will actually occur. This was evident in our own transfer research that we discussed above: both groups had the models at their disposal, but both groups did not equally demonstrate transfer of the available knowledge. Below I will try to clarify the activity theoretical transfer theory with the help of data from this research project.

For transfer to occur, the students had to acknowledge first of all the relevance of their available inscriptions for the problem at hand in the new situation. Furthermore, when the student realizes the relevance of this inscription in the new situation he or she must be able to transform the meanings related to the inscription to make them fit for the new situation. In other words the person must *recontextualize* his or her available inscriptions in the new situation, which implies at least three steps:

(a) *Seeing the situation from a perspective in which the inscription makes sense*; in our research the students had to see the new situations again as situations that call for mathematizing (mathematical activity). Actually, this is a first abstracting perspective that transforms the first pronounced focus (the situation given, the problem given) into an *intended focus* that articulates especially the mathematical tools (inscriptions, rules, concepts) that seem to be relevant for the problems at hand; it is typical for most school situations that this abstraction is already suggested to the students in the tasks (they know or are instructed when 'mathematics' (literacy, history, music etc) is on the agenda). In our research this was also true for the students: the "new" problems were already contextualized in a mathematical setting and the students could at least expect what kind of inscriptions they were supposed to mobilize for the tasks. In real life, however, finding out what activity is to be accomplished in a given situation is a first step toward contextualizing and finding out which tools we have available for dealing with the situation (see van Oers, 1998b);

(b) *Make a choice for a specific inscription (with associated actions)* that is considered appropriate for the new problem; this *attended focus* gives a new perspective on the situation and is –consequently- a new abstractive move; in our research project all students in the posttest had to decide on the attended focus. Half of the students (those in the co-construction group) were familiar with an open version of this step in the transfer process, as they had ample experience with model construction during the course; like in the course they had to construct (individually this time) a model for the solution of the

problems; the other half of the students (those in the model provided group) actually had to figure out that the model from their course should be used here on the basis of contextual cues (same teacher, same researcher, same type of problems; similar words used in the phrases of the problems etc.)[2]. The conditions in our research were such that no problems would be expected for either group in making this decision;

(c) *Transform the inscriptions or the actions suggested by the inscription* to make them fit in the new situation; this is the core of the transfer process: the inscription that was chosen as a tool by the student (the attended focus), often has to be adjusted to the problem at hand; the inscription itself represents just an abstract idea that is bound to the perspective taken (here: the perspective of applying this particular instrument for the problem at hand). If this instrument is fixed to one unique way of acting, it will be very difficult to achieve transfer that requires slightly different actions in the new situation: students who have learned to operate on percentages on the basis of (e.g.) a circle diagram, have to transform this model for the basis 1000 when they have to solve problems on permillages; if they rigidly accomplish only the actions on the 1/100-idea of percentages, they will have trouble with these new tasks. In other occasions students had to combine percentage operations with other operations and could not straightforward apply their knowledge on percentages, as in the following example:

> A fish bowl A has a volume of 20 liters and is twice as big as another bowl B. Fisbowl A is for 50% filled with water, while B is for 60 % filled with water. Can the water of B be poured into A?

There are different ways of completing this task, but in each way, the student cannot just add the two percentages. The student must understand that the percentages refer to different totals and that he or she must find a way to combine the two measures. In order to solve this problem the student doesn't have to change his concept of percentages (or: his 1/100-model), but he/she must certainly change the way the percentages are applied for concrete situations. In the 'model-provision-group' we found more answers like:

[2] This might look like a retreat to the common elements theory of transfer again. However, it is important to note that the contextuals cues only serve as heuristical means for the type of tools, or solutions strategies that could be useful. Such cues can work in every problem situation. But the choice of a correct tool (or inscription) is not yet transfer.

- “No A will not overflow, because it is much bigger”
- “Yes A will overflow, because 50% + 60 % is more than the total”

In the co-constructive group we found answers like:

- “60% of the half of A is not enough to let A overflow”

In my interpretation, the students in the co-constructive group were much more flexible in accomplishing their actions in diverse situations, and specifying their understandings for the new situation. For them the content of their abstract knowledge of percentages was not fixed but parametric and open for different concretizations. It is presumably this flexibility of their actions and abstract ideas that was the decisive finishing touch for the transfer process. We expect that this flexibility is a result of the way the abstract ideas on percentages were appropriated in the co-constructive group.

Overlooking the whole process of transferring old understandings to new situations underscores the importance of the different steps. It is also clear that the whole process is initially set in by the acknowledgement of the perspective that is presumably valuable for the solution of the problems given. Embedding the available inscriptions in this context (i.e. contextualizing these inscriptions) is a decisive step in ascending from the abstract to the concrete. These inscriptions can be brought in from previously encountered situations and constitute the transfer in the most literal sense. However, the introduction of the inscription into the new situation, will only lead to proper transfer in the psychological sense after *transforming the associated actions for the new situation*. This transformative ability psychologically underpins the transferability of abstract knowledge.

Ascending from the abstract to the concrete.

The perspectival view of abstraction that was described above opens a number of new viewpoints on transfer and learning. As the theory is described here, it is in itself still un-developed and particularly dependent on an activity theoretical perspective on sociocultural development in humans. The next step is to ascend from this abstract to the concrete and see how students do act in concrete situations that require transfer. In this article I just wanted to straighten out the idea of abstraction and transfer on a theoretical level in order to bring this viewpoint into discussion.

Empirical research, however, form this point of view is under way. One interesting issue is that abstractions are presumably widely available in pupils. Even young children can be said to take to work with abstractions (see also Egan, 1988), as they obviously can take on perspectives that relate different things into one coherent whole. Starting from that theory we have been able to engage young children (5 – 8 year olds) in schematizing perspectives on reality, in which they make pictorial or transformational representations of reality. Our research shows that this abstracting activity is indeed accessible for young children (see van Oers, 1994, 2002; van Oers & van Dijk, 2004). In a longitudinal follow-up study we examine how this abstracting ability (developed through education in 5 year olds, in non-mathematical contexts) transfers to the domain of mathematical thinking one year later (when the children are 6 years old). Our hypothesis is that looking at the world from a transformational point of view, and representing these transformations in schemes and models, bring the children in a better position for the construction and contextualization of mathematical models (inscriptions) that can help them solve mathematical problems.

The outcomes of these studies will be published in the near future. Ascending from the abstract to the concrete is also for academics a long lasting process.

To be continued.

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