Coordinating learning inside and outside the classroom in Vocational Education and Training (VET)[1]

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For more than 100 years now teachers have been complaining that their new learners "cannot calculate anymore (!)". As it is very improbable that the situation has deteriorated from generation to generation over the last hundred years, we at the Swiss Federal Institute for Vocational Education and Training (SFIVET) think that there must be something wrong with the teachers' expectations. As a consequence we started the project "Everyday mathematics at work". The idea is to bring the two learning sites – school and company – closer together.

In Switzerland two thirds of adolescents start vocational education and training (VET) after lower-secondary education, i.e. after their compulsory nine years of schooling. VET is predominantly based on a dual system: practical, work-based training (apprenticeship) on three to four days a week at a host company is supplemented by theoretical classes (vocational subjects and subjects falling under Language, Communication and Society LCS) on one to two days at a VET school. Vocational Subjects are usually not split up in separate "subjects" but taught in a holistic manner.

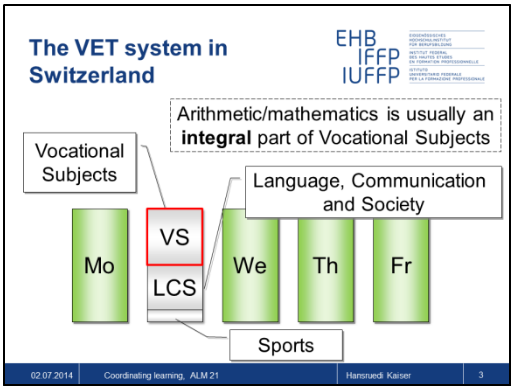

Figure 1: Four days at work, one day at school

For details see: http://swisseducation.educa.ch/en/vocational-education-and-training-0

[1] Prepared for the Proceedings of the 21st International Conference of Adults Learning Mathematics (ALM-21), Bern, Switzerland, 30 Jun – 3 July 2014

The project "Everyday mathematics on the job"

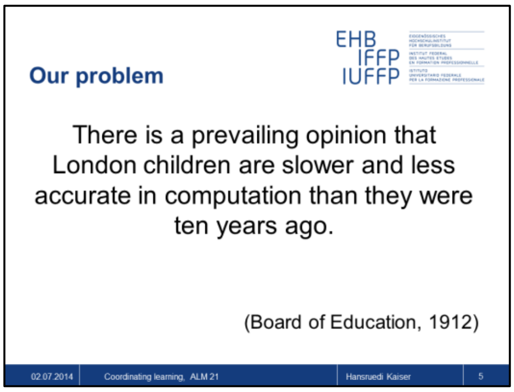

Figure 2: VET teachers complaining then (and now)

For more than 100 years now teachers have been complaining that their new learners "cannot calculate anymore (!)". As it is very improbable that the situation has deteriorated from generation to generation over the last hundred years, we at the Swiss Federal Institute for Vocational Education and Training (SFIVET) think that there must be something wrong with the teachers' expectations.

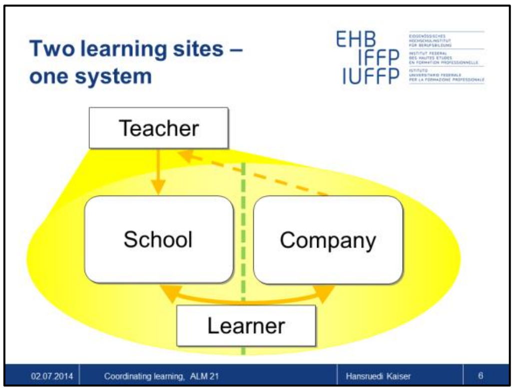

Figure 3: Helping learners by integrating school and work

As a consequence we started the project "Everyday mathematics at work". The idea is to bring the two learning sites – school and company – closer together so that the learners do not have to "cross boundaries" every time they go from school to work or vice versa, but experience the VET system as an integrated whole. One favourable precondition to this is that the teachers themselves are experienced professionals in the occupation they are teaching. They know both worlds very well and are in a good position to help the learners to integrate their learning at the different learning sites.

Background theory: Situated cognition

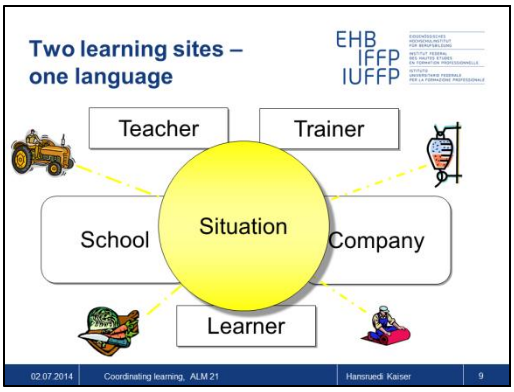

Figure 4: Stories about typical situations in everyday work life used as unifying language

To integrate the two learning sites the people at the two sites have to find a common language to talk about what the learners should learn. Abstract descriptions of competencies as found in regulatory frameworks are not very helpful, as they are insufficient to describe the ambiguous and open-ended challenges at the workplace (see e.g. Coben & Weeks, 2014; Lum, 2004). We found it more suitable to describe these challenges as typical situations of everyday life at the workplace (Kaiser, 2005a). To describe the situations we use stories which enable us to capture "soft" aspects that otherwise are easily lost. So the unit of teaching is always an authentic situation and the challenges it poses.

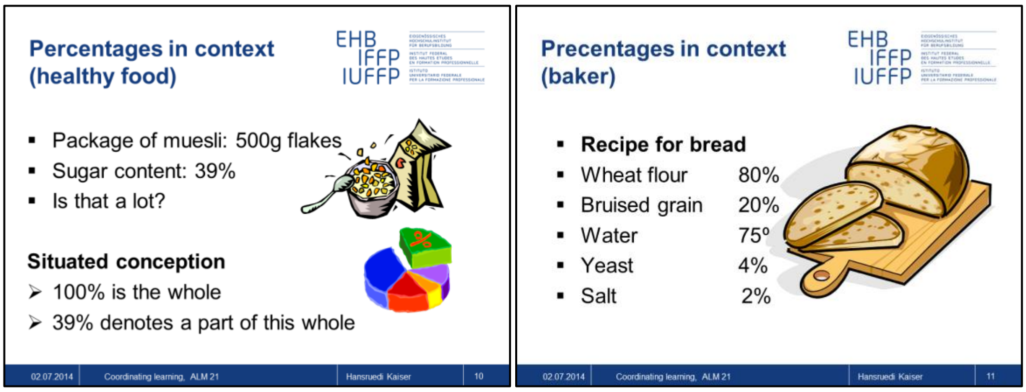

Figure 5: 100% being "the whole" does not work when baking bread

This connects directly with the situatedness of knowledge. We belief that the complaints of the teachers about learners who "cannot calculate anymore" are a direct consequence of them not seeing this situatedness. E.g. children usually learn to use percentages in a context where it is natural to think of 100% being "the whole" (Figure 6; left side). If all went well they can handle all kinds of situations where this idea of "100% is the whole" is applicable. However, when they enter an apprenticeship as baker they encounter professional bread recipes (Figure 6; right side). In this context, all ingredients are specified in percent of the amount of flour – which in no intuitive way is "a whole"! Intuitive "wholes" would be the dough mixed out of all ingredients or the finished bread. Searching for an intuitive "whole" the learners stumble and the teachers – rightly – complain that they "cannot do percentages".

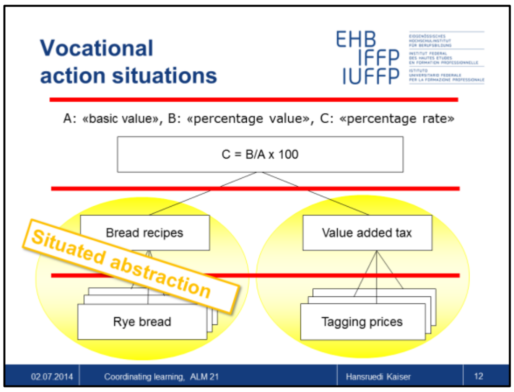

Figure 6: The two situations where bakers have to deal with the % sign

As a consequence we tell our teachers that they should not try to teach their learners "percentages" (or "the rule of three", etc.) but teach them to make bread. If the learners learn to use "baker percentages" in the situation of "making bread" (situated abstraction, Hoyles & Noss 2004) and do not realize that, from a more abstract mathematical point of view, the "baker percentages" are the same as the "part of a whole percentages" they will still be good bakers. All the professions we have worked with so far do not know many different professional situations where the same mathematical concept is applicable. For example, the only other situation where bakers have to handle percentages is when they "calculate VAT". It is therefore no problem to treat them as two different situations at school – and they are different: While calculating VAT the exact percentages to several decimal places is important; this is not the case with the percentages in a bread recipe.

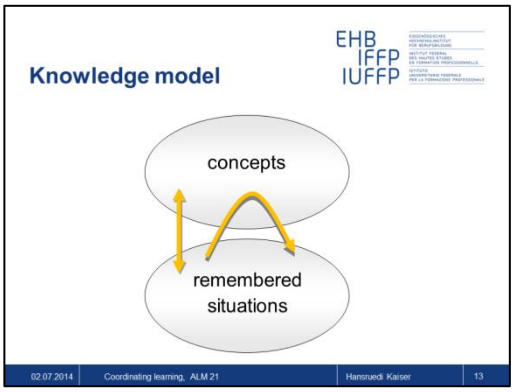

Figure 7: Two types of knowledge

To explain to our teachers why the learners think as they think, we use a model which works with two different types of knowledge: Memories of self-experienced situations and learned concepts (Kaiser, 2005b; see Vergnaud 1990 for a similar conception). Every time a learner encounters a new situation he or she is reminded of previous similar situations and tries to deal with the new situation in analogous ways as in these pervious situations. As a consequence, the learners' knowledge is portioned in packages of similar situations. Some learners manage to fuse the two packages "part of a whole percentages" and "baker percentages" to one package, but many do not.

Didactics: Learning how to use mathematics

The didactical model consists essentially of two rules:

A: Work from the concrete application to the abstract rules – and not the other way round.

B: Always stay in the context of situations that learners know from their workplace.

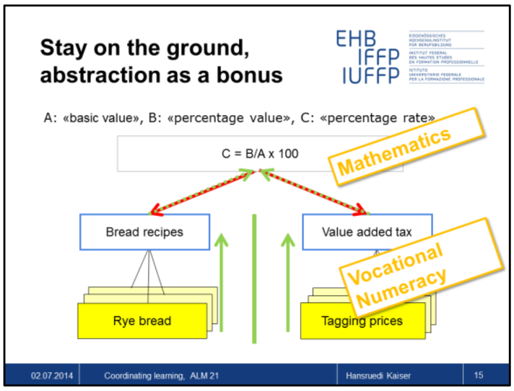

Figure 8: Rule A: Teach "to make bread" and not "percentages"

Rule A was mentioned before: "Do not try to teach your learners 'percentages' but teach them to make bread". This means: Do not start by recapitulating "percentages" and then apply them to bread recipes. Start with bread recipes and explain, what the % sign means in this context, and make sure that the learners learn to handle the situation "make bread" rather than "calculating percentages". Be prepared when later switching to the VAT to start again at the bottom and to explain, how the % sign is used in this new context. Important is that the learners learn to handle each of the two situations professionally (cf. "contextual coherence", FitzSimons 2014). Not so important is that they see the "mathematical" similarities between the two situations ("conceptual coherence", FitzSimons 2014).

Of course, if there is time and the learners are motivated, it is a good idea to discuss with them later on – after they feel confident with both situations – the similarities between the two situations and do some "mathematics". This will help them later on to adapt to changes at the workplace or to continue with a program in higher education. But you will not be able to do that with all of your learners.

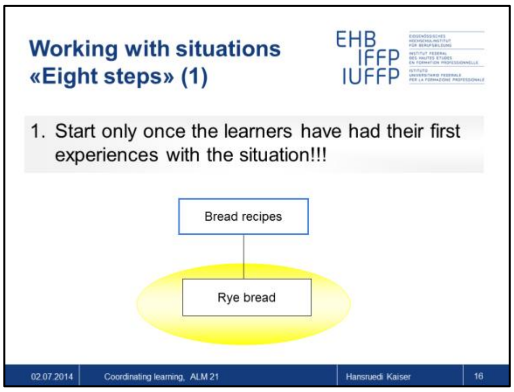

Figure 9: Bring the situation to the classroom (Steps 1 and 2)

For rule B we propose an eight step didactical model to our teachers. Step 1 in this model is actually more a stop-sign then a step. It just means: Do not try to teach the learners how to handle a situation they have not yet experienced at their workplace; it is a waste of time (see e.g. LaCroix 2014)!

To work with a situation like “baking bread” it is important that teachers and learners activate as many remembered situations as possible. This is the idea behind step 2. By listening to the learners’ stories the teacher also gains insight into how the learners perceive the situation and how this perception possibly differs from his professional perception.

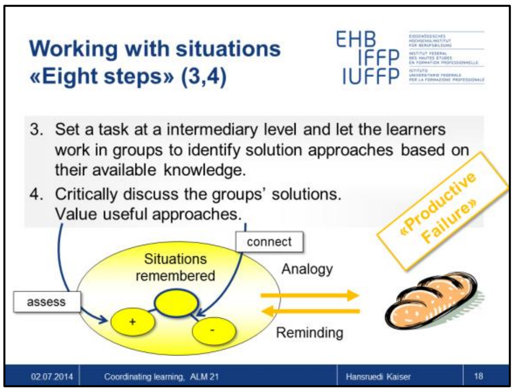

Figure 10: Find out and value what they already know (Steps 3 and 4)

Step 3 and 4: Kapur & Bielaczyc (2012) explored this way of working with learners’ prior knowledge under the heading of “productive failure” and showed how effective it can be. The idea is to start with what the learners already know instead of complaining about what they do not know. Working on the task and discussing the solutions has two functions: 1) Connecting what will follow with the already existing experiences, 2) critically evaluating these experiences in the light of a professional way of handling the task. These old experiences will stay in the package of similar situations and will continue to influence what the learners do when baking bread. So it is important that the learners know which remembered situations are reliably good examples and which are examples of situations to avoid. This is possible when the task is simple and familiar enough to remind them of earlier experiences and at the same time demanding enough so that they encounter the limits of their prior knowledge (productive failure).

Ideally, a list of open questions is the result of step 4; questions on which the learners agree that they need an answer to them. Sometimes there are no questions because the learners handled the situation already perfectly well. In this case the rest of the steps can (and should!) be skipped.

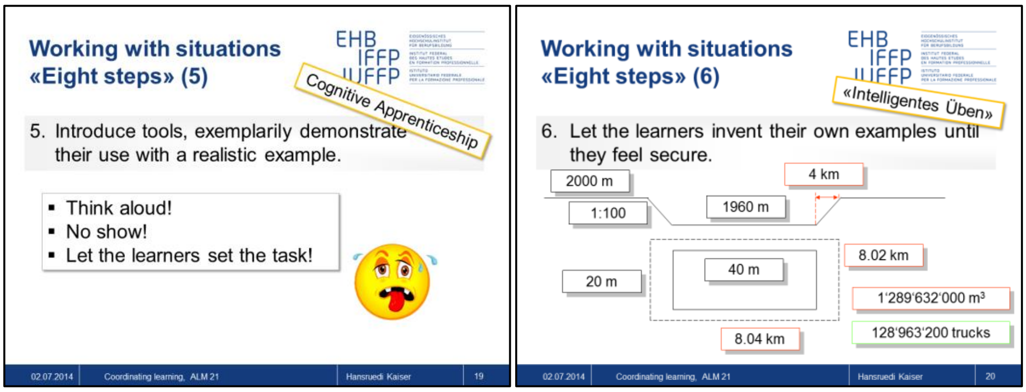

Figure 11: Model a professional solution and let them practice (Steps 5 and 6)

Step 5 provides the answer to the open questions from step 4 in form of a demonstration of how this type of situation is professionally handled. Step 5 corresponds to the modelling-step of the Cognitive Apprenticeship process (Collins et al. 1989; Weeks et al., 2013). We always tell our teachers that they should provide a real model and not a show. The learners should see and hear what a professional thinks and where even a professional has to think hard. As a rule we propose to not prepare a demonstration but to let the learners set the task and then try to solve it in front of them while thinking aloud.

Step 6 corresponds to the “coaching”, “scaffolding” and “articulation” parts of the Cognitive Apprenticeship process. Details about what is important in this step can be found in publications about Cognitive Apprenticeship. As an addition we propose our teachers not to work with a list of prepared examples but to let the learners invent their own examples (“Intelligentes Üben” [Intelligent practice], Leuders 2009). There are several advantages to this: First, you do not have to prepare anything! Second, learners usually find teacher set tasks boring, but enjoy working on tasks prepared by their colleagues. And third, learner constructed tasks sometimes explore aspects of the situation a teacher would never think of. My favourite example is from the time when I worked with construction workers. The task was to calculate how many truckloads of dirt had to be removed while excavating a pit. They decided to make a deep pit (40 m), with walls not too steep (1:100) to reduce the risk of a collapse. That gave them an upper rim of the pit of 8 by 8 kilometres and about 129 million truckloads of dirt. We laughed a lot but at the end several of the construction workers said that the example helped them a lot to understand what a slope of 1:100 or 3:4 really means. With the usual teacher set examples with “realistic” slopes of 2:1 und 3:2 there would not have been enough variation to get a feeling for the differences.

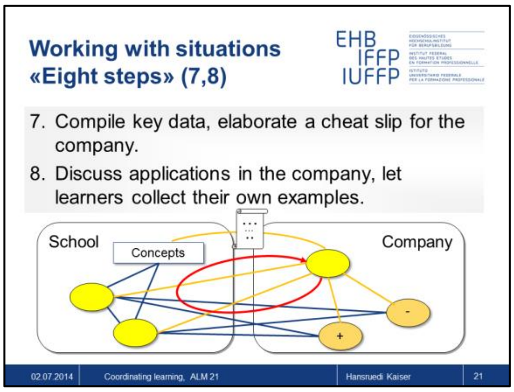

Figure 12: Help them to transfer to the workplace (Steps 7 and 8)

The function of the last two steps is to bring the learning process from the classroom back to the workplace. Step 7 prepares that move. The idea is that the learners construct an external memory that will help them to remember essential details of what they learned in school, once they are back at work. Step 8 has two parts. Part one is a discussion where the teacher and the learners try to anticipate what will happen when the learners begin to use at the workplace what they just learned in school. Part two takes place a week (or more) later. The learners come back to the classroom, tell what has happened, what did work and what did not, and where the problems were when they tried to apply the concepts and techniques learned at school. Solutions for these problems are discussed together and ideally at the end – after several weeks – every learner can add at least one positive example to his or her memory of remembered situations.

If all goes well, what happens by following the „Eight Steps“ is: The learners start with some remembered situations from the workplace (the brown circles in Figure 12). In steps 3 and 4 they learn in which instances these experiences have already been helpful to solve a new task and in which they have not (the plus and minus signs within the brown circles). Then in step 5 and 6 they add a few new situations to their memory by watching the teacher model and by working on self-constructed tasks. These memories are connected to the old situations and to some theoretical concepts (blue lines). Before going back to work they write a cheat slip (a kind of boundary object; Hoyles & Noss 2004) which is in their memory also connected to the school situations (brown arc on top). Back at work they encounter a new situation (yellow). This new situation will remind them of the old workplace situations, which will remind them of the new school situations, which will remind them of the newly learned concepts and the cheat slip. Based on all the remembered situations, the new concepts, and the cheat slip, they will try to handle the new workplace situation. They will end up with a new (hopefully positive) memory of a workplace situation which is not only connected to memories of old workplace situations but also to memories of school situations (red arc).

Figure 13: The "Eight Steps"

I presented the "Eight Steps" here in the way we tell our teacher trainers what they should tell the teachers about what the teachers should do in their classrooms so that in the end the learners learn something useful for their work at the workplace.

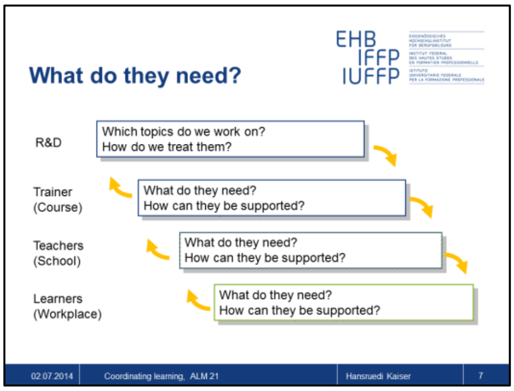

Figure 14: The transmission pipeline

There are many details to each of the eight steps and it is not very likely that each and every one survives the transmission pipeline (**Fehler! Verweisquelle konnte nicht gefunden werden.**). When we watch teachers we see many "mutations" to our ideas – even "lethal" ones (Brown & Campione 1996). But one advice seems to survive: "Do not prepare 'word problems'; work with real situations the learners tell you about". Already this is great, because once the teachers start to do this, they have to do steps 1 & 2. They will then realize that the learners know more than they always thought (steps 3 & 4) and they will have to tune their 'model' (step 5) to what is really going on at the workplace. This will help them realizing that applying this 'model' at the workplace (step 8) is never straightforward but a major step. All this happens because once they allow the learners to talk about what is going on at the workplace, the learners will insist on making connections between school and work. As two teachers told us: "The learners start to feel co-responsible for what is going on in the classroom. They want to show us how it is really done at the workplace. And they become co-teachers explaining and showing things themselves to each other." (For more information about the experiences of the two teachers, see Califano & Caloro 2013.)

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