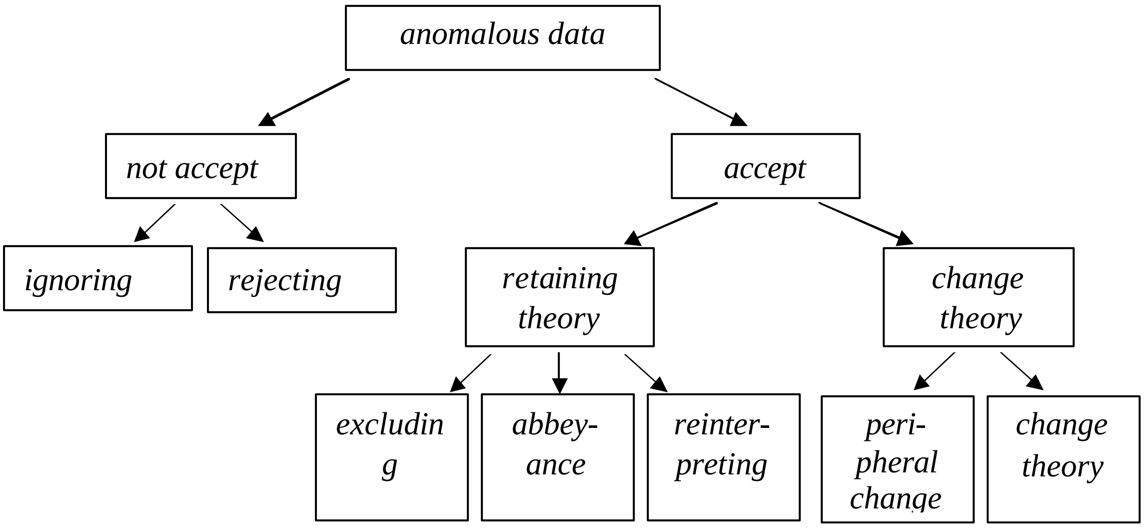
State of the art 'scientific thinking' in STIPPS partner institutions

Germany

The past studies in the research project "Wie Kinder die Welt sehen" are based on the idea of conceptual change. The main focus thereby is placed thereby on the process of conceptual change.

According to Chinn / Brewer pupils can react to anomalous data in different ways by simultaneously trying to retain their approved concepts. The range of reactions reaches from ignoring or rejecting the new data up to changing the full concept (Figure 1).

Figure 1: The Process of Conceptual Change



Source: According to Chinn / Brewer 1993, S. 4-14.

Concerning the stability of "new" concepts Jung stated that the preconcepts of children are often just repressed. They mostly appear again after a certain time whereas the "new" and "scientific" postconcepts disappear after a short time.[1]

To prevent the concepts to relapse again or to counteract against the conservation of preconcepts the pupils must understand the relations between everyday thinking and scientific thinking.

To make teaching activities successful according to the theory of Conceptual Change special conditions must be achieved.

- **Dissatisfaction** about the perceptions already existing
- **Intelligibility** of the new perceptions.
- **Plausibility** of the new perceptions.
- **Fruitfulness** of the new perceptions (also in other situations).[2]

Acquisition of new knowledge is possible by analogisation or by reasoning in induction – deduction terms. As long as children lack the ability of abstract generalisation they link single events (phenomena) by analogisation.

Using analogy is – according to Spreckelsen and other German researcher – one way for children to explain or analyse unknown aspects and occurring phenomena. Pupils thereby take their well known phenomena and interlink them with the new phenomena.

[1] See Jung 1986, pp. 5.

[2] See Duit 1996, pp. 150.

Because of the link the pupils are able to explain even unknown aspects.[3]
Within the analogies two different forms can be differentiated - phenotypic and genotypic analogies.[4]
(phenotypic = according to visible shape, i.e. two things are analogue because they look alike)
(genotypic = according to the invisible mechanism of action / function, i.e. two things are analogue because they are based on the same principle)

The weakness of analogies from pupils is often founded in the non adequate fund of experiences and their still very concrete way of thinking. Because of the missing experiences they can't identify the working principles or the system character of nature phenomena.[5]

To realise an adequate development of perceptions it is necessary to offer the pupils as much opportunities as possible to build up their experiences. The presentation of phenomena must therefore be systematic and related to a special context. The experiments itself must allow the pupils to use phenotypic and genotypic analogies.[6]
E.g. in the so called "Phänomenkreise" (circles of phenomena) different experiments with the same working system are presented. By working in such a "Phänomenkreis" the pupils can find out the relations and differences of the phenomena. According to this the focus is not on the understanding of every single aspect but on the realisation of the legality of science.[7]
Spreckelsen analysed the analogies used by children in interviews when they were asked to explain scientific phenomenon. Surprisingly younger children, compared with older children, preferred genotypic analogies instead of phenotypic analogies. He expected them to prefer the less abstract phenotypic analogies. Therefore he calculated the ratio of abstract (genotypic) analogies by the concrete (phenotypic) analogies (A/K-Wert). This figure shows the ability of thinking abstract. Values near to 1 indicate the ability to think abstract; values near 0 indicate primarily concrete thinking. The anomalous result is that younger children achieve higher figures. That indicates their ability to think abstract is further developed than that of older children. But this is a contradiction to the supposition that abstract thinking develops gradually.[8]

References:

Chinn, C. A., / Brewer, W. F. (1993): The role of anomalous data in knowledge acquisition: A theoretical framework and implications for science instruction. In: Review of Educational Research 63/1993, S. 1-49.

Duit, R. (1996): Lernen als Konzeptwechsel im naturwissenschaftlichen Unterricht. In: Duit, R. / von Rhöneck, C.: Lernen in den Naturwissenschaften. Kiel, S. 145-162.

Jung, W. (1986): Alltagsvorstellungen und das Lernen von Physik und Chemie. In: Naturwissenschaften im Unterricht. Physik / Chemie, H. 34, S. 2-6.

Spreckelsen, K. (1992a): Zum Verstehen physikalischer Erscheinungen im frühen Schulalter. In: Physik in der Schule, Heft 1, S. 6-9.

Spreckelsen, K. (1992b): Die Bedeutung des Analogischen für das physikalische Verstehen im Grundschulalter. In: Physik in der Schule, Heft 7-8, S. 256-258.

Spreckelsen, K. (1995): Verstehen in Phänomenkreisen. Über das Wiederentdecken des Ähnlichen. In: Möller, K. / Köhnlein, W. / Soostmeyer, M. / Spreckelsen, K. / Wiesenfarth, G.: Handeln und Denken im Sachunterricht. Festschrift zum 70. Geburtstag für Wolfgang Biester. Münster, S. 23-34.

[3] See Spreckelsen 1997, pp. 19; see also Spreckelsen 1995, pp. 24.
[4] See Spreckelsen 1992a, pp. 7.
[5] See. Spreckelsen 1995, pp. 24f.
[6] See. Spreckelsen 1995, pp. 25f.
[7] See. Spreckelsen 1992b, pp. 258.
[8] See Spreckelsen 2002, pp. 133-144.

Spreckelsen, K. (1997a): Wie Grundschüler physikalische Phänomene verstehen. In: Grundschule, H. 10, S. 18f.
Spreckelsen, K. (2002): Nachdenken über physikalische Probleme. Eine Untersuchung zum A/K-Wert in der Begegnung von Grundschulkindern mit physikalischen Problemen. In: Spreckelsen, K. / Möller, K. / Hartinger, A. (Hrsg.): Ansätze und Methoden empirischer Forschung zum Sachunterricht. Bad Heilbrunn, S. 133-144

Malta

The Faculty of Education at the University of Malta endorses the constructivist approach as the basic learning theory for primary science learning. Constructivism relates to the child being cognitively active during learning. This means that it is important to help children to think and reflect on what is being done during scientific activities. Thus, main teaching approaches advocated within the constructivist approach include the use of cognitive conflict; active language exercises; scaffolding and metacognition. These approaches come from different educational theorists such as Piaget, Vygotsky, Ausubel and Bruner. What they all have in common is that they all consider the learner as active during the learning process. There is also a significant influence of the work done on constructivism by Rosalind Driver during the 1980s and 90s as well as the research project SPACE that was carried out in the U.K..

Thus during teacher-training students are exposed to the different theoretical aspects of the constructivist approach and how this can be applied to science classrooms within the primary setting. Science sessions where children are first introduced to a topic, their ideas or misconceptions then elicited followed by activities of restructuring, bridging and review are advocated and student teacher given opportunities to design. Such sessions are designed to make students think about the scientific concepts being done in class but also in becoming aware of their own thinking processes during learning. At the pre-school age, the emphasis is more on developing the skills of observation and classification as well and introducing children to how to ask questions in science.

Dr. Suzanne Gatt
Lecturer in Primary Science and Environmental Education
Faculty of Education
University of Malta
5th December 2005.

Poland

The conceptual vision of scientific thinking must be based on

- developing creativity
- observation
- cognitive thinking

Scotland

A Theoretical Framework for Peer Assisted Learning (PAL) in Science

This model is presented here in 6 stages, which are considered to generally follow in sequence. Exemplifications of how this theoretical model could be applied to learning in science are drawn from the topic of Earth in Space. Possible activities that could support this model of peer assisted learning in a coherent sequence that offers progression and scaffolding for the learner are also included in the additional paper provided.

Topping & Ehly (1998, 2001) synthesized the empirical research on effective processes in Peer Assisted Learning in Face-To-Face environments in school, tertiary and lifelong education and proposed a model of the synergies among those processes (see Figure 1). The first of these includes organizational or structural features of the learning interaction, such as:

- the need and press inherent in PAL toward increased time on task (t.o.t.) and time engaged with task (t.e.t.), (e.g. keep the work practical – an example of this would be to use an Orrery or a Tellurian when exploring the seasons on Earth)
- the need for both helper and helped to elaborate goals and plans,
- the individualization of learning and immediacy of feedback possible within the small group or one-on-one situation, and
- the sheer excitement and variety of a different kind of learning interaction (e.g the use of new technologies to explore models of how the universe was created).

Cognitively, PAL involves conflict and challenge (necessary to loosen blockages to learning formed from old myths and false beliefs - reflecting Piagetian schools of thought). An example of this may be discussion with learners about why we experience day and night on earth. It has been reported that children will hold a range of views about science topics that can range from pre-causal e.g. *'Because God turns the lights off'* to accommodative *'Its (the sun) turns into a moon ..or..The sun goes behind a cloud'* to scientific, *'The Earth spins and as it spins we spin away from the sun.'* (e.g. Osborne, Wadsworth, Black and Meadows, 1990). It also involves support and scaffolding from a more competent other, necessitating management of activities within the Zone of Proximal Development. (ZPD is the zone for potential learning beyond what can be achieved alone, within what is achievable with the support of a more competent other, but not beyond the current combined capability of learner and helper). This is necessary to balance any potentially damaging excess of challenge - reflecting Vygotskian schools of thought. A god example of this would be learning about the phases of the moon. It is virtually impossible to approach this concept at anything other than a theoretical level without effective group work and learner co-operation.

The helper seeks to manage and modulate the information processing demands upon the learner so they are neither too much nor too little, in order to maximize the rate of progress. The helper provides a cognitive model of competent performance. However, the cognitive demands upon the helper are even greater. They have to monitor learner performance and detect, diagnose, correct and otherwise manage misconceptions and errors. Herein lies much of the cognitive challenge, exercise and benefit for the helper. PAL also makes heavy demands upon the communication skills of both helper and helped. In so doing it tends to develop those skills. Both might never have truly grasped a concept until they had to explain it to the other, thereby embodying and crystallizing thought into language – another Vygotskian idea. Listening, explaining, questioning, summarizing, speculating and hypothesizing are all valuable skills which should be transferable.

The affective component of PAL might also prove powerful. A trusting relationship with a peer who holds no position of authority might facilitate self-disclosure of ignorance and misconception. This should facilitate subsequent diagnosis and correction. Modelling of enthusiasm and competence and the simple possibility of success by the helper could influence the self-confidence of the helped. A sense of loyalty and accountability to each other might help to keep the pair motivated and on-task.

These five categories or sub-processes feed into a larger onward process of extending each other's:

declarative knowledge,
procedural skill,
and conditional and selective application of knowledge and skills

by

adding to and extending current capabilities (accretion),
modifying current capabilities (re-tuning),
and rebuilding new understanding (restructuring) (in areas of completely new learning or cases of gross misconception or error) (Rumelhart & Norman, 1976, 1983).

These are somewhat similar to Piagetian concepts of assimilation and accommodation. This should lead to the joint construction of a shared understanding between helper and helped – which is adapted to the idiosyncrasies in their perceptions (i.e. is inter-subjective). It might not represent absolute truth (whatever that is), and is firmly situated within the current authentic context of application (Derry & Lesgold, 1996; Lave & Wenger, 1991), but forms a foundation for further progress.

PAL might also enable and facilitate a greater volume of engaged and successful practice, leading to consolidation, fluency and automaticity of core skills. Much of this might occur implicitly, i.e., without the helper or helped being fully aware of what is happening with them. As this occurs, both helper and helped give feedback to each other, implicitly and/or explicitly. Indeed, implicit feedback is likely to have already occurred spontaneously in the earlier stages. PAL is likely to substantially increase the quantity and immediacy of feedback to the learner. The Think –Pair – Share structure adopted by a number of the activities to exemplify PAL in the Earth in Space topic would illustrate how to do this on a practical level. Explicit reinforcement might stem from within the partnership or beyond it, by way of verbal and/or non-verbal praise, social acknowledgement and status, official accreditation, or even more tangible reward e.g. during debriefing the teacher is often asked to review and assess cognitive development.

As the learning relationship develops, both helper and helped should begin to become more consciously aware of what is happening to them in their learning interaction, and consequently more able to monitor and regulate the effectiveness of their own learning strategies in different contexts.
This development into fully conscious explicit and strategic meta-cognition is likely to promote more effective onward learning. It should also make both helper and helped more confident that they can achieve even more, and that their success is the result of their own efforts. The inevitable conclusion of this is that the process is not actually a linear model. Instead the affective and cognitive outcomes should feed back into the originating five sub-processes – forming a continuous iterative process and a virtuous circle. As the PAL relationship develops, the process should continue to apply as the learning moves from the surface level to the strategic and on to the deep level, and from the declarative into the procedural and conditional.

References

Derry, S. J., & Lesgold, A. (1996). Toward a situated social practice model for instructional design. In D. C. Berliner & R. C. Calfee, (Eds.), *Handbook of Educational Psychology* (pp. 787-806). New York: Macmillan.
Lave, J., & Wenger, E. (1991) *Situated learning.* Cambridge: Cambridge University Press.
Osborne, J., Wadsworth, P., Black P. and Meadows, J. (1990) The Earth in Space. Primary SPACE. Project Research Report. Liverpool: Liverpool University Press.
Rumelhart, D. E., & Norman, D. A. (1976). *Accretion, tuning and restructuring: Three modes of learning.* La Jolla, CA: Center for Human Information Processing, University of California.
Rumelhart, D. E., & Norman, D. A. (1983). *Representation in memory.* San Diego, CA: Center for Human Information Processing, University of California.
Topping, K. J., & Ehly, S. (Eds.) (1998). *Peer-assisted learning.* Mahwah, NJ: Lawrence Erlbaum.
Topping, K. J. & Ehly, S. W. (2001) Peer assisted learning: A framework for consultation. *Journal of Educational and Psychological Consultation, 12* (2), 113-132.

Belgium

(see handouts ppp)