Chapter 5 : Developing a Theory of Formative Assessment

in J. Gardner (Ed), Assessment and learning

London, UK: Sage books (to appear, 2005)

Paul Black & Dylan Wiliam King's College London

A model for classroom transactions

Whilst previous chapters have described the development of formative assessment practices, and have explored various specific aspects of its development and operation, the aim in this chapter is both more holistic and more ambitious. We attempt to set out a theory of formative assessment. Such a theory should help inter-relate the discussion so far within a single comprehensive framework and thereby provide a basis for further exploration. It would be extravagant to claim that it achieves this purpose, not least because its limited basis is our indings from the KMOFAP project as described in chapter 1.

That project was designed to enhance learning through the development of formative assessment. The basic assumptions that informed the design of the work were in part pragmatic, arising from the evidence that formative assessment work did enhance students' performance, and in part theoretical. One theoretical basis was to bring together evidence about classroom questioning practices (e.g. research on optimal 'wait time') with the general principle that learning work must start from the learner's existing ideas. The other was provided by the arguments of Sadler that self-assessment and peer-assessment were essential to the effective operation of formative assessment, an argument that was supported in some of the research evidence, notably the work of White and Frederiksen (1998).

However, these are too narrow a basis for making sense of our project's outcomes. The need to expand the theoretical base was signaled in the response made by Perrenoud (1998) to our review:

> *This [feedback] no longer seems to me, however, to be the central issue. It would seem more important to concentrate on the theoretical models of learning and its regulation and their implementation. These constitute the real systems of thought and action, in which feedback is only one element. (p.86)*

By regulation, he meant the whole process of planning , classroom implementation, and adaptation, by which teachers' achieve their learning intentions for their pupils. In what follows, we try to link the ideas expressed in this statement with an expanded theoretical perspective. The principal aim is to provide a framework within which we can make sense of what it was that changed in the classrooms where teachers were developing their use of formative assessment

It is obvious that a diverse collection of issues is relevant to the understanding of classroom assessment and so it follows that, if there is to be a unifying framework, it will have to be eclectic, yet selective in eliciting mutually consistent messages from different perspectives. As one study expresses it:

> *... an attempt to understand formative assessment must involve a critical combination and co-ordination of insights derived from a number of psychological and sociological standpoints, none of which by themselves provide a sufficient basis for analysis. .*
>
> *Torrance & Pryor 1998 p.105*

However, if such a framework is to be more than a mere collection, it will have to serve to inter-relate the collection in a way that illuminates and enriches its components. It should also suggest new interpretations of evidence from classrooms, and new ideas for further research and development work.

In what follows, we develop theory on the basis of the work described in Chapter One. However, other approaches are mentioned throughout, and near the end we use the framework to make comparisons between this and other projects which were also designed to study or change teaching and learning in classrooms.

Starting points

We began by considering the classroom as a 'community of practice' (Lave and Wenger, 1991; Wenger, 1998) or as a 'figured world' (Holland *et al.* 1998). In both these perspectives, the focus is not so much on 'what is' but rather on what the various actors involved take things to be:

> *By "figured world," then, we mean a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is attached to certain acts, and particular outcomes are valued over others. Each is a simplified world populated by a set of agents [...] who engage in a limited range of meaningful acts or changes of state [...] as moved by a specific set of forces. (p52)*

The focus of the approach is a careful delineation of the constraints and affordances (Gibson, 1979) provided by the 'community of practice' or 'figured world' combined with a consideration of how the actors or agents, in this case the *teacher* and the *students*, exercise agency within these constraints and affordances. Their actions are to be interpreted in terms of their perceptions of the structure in which they have to operate, in particular the significance they attach to beliefs or actions through which they engage, i.e. the ways in which they, as agents, interact with the other agents and forces. These ways serve to define the roles that they adopt. Many of the changes arising in our project can be interpreted as changes in the roles adopted, both by teachers and students. However, these perspectives proved inadequate as explanatory or illuminative mechanisms.

This was because although the notions of communities of practice and figured worlds accounted well for the ways in which the actions of agents are structured, and that of figured world, in particular, accounts for the differing degrees of agency exhibited, neither conceptual framework provides for the activities of agents to change the structure. In Wenger's example, people learn to become claims processors, and are changed in the process, but the world of claims processing is hardly changed at all by the enculturation of a new individual. Similarly, in the examples used by Holland et al, agents develop their identities by exercising agency within the figured worlds of, for example, college sororities, or of Alcoholics Anonymous, but the figured worlds remain substantially unaltered. In contrast, the agency of teachers and students, both as individuals and as groups, within the classroom, can have a substantial impact on what the 'world of that classroom' looks like. Furthermore, our particular interest here is more in the *changes* that occurred in teachers' practices, and in their classrooms, as in the continuities and *stabilities.*

For this reason, we have found it more productive to think of the subject classroom as an *activity system* (Engeström, 1987). Unlike communities of practice and figured worlds, which emphasize continuity and stability, "activity systems are best viewed as complex formations in which equilibrium is an exception and tensions, disturbances and local innovations are the rule and the engine of change" (Salomon, 1993, p.8-9).

For Engeström the key elements of an activity system are defined as follows:

> *The subject refers to the individual or subgroup whose agency is chosen as the point of view in the analysis. The object refers to the 'raw material' or 'problem space' at which the activity is directed and which is molded or transformed into outcomes with the help of physical and symbolic, external and internal tools (mediating instruments and signs). The community comprises multiple individuals and/or subgroups who share the same object. The division of labor refers to both the horizontal division of tasks between the members of the community and to the vertical division of power and status. Finally the rules refer to the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system.*
>
> *(Engeström, 1993 p. 67)*

These elements form two inter-connected groups. The first group constitutes the *sphere of production* — the visible actions undertaken within the system directed towards achieving the desired goals, but these are merely the 'tip of the iceberg'. Underlying these elements are the *social, cultural and historic conditions* within which the goals are sought, and these two groups of elements, and the dialectic between them, together constitute an activity system.

As noted above, we believe that the most useful starting point for analysis is to analyse classroom as an activity system. It would, of course, be possible to consider the whole school, or even the wider community as an activity system, but such an analysis would necessarily ignore the particularities of the features of individual classrooms that would in our view paint too simplistic a picture. At the other extreme, we could view small groups of students in classrooms as an activity system, with the classroom as the wider context in which they act, but such groups are not well defined in most of the classrooms we observed, and thus would be rather artificial. Adopting the classroom as the activity system allows other sources of influence to be taken into account. The students' motivations and beliefs are strongly shaped by their lives outside the school, whilst the classroom is itself embedded in the context of a particular school

How teachers act, and students participate, in classrooms studying particular subjects will be influenced by their experiences in other subject classrooms, by the ethos of the school, and by the wider community. Therefore, we believe that it is important that the activity system is the *subject* classroom. There are important differences between a group of students and a teacher gathering in a particular place for the learning of mathematics and those meeting to learn science or English. Whilst this view derives in part from the initial emphasis of our work on classrooms in secondary/high schools, our more recent experiences with primary schools also suggest that, in primary classrooms also, the subject being taught at the time exerts a strong influence on the way that formative practices are implemented.

Before considering the implications of treating the subject classroom as an activity system , we need to discuss in more detail the changes in the practice of the KMOFAP teachers . We shall do this in terms of four key aspects which we suggest provide the minimal elements of a theory of formative assessment. First we discuss changes in the relationship between the teacher's role and the nature of the subject discipline. Second we discuss changes in the teachers' beliefs about their role in the regulation of the learning process (derived from their implicit theories of learning). Third, we discuss the student-teacher interaction, focusing specifically on the role of feedback in this process, which involves discussion of the levels of feedback, the 'fine-grain of feedback, and a brief discussion of the relevance of Vygotsky's notion of the 'zone of proximal development' (ZPD) to the regulation of learning. The fourth element of the model is the role of the student.

While a theory that focuses on these four components and the way that they play out in the classroom may not have sufficient explanatory power to be useful, we do not believe that any

attempt to understand the phenomena that we are studying without taking these factors into account is likely to be successful. We have formulated these components because we believe, on the basis of the data available to us, that they form key inputs for the formulation of any theory. Our intention is also to show that these four components form a framework which can be incorporated in, and illuminated by, a treatment of the subject classroom as an activity system.

First component: Teachers, learners, and the subject discipline

As the project teachers became more thoughtful about the quality, both of the questions they asked and of their responses to students' answers, it became evident that the achievement of quality depended both on the relevance of questions and responses in relation to the conceptual structure of the subject matter, and on their efficacy in relation to the learning capacities of the recipients. Thus there is a need to analyze the interplay between teachers' views of the nature of the subject matter, particularly of appropriate epistemology and ontology, and the selections and articulation of goals and subject matter which follow on the one hand, and their models of cognition and of learning (new theories of cognition could well be central here—see Pellegrino et al., 1999) on the other. The types of classroom interaction entailed in the learning contexts of different subject matters will not necessarily have a great deal in common with one another.

Comparisons between our experiences of work with teachers of English, science and mathematics respectively have strengthened our view that the subject disciplines create strong differences between both the identities of teachers and the conduct of learning work in their classes (Grossman & Stodolsky 1994, Marshall, 2001). One clear difference between the teaching of English and the teaching of mathematics and science is that in the latter there is a body of subject matter that teachers tend to regard as giving the subject unique and objectively defined aims. It is possible to 'deliver' the subject matter rather than to help students to learn it with understanding, and even where help with understanding is given priority, this is often simply help that is designed to ensure that every student achieves the 'correct' conceptual goal.

In the teaching of writing, there is little by way of explicit subject matter to 'deliver', except in the case of those teachers who focus only on the mechanics in grammar, spelling and punctuation. So there is no single goal appropriate for all. Thus most teachers of this subject are naturally more accustomed to giving individual feedback to help all students to improve the quality of their individual efforts at written communication. There is a vast range of types of quality writing – the goal can be any point in a whole horizon rather than one particular point. These inter-subject differences might be less sharp if the aims of the teaching were to be changed. For example, open-ended investigations in mathematics or science, or critical study of the social and ethical consequences of scientific discoveries, are activities that have more in common with the production of personal writing or critical appreciation in English.

It is also relevant that many teachers of English, at least at high-school level, are themselves writers, and students have more direct interaction with the 'subject', through their own reading and writing, than they do with (say) science. Nevertheless, whilst teachers might naturally engage more with use of feedback than many of their science colleagues, the quality of the feedback that they provide, and the overall strategies in relation to the meta-cognitive quality of that feedback, still need careful, often radical, development.

While much research into teacher education and teacher development has focused on the importance of teachers' subject knowledge, such research has rarely distinguished between abstract content knowledge and pedagogical content knowledge (Shulman, 1986). A study of

elementary school teachers conducted for the UK's Teacher Training Agency in 1995-1996 (Askew et al., 1997) found no relationship between learners' progress in mathematics and their teachers' level of qualification in mathematics, but a strong positive correlation with their pedagogical content knowledge. This suggests that it is important to conceptualize the relationship between the teacher and the subject matter as a two-way relationship, in that the teacher's capacity to explore and re-interpret the subject matter is important for effective pedagogy.

What is less clear is the importance of change in the interaction between students and the subjects they are studying. In the main, most middle and high school students seem to identify a school subject with their subject teachers: the teacher generally mediates the student's relationship with the subject, and there cannot be said to be any direct subject-student interaction. However, one aim of the teacher could well be to enhance the learner's capacity to interact directly with the subject's productions, which would involve a gradual withdrawing from the role of mediator. The meaning to be attached to such a change, let alone the timing and tactics to achieve this end, will clearly be different between different subjects. In subjects that are even more clearly performance subjects, notably physical education and musical performance, feedback is even less problematic in that its purpose can be evident to both teacher and student, and it is clear that the learning is entirely dependent on it. The students-as-groups aspect may also emerge more clearly insofar as students work together to reproduce, or at least to simulate, the community practices of the subject areas, e.g. as actors in a stage drama, or as a team in a science investigation.

Second component: The teacher's role and the regulation of learning

The assessment initiatives of our project led many teachers think about their teaching in new ways. Two of them described the changes as follows:

I now think more about the content of the lesson. The influence has shifted from 'what am I going to teach and what are the pupils going to do?' towards 'how am I doing to teach this and what are the pupils going to learn?'

(Susan, Waterford School)

There was a definite transition at some point, from focusing on what I was putting into the process, to what the pupils were contributing. It became obvious that one way to make a significant sustainable change was to get the pupils doing more of the thinking. I then began to search for ways to make the learning process more transparent to the pupils. Indeed I now spend my time looking for ways to get pupils to take responsibility for their learning at the same time making the learning more collaborative. This inevitably leads to more interactive learning activities in the classroom.

(Tom, Riverside School)

These teachers' comments suggested a shift from the regulation of activity ("what are the pupils going to do?") to the regulation of learning ("what are the pupils going to learn?"). In considering such regulation, Perrenoud (1998) distinguishes two aspects of the teacher's action. The first involves the way the teacher plans and sets up any lesson. For this aspect, we found that a teachers' aim of improving formative assessment led them to change the ways in which they planned lessons, with a shift towards creating 'didactic situations'—in other words, they specifically designed these questions and tasks so that they generated 'teachable moments'—occasions when the teacher could usefully intervene to further learning. The second involves the teachers' actions during the implementation of such plans, determined by the fine detail of the way they interact with pupils. Here again teachers changed, using enhanced wait time and changing their roles from presentation to encouragement of dialogue

Overall, it is also clear from these quotations that the teachers were engaged in 'interactive regulation' by their emphasis on the transfer to the students of responsibility for their learning. This transfer led teachers to give enhanced priority to the need to equip students with the cognitive strategies required to achieve the transition to the new understandings and skills potentially accessible through the subject matter. This implied giving more emphasis on cognitive and meta-cognitive skills and strategies than is usually given in schools. Such changes were evident in the shifts in questioning, in the skilful use of comments on homework, and particularly in the new approach to the use of tests as part of the learning process. It is significant that, a few months into the project, the teachers asked the research team to give them a talk on theories of learning, a topic that we would have judged too theoretical at the start of the project.

Some teachers have seemed quite comfortable with this transfer of responsibility to students, and the implications for the change in the student's role, and in the character of the teacher-student relationships, are clear. However, some other teachers found such changes threatening rather than exciting. Detailed exploration of the trajectories of development of different teachers (see, for example, Lee, 2000, and Black *et al.* 2003) show that the changes have been seen as a loss of control of the learning, by some who were trying seriously to implement them. Although one can argue that, objectively, the teacher's control was going to be just as strong and just as essential, subjectively it did not feel like that to these teachers, in part because it implied a change in their conception of how learning is mediated by a teacher. Such a change alters the whole basis of 'interactive regulation' which is discussed in more detail in the following section.

Third component: Feedback and the student-teacher interaction

The complex detail of feedback

It emerges from the above discussion that in the four-component model that we propose, the crucial interaction is that between teacher and student, and this is clearly a central feature in any study of formative assessment. As already pointed out, our starting position was based in part on the seminal paper of Sadler (1989) on formative assessment. One main feature of his model was an argument that the learner's task is to close the gap between the present state of understanding and the learning goal, that self-assessment is essential if the learner is to be able to do this, and that the teacher's role is to communicate appropriate goals and to promote self-assessment as students work towards them. In this process, feedback in the classroom should operate both from teacher to students and from students to the teacher.

Perrenoud (1998) criticised the treatment of feedback in our 1998 review. Whilst we do not accept some of his interpretations of that paper, his plea that the concept of feedback be treated more broadly, as noted earlier, is a valuable comment. The features to which he drew attention were:

- the relationship of feedback to concepts of teaching and learning;
- the degree of individualisation (or personalisation of the feedback);
- the way the nature of the feedback affects the cognitive and the socio/affective perspectives of the pupils;
- the efficacy of the feedback in supporting the teachers intentions for the pupils' learning;

- the synergies between the feedback and the broader context of the culture of classroom and school, and the expectations of the pupils

Some aspects of these points have already been alluded to above. However, a more detailed discussion is called for, which will be set out here under three headings, namely, the different levels of feedback, the fine-grained features of feedback, and the relevance of Vygotsky's notion of the zone of proximal development (and in particular the importance of differentiation).

Levels of feedback

The enactment of a piece of teaching goes through a sequence of stages, viz.:

(a) a design with formative/feedback opportunities built in;

(b) implementation in which students' responses are evoked;

(c) reception and interpretation of these responses by a teacher (or by peers);

(d) further teaching action based on the interpretation of the responses;

(e) reception and interpretation of these responses by the student;

(f) moving on to the next part of the design.

This is set out to make clear that both students (in b and e) and teachers (in c and d) are involved in feedback activities. Feedback can involve different lengths of loop, from short term loops, i.e. c to d to e and back to c, to longer term loops around the whole sequence, i.e. a to e and then back again when the whole sequence may be re-designed. The concept of regulation involves all of these.

Two points made by Perrenoud are relevant here. One is to emphasize that the mere presence of feedback is insufficient in judging the guidance of learning (see Deci & Ryan, 1994). The other is that learning is guided by more than the practice of feedback. In particular, not all regulation of learning processes uses formative assessment. If, for example, the teaching develops metacognitive skills in the students, they can then regulate their own learning to a greater extent and thus become less dependent on feedback from others. More generally, it is important to look broadly at the 'regulation potential' of any given learning activity, noting however that this depends on the context, on what students bring, on the classroom culture that has been forged 'upstream' (i.e. the procedures whereby a student comes to be placed in a context, a group, a situation), and on ways in which students invest themselves in the work. Several of the project teachers have commented that now when they take a class substituting for an absent teacher, the interactive approaches that they have developed with their own classes cannot be made to work.

The fine-grain of feedback

Whilst the inclusion in our framework of models of learning, of teachers' perceptions of the subject matter, and of their pedagogical content knowledge, deals in principle with the necessary conditions for effective feedback, these are but bare bones, and in particular may mislead in paying too little attention to the complexity of what is involved. The complexities are discussed in some detail by Perrenoud, and some of his main points are briefly summarized here.

The messages given in feedback are useless unless students are able to do something with them. So the teacher needs to understand the way students think and the way in which they take in new messages both at general (subject discipline) and specific (individual) levels. The problem is that this calls for a theory of the mental processes of students that does not exist (although some foundations have been laid: see Pellegrino, *et al.,* 2001). Teachers use intuitive rudimentary theories, but even if good theory were to be available, applying it in any specific context would be a far from straightforward undertaking.

For both the teacher, and any observer or researcher, it follows that they can only draw conclusions from situations observed in the light of theoretical models. As Perrenoud (1998) argues:

Without a theoretical model of the mediations through which an interactive situation influences cognition, and in particular the learning process, we can observe thousands of situations without being able to draw any conclusions. (p.95)

In framing and guiding classroom dialogue, judgments have to be grounded in activity but to achieve detachment from it (i.e. to transcend it) in order to focus on the knowledge and the learning process. The teacher's intervention to regulate the learning activity has to involve:

> *. . . an incursion into the representation and thought processes of the pupil to accelerate a breakthrough in understanding, a new point of view or the shaping of a notion which can immediately become operative. (p.97)*

Torrance and Pryor (1998) studied the fine grain of feedback through video recordings on episodes in primary school classrooms. Many of their findings echo those of our study , albeit as an analysis of the variations of practice between teachers rather than as part of an intervention. What they are keen to emphasise is the complexity of the social interaction in a classroom, which leads them to look closely at the issues of power, mainly as exercised by teachers at different levels e.g exerting *power over* with closed questioning, or sharing *power with* (Kreisberg 1992) using more open questioning. They also give an example of how feedback that does no more than guide a group discussion which the teacher is mainly trying to observe, transfers power, but that this is then unevenly distributed amongst the pupils.

The zone of proximal development and differentiation

Sadler's emphasis on the teacher's task in defining the gap between what the learner can achieve without help and what may be achieved with suitable help, and the fact that this lays emphasis on the social and language aspects of learning, might seem to connect directly with a common interpretation of Vygotsky's concept of a Zone of Proximal Development (Vygotsky, 1986). Also relevant are the concepts of *scaffolding* as developed by Wood, Bruner and Ross (1976), and Rogoff's (1990) broader notion of *guided participation,* which serve to emphasise and clarify the role of the teacher.

However, discussions of the ZPD are difficult to interpret without knowing precisely how the authors interpret the concept. Here we draw on the analysis of Chaiklin (2005, who points out that for Vygotsky, the zone has to be defined in terms of a model of development, in which different 'ages' of development are defined as a sequence of coherent structures of interacting intellectual functions. A particular learner will have achieved a particular 'age' of development, and possess immature but maturing functions which will lead to the next 'age'. In an interactive situation, one which may be aimed at diagnosis rather than for specific teaching purposes, the learner may be able to share, in collaboration, only the mature functions :

> *"the area of immature, but maturing, processes makes up the child's zone of proximal development" (Vygotsky 1998 p.202).*

Teaching should then focus on those maturing functions which are needed to complete the transition to the next age period. Whilst the age periods are objectively defined, the ZPD of each learner will be subjectively defined. Interventions such as those of the thinking skills programmes (Shayer & Adey, 1993) may succeed because they focus on maturing processes of general impotance. It follows that what is needed is learning tasks in which the learner is involved, in interaction with others, and which will serve to identify the particular areas of intellectual function which, in relation to achieving the next 'age' of development for that learner, are still immature. This has to be done in the light of a comprehensive model of 'ages' of intellectual development.

This is clearly a task of immense difficulty, one that is far more complex than that implied by the notion of a 'gap' than many see implied by Sadler's analysis. It is probably true that less sophisticated notions of a 'gap', and of scaffolding interventions to close such a gap, are of practical value. However, they cannot be identified with Vygotsky's concept of the ZPD, and they will not attend to the real complexity of the obstacles that learners encounter in advancing the maturity of their learning.

The argument serves to bring out the point that success in fostering and making use of enhanced teacher-student interactions must depend on the capacity to adapt to the different ZPDs in a class, i.e. on the capacity of the teacher to handle differentiation at a rather subtle level of understanding of each learner. However, it does not follow that the problem reduces to a one-on-one versus whole class dichotomy, for social learning is a strong component of intellectual development and capacity to learn in interaction is an essential diagnostic tool. Self-assessment, peer-assessment, peer-teaching and group learning in general have all been enhanced in our project's work, and the way that the need for differentiation is affected by these practices remains to be studied. The fact that in some research studies enhanced formative assessment has produced the greatest gains for those classified initially as 'low-achievers' may be relevant here.

The overall message seems to be that in order to understand the determinants of effective feedback, or, to broaden the perspective, to detect and interpret indicators of effective regulation, we need theoretical models that acknowledge the situated nature of learning (Greeno et al, 1998) and of the operation of teaching situations, we have to understand the context of the schemes of work of teachers, and we have to study how they might plan for and interact on the spot to explore and meet the needs of different pupils. This sets a formidable task for any research study of formative work in the classroom.

Fourth component: The student's role in learning

The perceptions of our teachers, as reported above, are that their students have changed role, from being passive recipients to being active learners who can take responsibility for, and manage, their own learning. One teacher reported this as follows:

> *They feel that the pressure to succeed in tests is being replaced by the need to understand the work that has been covered and the test is just an assessment along the way of what needs more work and what seems to be fine. […] They have commented on the fact that they think I am more interested in the general way to get to an answer than a specific solution and when Clare [a researcher] interviewed them they decided this was so that they could apply their understanding in a wider sense.*
>
> *(Belinda, Cornbury Estate School)*

Other, albeit very limited, interviews with students have also produced evidence that students saw a change in that their teacher seemed really interested in what they thought and not merely on whether they could produce the right answer. Indeed, one aspect of the project has

been that students responded very positively to the opportunities and the stimulus to take more responsibility for their own learning.

These changes can be interpreted in terms of two aspects. One, already mentioned in an earlier section, is the development of meta-cognition, involving as it must some degree of reflection by the student about his or her own learning (Hacker *et al.*, 1998). Of significance here also is the concept of self-regulated learning as developed by Schunk (1996) and Zimmerman and Schunk (1989), and the findings of the Melbourne Project for Enhanced Effective Learning (PEEL) summarized in Baird & Northfield (1992).

Analysis of our work may be taken further along these lines, by relating it to the literature on 'meta-learning' (Watkins *et al*. 2001). Many of the activities described in our first section could readily be classified as meta-cognitive, on the part of both teachers and their students. The distinction, emphasized by Watkins *et al*., between 'learning orientation' and 'performance orientation' (see Dweck, 1986, 2000) is also intrinsic to our approach. The achievement of meta-learning is less clear, for what would be required is that students had reflected on the new strategies in which they had been involved, and would seek to deploy them in new contexts. The practice of active revision in preparation for examinations, or the realization that one needs to seek clarity about aims if one is to be able to evaluate the quality of one's own work, may well be examples of meta-learning, but evidence about student's perceptions and responses to new challenges would be needed to support any claims about outcomes of this type.

A second aspect, reflected in changes in the students' perceptions of their teacher's personal interest in them, is the conative and affective aspects. Mention has been made above, in the account of the abandonment of the giving of marks or grades on written work, of Butler and Neuman's (1995) account of the importance of such a change. It's not merely that a numerical mark or grade is ineffective for learning because it does not tell you what to do, it also affects your self-perception. If the mark is high, you're pleased but have no impetus to do better, if it is low it might confirm your belief that you are not able to learn the subject. Many other studies have explored the negative effects not only on learning, but also on self-concept, self-efficacy and self-attribution, of the classroom culture in which marks and grades come to be a dominant currency of classroom relationships (see e.g. Ames, 1992; Cameron & Pierce, 1994; Butler & Winne, 1995; Vispoel & Austin, 1995). In particular, as long as students believe that effort on their part cannot make much difference because of their lack of 'ability', efforts to enhance their capability as learners will have little effect.

The importance of such issues is emphasised by Cowie's (2004) study which explored pupils' reactions to formative assessment. One of her general findings was that pupils are, in any activity, balancing three goals simultaneously, namely completion of work tasks, effective learning, and social-relationship goals. When these conflict, they tend to prioritise the social-relationship goals at the expense of learning goals: so, for example, many will limit disclosure of their ideas in the classroom for fear of harm to their feelings and reputation. The way in which the teacher deals with such disclosures is crucial. The respect shown them by their teacher and their trust in that teacher affects their response to any feedback – they need to feel safe if they are to risk exposure. Cowie also found that the students' responses to formative feedback cannot be assumed to be uniform. Some prioritise learning goals and so look for thoughtful suggestions, preferably in one-to-one exchanges, whilst others pursue performance goals and so want help to complete their work without the distraction of questions about their understanding. Sadly, many felt that the main responsibility for their learning rested with the teacher and not with themselves. In an activity theory representation , all of the issues raised by such work are represented by the element labelled 'community'; the

connections of this element with the other elements of the diagram are both important and complex.

Much writing about classroom learning focuses either on the learner as individual or on learning as a social process. Our approach has been to treat the social-individual interaction as a central feature, drawing on the writings on Bredo (1994) and Bruner (1996). Thus, feedback to individuals and self-assessment has been emphasized, but so have peer-assessment, peer support in learning, and class discussions about their learning.

For the work of students in groups, the emphasis by Sadler (1989, 1998) and others that peer assessment is a particularly valuable way of implementing formative assessment has been amply borne out in the work reported here. Theoretically, this perspective ought to be evaluated in the broader context of the application to classrooms and schools of analyses of the social and communal dimensions of learning, as developed, for example in Wenger's (1998) study of communities of practice. These points are illustrated by the following extract from an interview with a student in the KMOFAP project discussing peer marking of his investigation:

> *After a pupil marking my investigation, I can now acknowledge my mistakes easier. I hope that it is not just me who learnt from the investigation but the pupil who marked it did also.*
>
> *Next time I will have to make my explanations clearer, as they said 'It is hard to understand', so I must next time make my equation clearer. I will now explain my equation again so it is clear.*

This quotation also bears out Bruner's (1996) emphasis on the importance of externalizing one's thoughts by producing objects or *oeuvres* which, being public, are accessible to reflection and dialogue, leading to enrichment through communal interaction. He points out that awareness of one's own thinking, and capacity to understand the thinking of others, provides an essential reasoned base for interpersonal negotiation that can enhance understanding.

The importance of peer-assessment may be more fundamental than is apparent in accounts by teachers of their work. For self-assessment, each student has to interact mainly with text; interactions with the teacher, insofar as they are personal, must be brief. Discussing the work of Palincsar and Brown (1984) on children's reading, Wood (1998) states:

> *This work, motivated by Vygotsky's theory of development and by his writings on literacy, started from the assumption that some children fail to advance beyond the initial stages of reading because they do not know how to 'interact' with text – i.e. they do not become actively engaged in attempts to interpret what they read. Briefly, the intervention techniques involved bringing into the open, making public and audible, ways of interacting with text that skilled readers usually undertake automatically and soundlessly. (p. 220-1, emphasis in original)*

Thus if a student's interpretation of aims, and of criteria of quality of performance, is to be enriched, such enrichment may well require 'talk about text', and given that it is impracticable to achieve this through teacher-student interactions, the interactions made possible through peer-assessment may meet an essential need.

Overall, it is clear that changes in the student's role as a learner are a significant feature in the reform of classroom learning, that our formative assessment initiative has been effective in its impact on these features, and that changes in the student's own beliefs and implicit models of learning also underlie the developments involved.

Applying activity theory

In considering the interpretation of these four components in terms of a representation of the subject classroom as an activity system, we concentrate mainly on the 'tip of the iceberg': subjects, objects and cultural resources, and the relationships between these three elements. As will be clear in our exposition of these ideas, the nature of these relations is strongly influenced by the other elements of activity systems i.e. rules, community and division of labor) The discussion of these relationships will be brief – a full exploration would require a far longer treatment than is possible here.

In the activity system of the subject classroom, the *tools* or cultural resources that appear to be particularly important in the development of formative assessment are:

- views and ideas about the nature of the subject, including pedagogical content knowledge
- methods for enhancing the formative aspects of interaction, such as rich questions, ideas about what makes feedback effective, and techniques such as 'traffic lights' and so on
- views and ideas about the nature of learning

The *subjects* are, as stated earlier, the teacher and the students, although it is important to acknowledge that it useful to distinguish between students as individuals and students in groups in the classroom (Ball and Bass, 2000).

The *object* in most of the subject classrooms we studied was increased student success, either in terms of better quality learning, or simply better scores on state-mandated tests. Many teachers spoke of their interest in participating in the project because of the promise of better results. However, as well as this object, which, as noted above, was secured by most of the participating teachers, the *outcomes* of the projects included changes in the expectations that teachers had of their students, and also changes in the kinds of assessments that these teachers used in their routine. The most important change in the teachers' own assessments was a shift towards the use of assessments that provided information for the teacher not only about who had learnt what, but also provided some information about why this was, and in particular, when interpreted appropriately, gave insights into what to do about it—in other words, a shift towards assessments that could be formative *for the teacher*.

«Figure 1 about here»

Figure 1 represents how the various components of the theoretical framework outlined above and their inter-relationships.. Components 1, 2 and 4 are represented as tools, while component 3 is represented in the links between the teacher and the students (both individually, and in groups). Solid headed arrows are used to represent the key influences in the KMOFAP project. Using this framework, the course of the project can be seen as beginning with *tools* (in particular findings related to the nature of feedback and the importance of questions) which prompted changes in the relationship *between the subjects* (i.e. in the relationship between the teacher and the students) which in turn prompted changes in the *subjects* themselves (i.e. changes in the teacher's and students' roles). These changes then triggered changes in other *tools* such as the nature of the subject and the view of learning. In particular, the changes prompted in the teachers' classroom practices involved moving from simple associationist views of learning to embracing constructivism, taking responsibility for learning linked to self-regulation of learning, metacognition and social learning.

Figure 1 does not represent the activity system in the canonical way. This more common representation, using the nested triangles, is shown in Figure 2. Here, the relationships are

brought out more clearly by allocating tools are at the apex and subjects, and objects and outcomes, for the base of the upper triangle. Thus it would be possible in principle to map figure 1 into the this part of figure 2, but the much of the detail would either be lost or appear confusingly complex.

«Figure 2 about here»

However, what the canonical representation would make more explicit are the elements in the lowest row of figure 2 and their links with the rest. Whilst the community, deemed as the subject classroom, is a given, both the *rules* and the *division of labour* are changed by a formative innovation. For the *rules*, if teachers cease to give grades or marks on homework in order to focus on feedback through comments, they may be in conflict with management rules and parental expectations for many schools – although in two of the KMOFAP schools those rules were eventually changed, the new rule being, for the whole school, that marks and grades were not to be given as feedback on written homework. The more pervasive '*rule*', that schools are under pressure to produce high grades in national tests, did limit some formative developments, and it is clear that synergy between teachers formative practices and their responsibilities for summative assessments would be hard to achieve without some room for manoeuvre in relation to high-stakes testing.

The *division of labour* is a feature that is radically transformed, as made clear in the second component for changes in the teacher's role, and in the fourth component for changes in the student's role. One aspect of the transfer of power and responsibility that is involved here is that the students begin to share ownership of the tools, for example by involvement in summative testing processes, and by becoming less dependent on the teacher for their access to subject knowledge.

What is obvious from this discussion is that there are strong interactions between the various elements of the system. This suggests that any attempt to record and interpret the dynamics of change as an innovation, notably in formative assessment, could do well to adopt and adapt an activity theory approach along the lines sketched here.

Strategies for development

KMOFAP and BEAR

It is useful at this point to contrast the approach adopted in our project with an alternative strategy, clearly exemplified in the BEAR project (Wilson & Sloane 2000), a project which is impressive in the evidence of learning gains associated with the emphasis on formative assessment. This differed from the work described in the first part of this paper in the following ways:

- it was part of a curriculum innovation into which were 'embedded' new formative assessment practices;
- an important aim was to secure and establish the reliability and validity of 'alternative' assessment practices so that assessment by teachers could withstand public scrutiny and claim equal status with the external standardized tests which have such negative effects on education in the USA;
- the aims were formulated as a profile of a few main components, with each component being set out as a sequence of levels to reflect the expected progression of learning within each;

- the assessment instruments were written tests provided externally, some to be used as short term checks on progress, some longer to be used a medium term checks;
- whilst formative use was emphasized, there was very little account of the ways in which feedback was deployed or received by students.

To over-simplify, it could be said that the apparent weakness of the BEAR project is in those aspects in which our project was strong. At the same time, its strengths, in the quality of the assessment instruments and the rigor in their use and interpretation, throws into sharp relief the weakness of our project, for the cognitive quality of the questions used by our teachers and of their feedback comments, whether oral or written, still needs further attention. Whilst the two approaches may be seen as complementary, and each may have been the optimum approach for the particular context and culture or which it was designed to operate, there remains the issue of whether some aspects of either could be incorporated, albeit at a later stage in implementation, in the other.

In terms of our model, the BEAR project imports theories of the subject and of learning and requires teachers to work to these models, but is not explicit on the nature of the teacher-student interactions or on the changes of in the roles of either teachers or students. Thus the project does not seem to have affected the classroom community through any significant change in the division of labour. Similar, although not identical, contrasts could be drawn by analysis of many of the research initiatives described in the 1998 review by Black and Wiliam. The contrast between our work and the work of the BEAR project is brought out clearly in figure 1, which shows the patterns of influence in the two projects.

This comparison can help to draw attention to the options available in any program of teacher development. The partial successes of our own approach have a peculiar significance in that they have led to changes transcending the boundaries envisaged in our initial concentration on formative assessment. This expansion may in part have arisen because of our emphasis on the responsibility of the teachers as partners with us, sharing responsibility for the direction of change. It might have been predictable that their initiatives would broaden the scope, because their work has to marry into the full reality of classroom work and cannot be limited to one theoretically abstracted feature. Indeed we have come to think of formative assessment as a 'Trojan Horse' for more general innovation in pedagogy – a point to which we shall return in the concluding section below.

Other related research and development studies

The BEAR study was similar in many respects to our own, so it is particularly interesting to explore the comparison in detail. However, we have developed the view that what is at issue is a theory of classroom pedagogy, and from this perspective, the number of relevant studies becomes far too great for any synthesis to be attempted here.

Three examples of related studies may suffice to indicate possibilities. The first is the Cognitive Acceleration work associated with Shayer (1999). In comparison with the cognitive acceleration initiative, our formative intervention did not target specific reasoning skills and so does not call for ad hoc teaching, although within the set piece lessons of that initiative many of the practices have much in common with the formative practices. In terms of the scheme of figures 1, the work involves very specific *tools*, and is characterised by a more explicit – and thereby less eclectic – *learning analysis* which impacts directly on the *role of the teacher*. It resembles the BEAR project in these respects, but it does not resemble it in respect of the direct link to *externally set tests and criteria*.

A second example is the work on "Talk Lessons" developed by Neil Mercer and colleagues (Mercer 2000, Mercer et al. 2004). These lessons could indeed be seen as a powerful way of

strengthening the development of peer-assessment practices in enhancing pupils' capacity to learn. This initiative develops different specific tools, but it also, in terms of figure 1, works to direct links between *the learning analysis*, *the interaction methods*, and the division of labour by focussing its effort on *the role of the student in a group.*

The third example is related to the second, but is the broader field summarised in Alexander's (2004) booklet *Towards Dialogic Teaching*, which draws on a range of studies of classroom dialogue. The main argument here starts from the several studies which have shown that classroom dialogue fails to develop pupils' active participation, reducing dialogue to a ritual of superficial questions in a context of 'delivery' teaching in which thoughtful participation cannot develop. His arguments call for emphasis on all three of the *tools* areas in figure 1, but also puts extra emphasis on the community element represented directly in figure 2, but only indirectly in the connecting arrows between teacher role and student roles in figure 1.

Conclusions and Implications

We have focussed the discussion in this chapter on our own study, in part because our approach to theory was grounded in that work, in part because we do not know of any other study which is grounded in a comparably comprehensive and sustained development with a group of teachers. Whilst we regard the theory as a promising start, there is clearly further work to be done in developing it and relating empirical evidence to it.

If we consider the potential value of the four component model that we have explored and discussed, an obvious outcome is that it could be used to suggest many questions which could form the starting point for further empirical research, many of which would require fine-grained studies of teacher-student interactions (see e.g. Torrance and Pryor, 1998; Cowie, 2004). However, the more ambitious target for this chapter is a more fundamental one - to help guide the direction and interpretation of further research through the theoretical framework that is proposed.

We have explored above, very briefly, the possibility for developing the theory through attempting new interpretations of initiatives already published. This exploration, which involves attempting to embed the formative aspect in a broader view of pedagogy, reflects the point made by Perrenound, quoted at the beginning of this chapter, that it is necessary to consider formative feedback in the wider context of '*models of learning and its regulation and their implementation'*. This may seem to be over-ambitious in attempting a complete theory of pedagogy rather than of that particular aspect of pedagogy which is labelled formative assessment. However, such an attempt seems inevitable given our experience, namely that our initially limited aim of developing formative assessment led to much more radical changes.

One function of a theoretical framework should be to guide the optimum choice of strategies to improve pedagogy, by identifying those key determinants that have to be evaluated in making such choices and in learning lessons from experiences in other contexts. It follows that the framework might be used retrospectively to evaluate, retrospectively or prospectively, the design of the any initiative in teaching and learning. In the case of the KMOFAP initiative, it should help answer the question of whether it was the optimum way of devoting effort and resources for the improvement of classroom pedagogy. This would seem a very difficult question to answer in the face of the potential complexity of the comprehensive theory of pedagogy that might provide the basis for an answer. However, some significant insight can be distilled in a way that can at least help resolved the puzzle of the project's unexpected success, represented by the metaphor of the Trojan Horse mentioned in the previous section.

The argument starts by pointing out that the examples of the changes that the teachers described seem to confirm that working at improving the teacher-student interaction through formative assessment can serve to catalyse changes in both the teacher's role and those adopted by that teacher's students. The changes motivate, perhaps demand, changes in the various interactions of both students and teachers with their theories of learning and with the ways in which they perceive and relate to subject matter that they are teaching. Thus, whilst we cannot argue that development of formative assessment is the only way, or even the best way, to open up a broader range of desirable changes in classroom learning, we can see that it may be peculiarly effective, in part because the quality of interactive feedback is a critical feature in determining the quality of learning activity, and is therefore a central feature of pedagogy.

We might also speculate that a focus on innovation in formative assessment might be productive because many teachers, regardless of their perceptions of their teaching role and of the learning roles of their students, can see the importance of working on particular and limited aspects of feedback, but might then have their perspectives shifted as they undertake such work. In the project, the tools provided led teachers to think more deeply – about their pedagogical content knowledge, about their assumptions about learning, and about their interactions with their students, hence activating for them all of the components of our framework.

Given that development of formative assessment has this peculiar potential to catalyse more radical change, a theory which helps design and track such change would be an important resource. The approach sketched out here may help such tracking, in that the fact that the components of our model, interpreted in terms of an activity system framework, do seem to interact strongly and dynamically, would help in interpreting any change process. A central feature may be that inconsistencies between the various elements of the classroom system are hard for the actors to tolerate. The interaction lines in the frameworks of figures 1 and 2 are all-important, for they signal that any innovation that succeeds in changing one element might well de-stabilize the existing equilibrium, so that the whole pattern of pedagogy is affected to achieve a new equilibrium.

Acknowledgements

We acknowledge the support given by the Nuffield Foundation in funding the first phase of the KMOFAP, and by the National Science Foundation for funding the subsequent phase through their support of our partnership with the Stanford CAPITAL project (NSF Grant REC-9909370). This present paper reports findings of our work in England to date: comparative and synthesizing findings with the Stanford partners will be subjects for later study.

We are grateful to Sue Swaffield from Medway and Dorothy Kavanagh from Oxfordshire who, on behalf of their authorities, helped to create and nurture our links with their schools. The teachers in this project have been the main agents of its success. Their willingness to take risks with our ideas was essential, and their voices are an important basis for the main message of this paper.

References

Alexander, R. (2004) *Towards Dialogic Teaching: Rethinking classroom talk.* Cambridge UK: Dialogos, Cambridge Faculty of Education.

Ames, C. (1992). Classrooms: Goals, Structures, and Student Motivation. *Journal of Educational Psychology,* **84** (3), 261-271.

Askew, M., Brown, M. L., Rhodes, V., Johnson, D. C. & Wiliam, D. (1997). *Effective teachers of numeracy: final report*. London, UK: King's College London School of Education.
Baird, J.R. & Northfield, J.R. (1992) *Learning from the PEEL Experience*. Melbourne: Monash University.
Ball, D. L. & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: knowing and using mathematics. In J. Boaler (Ed.) *Multiple perspectives on mathematics teaching and learning* (pp. 83-104). Westport, CT: Ablex.
Black, P.; Harrison, C.; Lee, C.; Marshall, B. & Wiliam, D. (2003). *Assessment for learning: putting it into practice*. Buckingham, UK: Open University Press.
Black, P. & Wiliam, D (1998a). Assessment and Classroom Learning. *Assessment in Education* **5**(1), 7-73.
Bredo, E. (1994) Reconstructing Educational Psychology. *Educational Psychologist,* **29** (1), 23-45.
Bruner, J. (1996) *The Culture of Education.* Cambridge MA: Harvard University Press
Butler, D. L. & Winne, P. H. (1995). Feedback and Self-Regulated Learning: A Theoretical Synthesis. *Review of Educational Research,* **65** (3), 245-281.
Butler, R. & Neuman, O. (1995). Effects of Task and Ego-Achievement Goals on Help-Seeking Behaviours and Attitudes. *Journal of Educational Psychology,* **87** (2), 261-271..
Chaiklin, S. (2005) The Zone of Proximal Development in Vygotsky's analysis of learning and instruction. On web site http://www.education.miami.edu/blantonw/mainsite/componentsfromclmer/Component5/ChaiklinTheZoneOfProximalDevelopmentInVygotsky.html
Cameron, J. & Pierce, D. P. (1994). Reinforcement, Reward, and Intrinsic Motivation: A Meta-Analysis. *Review of Educational Research,* **64** (3), 363-423.
Cowie, B. (2004) *Student commentary on formative assessment.* Paper given at the annual conference of the National Association for Research in Science Teaching. Vancouver Marh 2004.
Deci, E.L. & Ryan, R.M. (1994). Promoting Self-determined Education. *Scandinavian Journal of Educational Research,* **38**(1), 3-14.
Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist (Special Issue: Psychological science and education),* **41** (10), 1040-1048.
Dweck, C.S. (2000) *Self-Theories: Their role in motivation, personality and development*. Florence KY: Psychology Press
Engeström, Y. (1987). *Learning by expanding. An activity-theoretical approach to developmental research.* Helsinki, Finland: Orienta-Konsultit Oy.
Engeström, Y. (1993). Developmental studies of work as a testbench of activity theory: the case of primary care in medical education. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: perspectives on activity and context* (pp. 64-103). Cambridge, UK: Cambridge University Press.
Gibson, J. J. (1979). *The ecological approach to visual perception*. London, UK: Houghton Mifflin.
Greeno, J. G. & The Middle-School Mathematics Through Applications Project Group (1998). The situativity of knowing, learning and research. *American Psychologist,* **53**(1), 5-26.
Grossman, P.L. & Stodolsky, S.S. (1994) Considerations of Content and the Circumstances of Secondary School Teaching. *Review of Research in Education.* **4**, 179-221.
Hacker, D. J.; Dunlosky, J. & Graesser, A. C. (1998). *Metacognition in educational theory and practice*. Mahwah, NJ: Lawrence Erlbaum Associates.
Holland, D.; Lachicotte Jr, W.; Skinner, D. & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.
King, A. (1995). Inquiring minds really do want to know - using questioning to teach critical thinking. *Teaching Of Psychology,* **22** (1), 13-17.
Kreisberg, S. (1992) *Transforming Power: Domination, Empowerment and Education*. New York :State University of New York Press
Lave, J. & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
Lee, C. (2000, September) *Studying changes in the practice of two teachers.* Paper presented at Symposium entitled 'Getting Inside the Black Box : Formative Assessment in Practice' at the British Educational Research Association 26th annual conference held at Cardiff University. London, UK: King's College London School of Education..
Marshall, B. (2001) Formative Assessment in English. Private communication - in preparation for publication.
Mercer, N. (2000) *Words and Minds* London: Routledge.
Mercer, N., Dawes, L., Wegerif, R. and Sams, C. (2004) Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Research Journal 30*(3), 359-377.
Nisbet, J. & Shucksmith, J. (1986) *Learning Strategies.* London: Routledge & Kegan Paul
Palincsar, A.S. & Brown A.L. (1984) *Reciprocal teaching of comprehension fostering and monitoring activities: cognition and instruction.* Hillsdale, N.J.: Lawrence Erlbaum.
Pellegrino, J.W., Baxter, G.P. & Glaser, R. (1999) Addressing the 'Two Disciplines' problem: Linking Theories of Cognition with Assessment and Instructional Practice. *Review of Research in Education*. **24**, 307-353.
Pellegrino, P., Chudowsky, N. & Glaser, R. (2001) *Knowing What Students Know.* Washington DC: National Academies Press

Perrenoud, P. (1998). From Formative Evaluation to a Controlled Regulation of Learning Processes. Towards a wider conceptual field. *Assessment in Education.* **5** (1), 85-102.
Rogoff, B. (1990) *Apprenticeship in Thinking: Cognitive Development in Social Context.* Oxford: Oxford University Press
Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science,* **18**, 119-144.
Sadler, D.R. (1998) . Formative Assessment: revisiting the territory. *Assessment in Education,* **5**(1), 77-84.
Salomon, G. (1993). Introduction. In G. Salomon (Ed.), *Distributed cognitions: psychological and educational considerations*. Cambridge, UK: Cambridge University Press.
Schunk, D. H. (1996). Goal and Self-Evaluative Influences During Children's Cognitive Skill Learning. *American Educational Research Journal,* **33** (2), 359-382.
Shayer, M. (1999) Cognitive acceleration through science education II: its effects and scope. *International Journal of Science Education*. 21(8): 883-902.
Shayer, M. & Adey, P. (1993) Accelerating the development of formal thinking in middle and high-school students 4. 3 years after a 2-year intervention. *Journal of Research in Science Teaching.* **30**, 351-366.
Shulman, L. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher,* **15**(1), 4-14.
Torrance, H. & Pryor, J. (1998*). Investigating Formative Assessment: teaching, learning and assessment in the classroom.* Buckingham: Open University Press.
Vispoel, W. P. & Austin, J. R. (1995). Success and failure in junior high school: A critical incident approach to understanding students' attributional beliefs. *American Educational Research Journal,* **32**(2), 377-412.
Vygotsky, L.S. (1986) *Thought and Language.* Cambridge, MA: Harvard University Press.
Vygotsky, L. S. (1998). The problem of age (M. Hall, Trans.). In R. W. Rieber (Ed.), The collected works of L. S. Vygotsky: Vol. 5. Child psychology (pp. 187-205). New York: Plenum Press. (Original work written 1933-1934)
Watkins, C., Carnell, E., Lodge, C., Wagner, P. & Whalley, C. (2001) *N.S.I.N Research Matters No.13: Learning about Learning enhances performance.* London: Institute of Education.
Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.
White, B.J. and Frederiksen, J.R. (1998) Inquiry, Modeling, and Metacognition: Making Science Accessible to all Students. *Cognition and Instruction*, **16** (1) pp 3-118
Wilson, M. & Sloane, K. (2000) From principles to practice: An embedded assessment system. *Applied Measurement in Education.* In press.
Wood, D. (1998*) How Children Think and Learn. The Social contexts of Cognitive Development* . 2nd edition. Oxford: Blackwell.
Wood, D., Bruner, J.S., and Ross, G. (1976) The role of tutoring in problem solving, *Journal of Child Psychology and Psychiatry, and Allied Disciplines,* **17**, 89-100.
Zimmerman, B.J. & Schunk, D.H. (eds.) (1989) *Self-Regulated Learning and Academic Achievement: Theory, Research, and Practice.* New York: Springer.

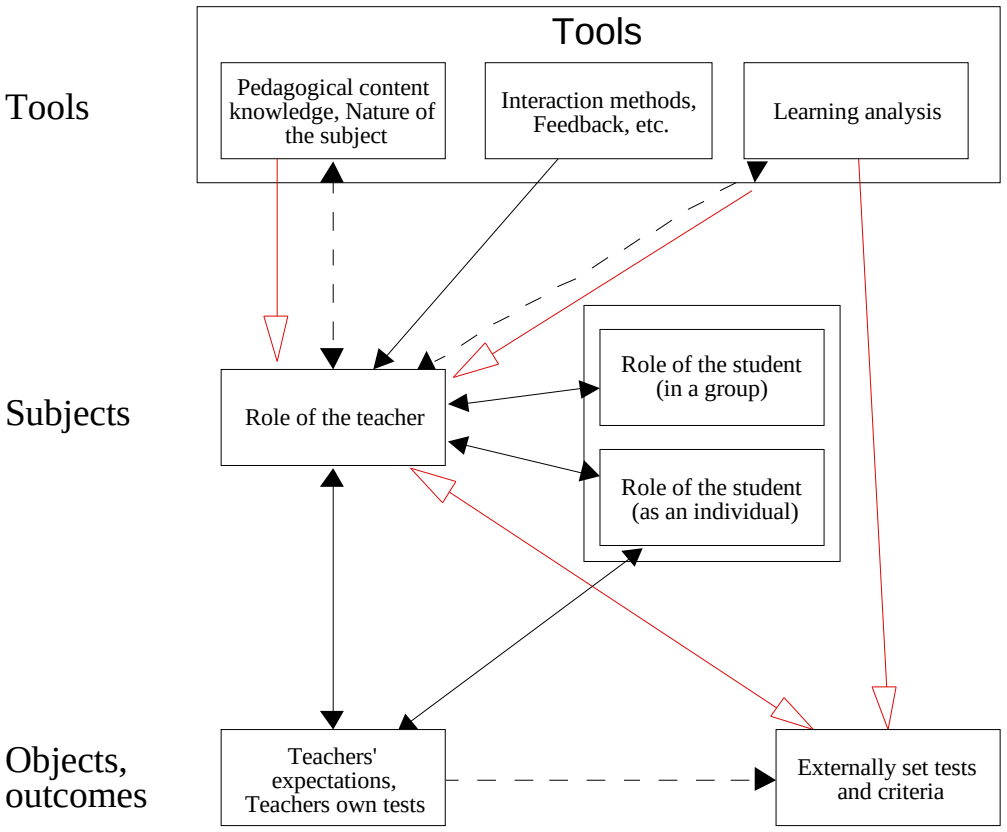

Figure 1: patterns of influence in the KMOFAP and BEAR projects (solid-headed arrows represent influences in KMOFAP; open-headed arrows represent influences in BEAR).

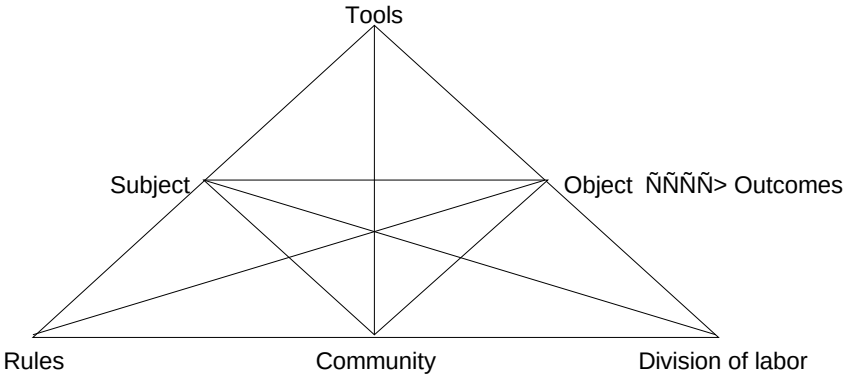

Figure 2: elements of activity systems (Engeström, 1987)