Report

S-TEAM

WP 4 Training materials Part 2

Pairform@nce

October 2010

Deliverable 4c

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Preface

This deliverable brings together three products, which involve teacher collaboration in the improvement of practice. Products 4.3 and 4.4, respectively the DVD (in French) and report (in English), describe the Pairform@nce project, which combines a web platform with computer simulations and collaborative teacher development activities. Product 4.6 describes a small-scale project in teacher action research, which points to the benefits of collaborative research into teachers' classroom practice. This is particularly important when teachers are being called upon to implement inquiry-based methods (IBST) in science and mathematics. As some of the other S-TEAM deliverables have shown[1], teacher confidence is key to the effective implementation of IBST. Mutual support and improvement through collaborative research into practice can provide this confidence.

The two sub-projects reported here approach teacher collaboration from two directions. Pairform@nce starts from the provision of a nationally available website and set of design resources, whereas the other sub-project reports on an activity stimulated by a single researcher. Both methods are shown to be effective, with their own strengths and weaknesses. The deliverable presented here will help policymakers and others to assess how best to encourage and support teacher collaboration, in order to promote inquiry based science teaching methods.

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[1] See, e.g deliverable 5a in this group, available from www.ntnu.no/s-team

In-service teacher education, collective teacher work and investigation in science with *Pairform@nce*

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Introduction

This section of the document provides a brief description of some teacher training activities based around the Pairform@nce platform in France. Its particular interest for S-TEAM is that it is designed to encourage inquiry-based science teaching, or classroom investigation, through the use of:

- Teacher collaboration
- A specific software platform to support teacher collaboration
- Software tools embedded in the platform for classroom modelling and simulations
- Face-to-face teacher meetings over an extended period
- Built-in provision for redesign as a result of user requirements or feedback

All these features are convergent with other S-TEAM training or teacher professional development (TPD) activities. For dissemination purposes the next phase of activity in connection with this deliverable is to circulate it within the project, in order for national partners outside France to assess its usefulness as a design concept. At the same time, the S-TEAM project, and in particular Work Package 4 led by Michel Grangeat, has created a number of dissemination routes to make Pairform@ance better known and accepted in France.

There is an accompanying DVD, which describes the main features of Pairform@nce, including interviews with teachers, trainers and designers. This will shortly be available via the S-TEAM video portal.

Pairform@nce, an innovative teacher-training programme in France.

The French national project Pairform@nce2 (http://national.pairformance.education.fr/) is aiming to develop in-service teachers' skills in using ICT in class with their students. Pairform@nce proposes professional development programs, for all class levels from primary to secondary, and all topics (Gueudet *et al.* 2009).

Figure 1. The Pairform@nce national platform

The Pairform@nce programmes are based on three main principles:

(i) Collaboration among teachers: professional development, especially concerning ICT, cannot only be an individual process; it results from the collective activity and experience of peers;

(ii) Co-design of lessons with ICT and implementation in class: a teacher development programme cannot simply be based upon out of school training, it necessarily implies experimentation with resources in the field and subsequent shared reflection;

(iii) Continuous process: working efficiently on resources requires collaboration to be maintained, combining face-to-face and on-line activities.

Pairform@nce has the central feature of being organised around training paths available on an on-line

2 The word "Pairform@nce" is a modification of the French word "performance", where the first part "per" has been replaced by the word "pair". Per and pair have the same pronunciation in French but "pair" means peer. An English translation could be "Peerform@nce", pointing out the principle of collaboration among teachers.

platform. The training paths gather contents, resources and tools for collaboration, enabling teacher trainers to set-up Pairform@nce training sessions.

All Pairform@nce paths comprise 7 stages. These 7 stages are not just successive steps; some of them are strongly intertwined. They are more like 7 different objectives of the trainers and trainees activity, during the training.

The first stage is the introduction, the beginning of the training. During this stage, the trainees meet each other, and meet the trainers. They also find out about the training. This introduction must involve face-to-face interaction. Some exchanges can be done using e-mail, or a web forum. For example, each trainee can upload a personal presentation, and discuss his or her expectations on such a forum.

The second stage is the creation of teams, and selection of the topics. The trainers can decide on a given composition for the teams. For example, they can form teams with teachers working in the same school. They can also leave the responsibility of forming the teams to the trainees. When the teams have been formed, they start to discuss possible common themes for the lesson they will design together. Choosing the theme can require some time, face-to-face and at a distance. The team can start with a general idea, which will be progressively elaborated during discussions.

Stage 3 is called “self and co-training”. During this stage, the trainees are trained, and train themselves, according to the path objectives. On the one hand they learn to use the ICT tools integrated into the path. All the paths have didactical objectives, in addition to the objective of technical mastery. In the paths we consider here, the trainees learn about setting up inquiry-based activities in class at this stage. For this stage, the path offers many resources: quickstart documents for the software used; articles about educational research; examples of lessons. The trainers’ contributions, during the face-to-face sessions, are essential. Naturally, however, the most important part of the training is the design and testing of the lesson.

The design of the lesson is stage 4. The trainees, in the team, elaborate a specific content for the lesson during their face-to-face meetings and electronic discussions. For these discussions, a path-specific forum can be created on the platform, for each team. Specific spaces for uploading files can also be made available. The trainers offer their support during the whole design phase.

Stage 5 is the stage of classroom implementation. The lesson designed must be tested in class at least once; but several variations are possible. For example, several trainees in the team can implement the lesson with their pupils. Or one trainee can test it in different classes. If the lesson is tested several times, it is better to organise a schedule enabling modifications between successive tests, as suggested by observations. The potential faults can thus be corrected and improvements can be proposed.

Stage 6 is called “reflexive look back”. In this stage the trainees look back at the lesson designed, they reflect about what went wrong, and what should be modified. Often a lesson does not work well the first time; sometimes a classroom activity requires more time than intended; sometimes the trainees must leave out some parts, due to time pressure.

Stage 7, the final stage, is an evaluation of the training. During this stage, the trainees fill in questionnaires, explaining whether the training met their expectations or not. They also suggest modifications. The trainers also evaluate the training. They can send their remarks and suggestions to the path designers.

All the questionnaires that we studied indicate that the teachers appreciate collective work. In France, teachers are not used to designing lessons together. This work requires strong commitment. But the different lessons designed can then be shared between teams, so they do not feel that they have wasted their time. After the training, they generally declare that they intend to go on working together.

A training path proposes, for trainers and for trainees, specific training resources of various kinds: examples of lessons; guides for using the ICT tools; articles coming from educational research; and many collaboration tools. We present below two training paths, one in mathematics and one in geology.

Section 2: Investigation and ICT in mathematics: example of a training path

2.a Investigation in mathematics and ICT

Investigation in mathematics takes specific forms, since mathematics is not an experimental science (Dias, 2007, Kuntz, 2007, NCTM, 1989, 2000). It is strongly connected with problem solving (Schoenfeld, 1985).

Implementing investigation in the mathematics classroom requires an appropriate situation, allowing the students to "manipulate" numbers, or geometric figures, or equations. The move from the situation to the "manipulations" is often not straightforward, requiring first the important work of 'modelling'. Drawing on manipulations, students can observe possible properties, suggested by specific patterns. These conjectured properties have to be tested; finding counter-examples, which enable wrong assumptions to be discarded is an important ability for pupils to develop. When a property is likely to be true, the next step, specific to mathematics, is to build a formal proof. Is this formal proof necessary, or is it possible to propose investigations without proof? This is an important topic of debate for mathematics teachers. The other topics of discussion are less specific to mathematics:

- How can investigation be integrated into the prescribed courses?
- Is investigation limited to the beginning of a chapter in the relevant textbook?
- Can it be used as an approach to new topics?
- Can it also be used for practising with "old" notions?
- How should investigations be assessed?

Specific software packages seem to be helpful for developing investigation in mathematics.

In geometry, dynamic geometry software (DGS) permits the construction of dynamic geometrical figures. The students can then test many possible cases; they can also display numerical results, such as the value of an area, or the graph of a function, etc. According to Leung (2003), the simultaneity between the student's action and the DGS feedback is a promising agent for bridging the gap between experimental and theoretical mathematics, or the transition between the processes of conjecture and formalization:

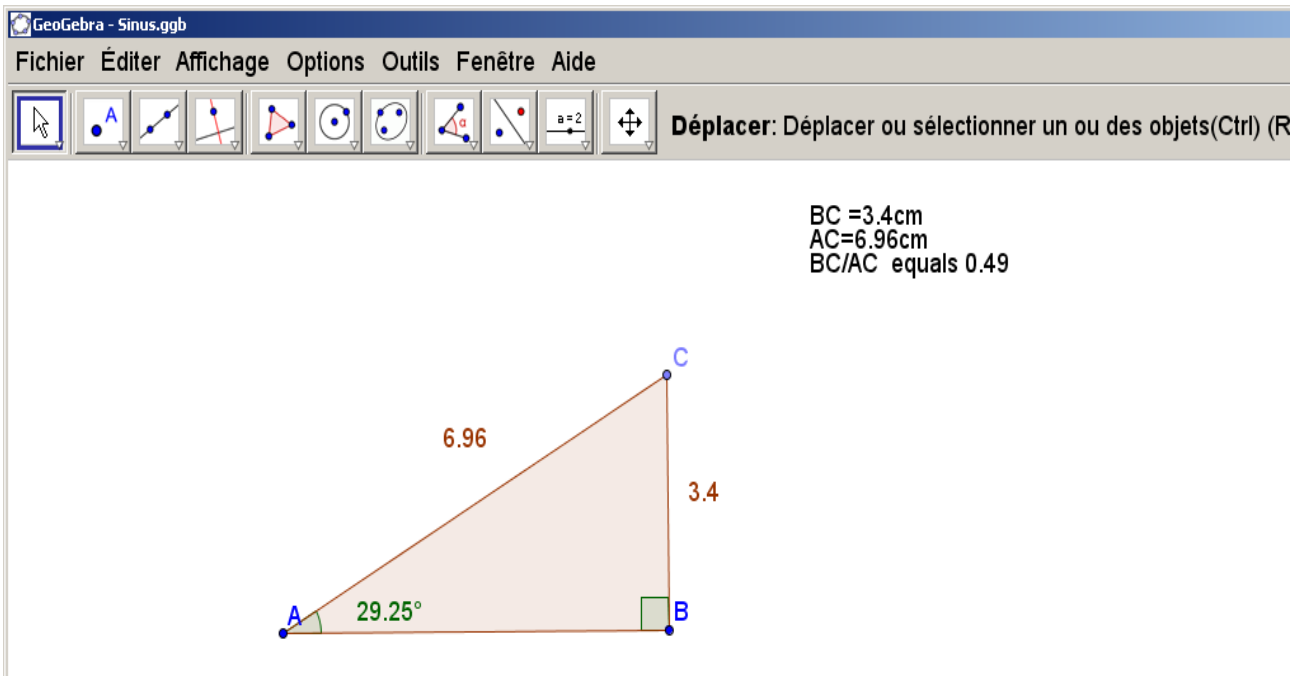


Figure 2. Introducing sine with *Geogebra*. The students move the point B and observe that BC/AC does not change.

Spreadsheets are another kind of mathematical software which can be used for investigation, in particular in the areas of statistics and probabilities. Spreadsheets allow the study of statistical data; they can also simulate probabilistic models.

Investigation is not often practised by mathematics teachers in class, and technology is not often used for investigation (Ruthven, 2007). So proposing a change of practice associating investigation and ICT is a double challenge, which requires specific training. We have therefore developed a Pairform@nce training path for this purpose.

2.b Presentation of the "Investigation with ICT in mathematics" path

The "Investigation with ICT in mathematics" path has been designed by a team associating researchers and teacher trainers. It is addressed to mathematics teachers, teaching from grade 6 to 9 (lower secondary school).

Figure 3. Investigation with ICT in mathematics, a training path

The proposed training lasts 13 weeks (holidays are not included); it comprises three face-to-face workshops. We give below a chronological description of the training.

Before the first face-to-face workshop

The training starts with an e-mail contact, one week before the first face-to-face workshop. Attached to this e-mail, the trainer sends a first questionnaire for the trainees. This questionnaire is designed to record the trainees' expectations, and to collect information about the materials they use in their schools. The trainers also collect informations about the technical skills of the trainees. For the trainees who are novices with the software, a specific session with a trainer can be organised.

In the questionnaire, the trainees are also asked about their ideas and experiences concerning inquiry in class.

The results from this questionnaire are presented and discussed during the first face-to-face workshop with the group of trainees.

The first workshop

During the first workshop, the training programme is presented. The trainers must ensure that all trainees are familiar with the principles of the training. They must present the platform, and check that all the trainees are able to connect, and to download and upload documents.

The results from the initial questionnaire are presented; this leads to an opening discussion, about the trainees' beliefs and attitudes towards inquiry in class. This is just the beginning of a long process, which will

continue during the whole training programme!

The trainees' teams are then formed. The teams, if possible, comprise four teachers: two from one school, and two from another school. This way, the teachers will easily be able to meet in pairs; but they will also be obliged to use distance communication, via the platform. This will ensure regular connection to the platform, which is necessary in order to view the resources suggested by the trainers.

Examples of lessons are presented. These examples permit the development of the discussion, by emphasizing important aspects of inquiry in mathematics:

- How is it possible to articulate inquiry, and the usual curriculum? How can teachers avoid losing time for teaching the mathematical content of the curriculum?
- What is the link between investigation and proof? Is there a risk that investigation hinders the learning of mathematics?

The sample lessons are central resources in the path. They are presented by the trainers, leading to debates in the trainees' group. These debates are very important, as they encourage essential reflections, and are likely to yield improvements in the teachers' practices. During the first workshop, the trainees can also improve their technical skills on the software.

Finally, two mathematical situations are presented by the trainers in the form of texts. Each team will have to choose one of these situations, and plan a scenario for implementing it in class, with an inquiry-based approach. The scenario design is the first distance collaborative work for the teams of trainees. It takes place between the first and second face-to-face workshops. The objective is to initiate collaboration around the design process for the chosen scenario. The proposed scenario must include an element of inquiry.

Between workshops 1 and 2

Between the face-to-face workshops 1 and 2, the trainee teams design a scenario, corresponding to the text chosen during workshop 1. This distance work uses a specific forum, and a folder for exchanging the files on the platform. The trainers support this distance work, but do not try to influence the decisions of the team.

After the first workshop, the trainer uploads a report of this workshop to the platform. If they consider that the trainees are getting behind in the design of the scenario, they send e-mail reminders. They can formulate advice about the scenario's propositions. They also answer requests for support from the trainees, if necessary.

The second workshop

During the second workshop, the trainers present a slide show about inquiry in class, grounded in research results. The scenarios proposed by the teams are then presented and collectively analysed, using categories presented in the slide show:

- A problem with a real challenge, but one that is possible to tackle in class;
- Organisation of an appropriation phase, contruction of an experiment,
- Observation, formulation of conjectures;
- Testing of the conjectures, search for elements of proofs;
- Debate, argumentation.

Moreover the role of the software is investigated: do the students build an experiment with it? Do they only manipulate and observe? Is the computer used for building the proof? All these elements yield discussions amongst the group of trainees, and suggested modifications for the scenarios.

During the second workshop, the trainee teams also start to design the lessons they will test in class.

Between workshops 2 and 3

Each team elaborates the first version of a lesson (during exchanges on the preparation forum). This lesson is set up in class by one of the trainees; at least one other trainee observes the lesson and takes notes. Suggestions for improvements are formulated. If possible, another test, incorporating the modifications, is organized. New suggestions for improvements are formulated. The description of the lesson is uploaded on the platform, at least one week before the last workshop.

Trainers and trainees read all the lesson descriptions. The trainee teams are associated in pairs, and each team has to provide feedback about the lesson of the other team.

The third workshop

During this third workshop, the lessons are discussed and proposals for improvements are formulated. During this workshop, the trainees also contribute to the evaluation of the training, by completing a questionnaire and also directly expressing their opinion: does the training meet their expectations, do they have suggestions or criticisms to formulate?

The resources of the path

In the path, resources are proposed for the trainees and for the trainers.

For each stage a “training assistance pack” is offered to the trainer. It offers a description of all the activities, of the trainers and of the trainees. It also includes all the resources necessary for the trainers: slide shows, analysis grids etc.

Figure 4. Pedagogical notes, including resources. These notes can only be seen by the trainers.

Many resources are also provided for the trainee, such as technical notes for the software and research articles. Some of these resources are essential for supporting the collaborative work. The path proposes a system of 3 grids:

- grid for lesson description;
- grid for observation of an inquiry-based lesson;
- final report grid.

These grids can be proposed by the trainers, or elaborated with the trainees. They are essential, since if each team (or worse, each teacher) chooses a personal template for describing the designed lesson, the discussions become difficult or even impossible. It is always a difficult task for one teacher to understand a lesson constructed by another teacher. Choosing a common template is thus necessary.

2.c Teachers collaboration in a training activity built on the "Investigation with ICT in mathematics" path.

Teacher collaboration takes several forms, in a training activity corresponding to this path.

Collaboration within the teams

The collaboration within the teams, to design the lesson, is very important. It takes place during the workshops, in the traditional manner. Between the workshops, the teams use the platform, for discussions on the forums and to share files. These discussions, event distant, are always easier for teachers working in the same school. Within the teams of four teachers, in fact the distant communication happens mostly inside the pairs of teachers working in the same school; the collaboration of the whole team requires face-to-face meetings.

Collaboration within the whole training group

The whole training group comprises between 16 and 24 teachers. They mostly work together during the face-to-face workshops. An essential tool for these collaborations is the use of common grids to describe the lessons, to report classroom observations and to propose lesson analyses.

Within the whole group, very different positions towards investigation and ICT always appear, leading to interesting debates.

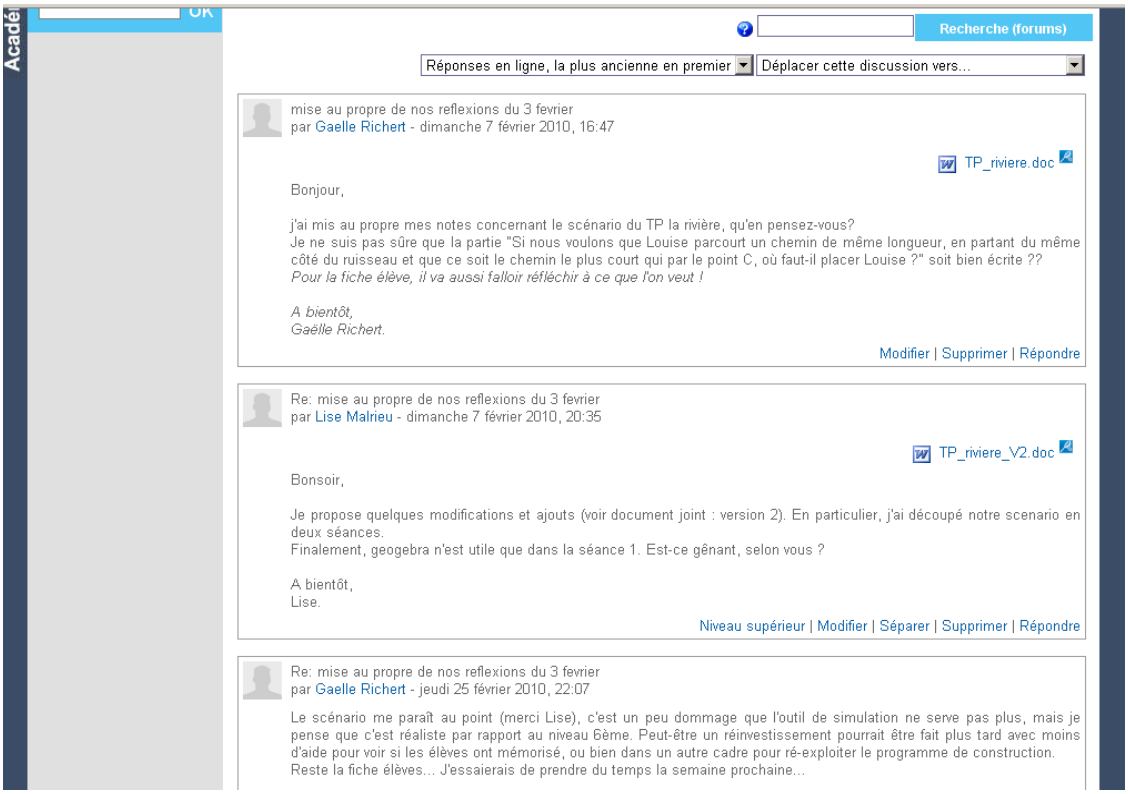


Figure 5. Discussion on a forum during the training

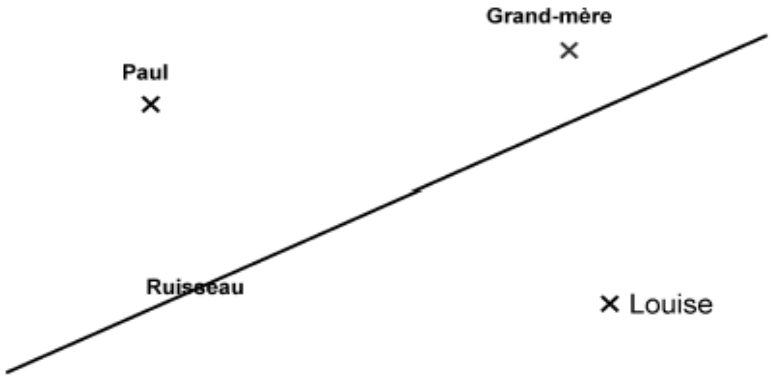
2.d "The river": example of a situation in geometry for investigation in the "Investigation with ICT in mathematics" path.

Problem text

The river is a well-known mathematics problem. We give here an example of the way it can be implemented in class. This example can be presented to the trainees and discussed with them. The scenario proposed here is at the level of the grade 7 curriculum in France.

> Paul's and Louise's grandmother cannot walk any more. Each day, one of them goes to the river, take water and bring it to Grandmother. One day, Paul goes to the river, takes water, and goes to Grandma.

The following day, Louise goes. The children are always hurrying; they want to find the shortest way.



Can you draw the shortest way for Louise to go to the river and then to her Grandma's place?
Can you draw the shortest way for Paul to go to the river and then to his Grandma's place?

Let us recall the mathematical solution of the problem. Paul's position is represented by a point P, Grandma by a point G; the river is a straight line D. If P is reflected along D, it gives a point L. L is on a side of D opposed to the side where G is. Then the shortest way from L to G is the straight line. Let R be the point obtained by the intersection of D and the straight line (LG). The distance LG equal LR+RG, since the three points are aligned in this order. This distance equals PR+RG. Hence the point R found here exactly provides the minimal distance.

For grade 7 students (but also later, since this problem can even be used at university), there is a major difficulty with this problem: the point P must be reflected along the line D, which is not natural. How can dynamic geometry help?

Proposed scenario

The proposed scenario starts with a paper and pencil exercise. For Louise, living on the other side of the river, the solution is simple! The shortest way is the straight line, going from Grandma's house to Louise's home. Naturally, we consider here that the river is a straight line, and that Louise can cross it where she wants.

The students find the solution quickly. For Paul it is more complex. Each student makes one or two attempts on paper. They place a point “on the river”, measure the two segments obtained and add the lengths to find the length of Paul's way. Students discuss the lengths of the paths found, and how to choose the shortest path.

After this stage, the students will look for a solution with dynamic geometry. First, they receive a file where points P, G and the line D have been constructed, in the same way as they were constructed on paper. They

do the construction in the software as they did on paper. They place a point R on the line D. They draw segments PR and RG, and display the distance sum: PR+RG. They move point R and observe the evolution of the sum's value as it approaches the point R at which the length of the path is at a minimum.

After this stage, the aim is that the students find how to construct the correct point R.

This search is organised around a “black box” (Laborde 2001). The construction has been done (with point L), but the steps are concealed in the software. Students have to find these steps, by moving the points and observing the properties of the figure. They can for example display the line (PL) and observe that it is perpendicular to D. They can display the lengths PR and LR and observe they are equal.

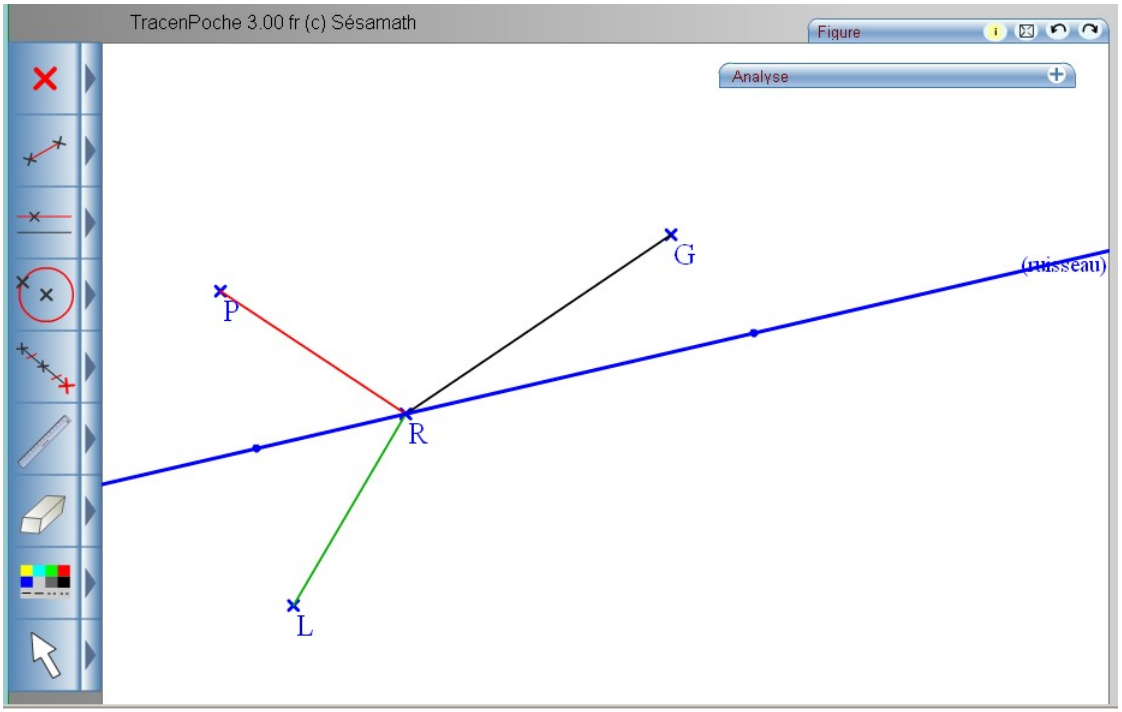


Figure 6. The “black box” file provided to the students

A test in class has proven that this work remains very difficult (for pupils in grade 7) Even with the black box, some students did not identify the point L and its role by the end of the session.

For training purposes, this lesson example is very rich, because it raises a number of issues, and stimulates the trainees’ reactions. Many trainees wonder how they can help the students, without suppressing the investigation aspects. With this aim, proposing a black box is interesting. However, black boxes constitute a particular form of investigation, which always lead to reactions from the trainees. Some of them consider that it invites the students to “guess”, which seems opposed to their idea of rigorous mathematics. Some trainees also say that they cannot imagine how to insert this problem in the curriculum. These last trainees

are usually convinced by others, who show them that students can use mathematical knowledge about distance, symmetry etc.

2.e "The liquorice" example of a situation in probability and statistics for the "Investigation with ICT in mathematics" path: Investigation in probability and statistics with a spreadsheet.

The statistics taught at secondary school in France have several aspects. They can on the one hand be descriptive statistics. In this case, a set of data is given and studied.

Numerical data can be presented in a table, grouped in classes; percentages can be computed etc. Statistical measures can be position characteristics, like mean or median. They can also be dispersion characteristics, like the standard deviation, or quartiles. Representations can also be used for studying the data: bar chart, pie chart, etc. A spreadsheet allows the necessary computations to be made. When a large quantity of data is given, it cannot be studied without a specific software tool such as a spreadsheet. Moreover, the spreadsheet enables students to create all the representations evoked here. The spreadsheet can be considered as a tool of data investigation.

Other aspects of statistics are also taught. In inferential statistics, hypotheses, associated with a probability, are drawn from the data. The articulation between statistics and probability is complex, and can be tackled by studying, for example, the fluctuation of the statistical results obtained, for different populations. For large populations, this fluctuation is reduced. For the simulation of large populations, a spreadsheet is needed.

Several possible uses of the spreadsheet

Using the spreadsheet in class requires that the students have technical skills; some of these can be complex. They must be able to write formulas. For simulations, they must know the RANDOM function.

They must be able to test if the result of a experiment is positive, and able to count the number of positive results, to compute the frequency.

For working in class with a spreadsheet, the teacher faces the same questions that arise with other kinds of software: do the students work on the computer, or does the teacher manipulate the computer? For an inquiry-based lesson, it is important that the students have control.

The “Liquorice” example, problem text:

Three friends want to share a stick of liquorice. They decide to cut it in two places obtained randomly, eyes closed, placing simultaneously two marks on the stick. The most voracious wants to take the piece in the middle. He says that it is likely to be longer than the half of the whole stick. What is the probability, for the piece in the middle, to be longer than the half of the stick?

Several mathematical models can be associated with this experience. We retain here the following one: two numbers *x* and y are randomly chosen between 0 and 1, with a uniform law. Let *x* be the smallest value. We must compute the probability for (*y*-*x*) to be greater or equal to ½, which means *y* greater than *x*+1/2. Reasoning on the area of triangles, it is easy to compute that this probability is 0.25.

The pupils do not necessarily compute this probability. They elaborate a simulation with the spreadsheet. This simulation allows pupils to perform a large number of experiments. They will observe this way that the frequency of a positive issue seems to vary greatly, when a small number of experiments is done. For a large number of experiments, it stabilizes around 0.25.

Proposed scenario

With the students, the teacher can start by asking pupils to perform a physical experiment, for example with spaghetti. Each pupil cuts ten pieces of spaghetti in three, and the number of positive issues is computed. This concrete experiment can be used to discuss the model.

Then we suggest switching to the geometrical interpretation: the pupils must find a way of modelling the situation, in terms of segments and points. Then they complement the modelling with an interpretation in terms of segment length. The liquorice stick is modelled by a segment of length 1. Two points M and N are randomly placed on the segment, their abscissa are between 0 and 1.

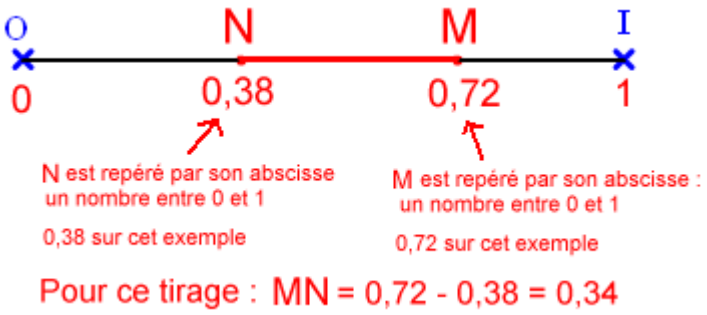


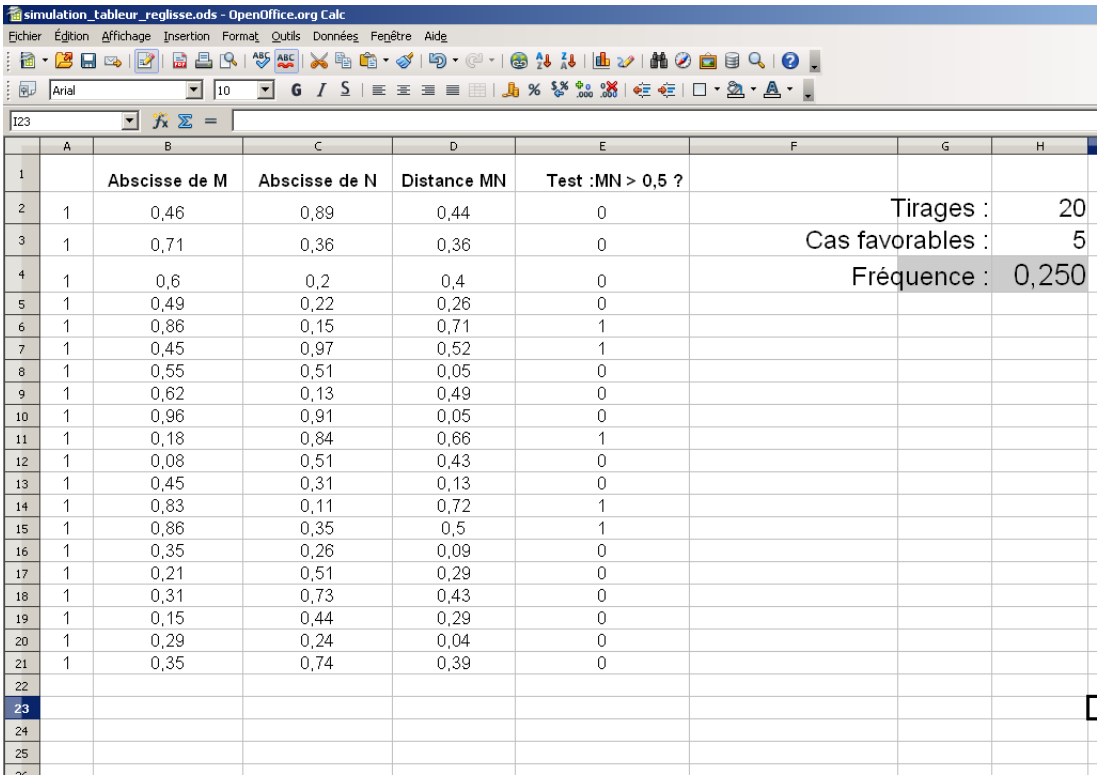
Figure 7. The geometrical representation of the situation

The students compute the length MN. The result is positive if this length is greater than ½. This modelling

phase is difficult for the students, and it is not often practised.

Once this geometrical modelling is done, the students work on the spreadsheet. The teacher must help, for the technical aspects, if the students are not familiar with the two important functions used here:

-the simulation of a random number between 0 and 1;



	A	B	C	D	E	F	G	H
1		Abscisse de M	Abscisse de N	Distance MN	Test :MN > 0,5 ?			
2	1	0,46	0,89	0,44	0		Tirages :	20
3	1	0,71	0,36	0,36	0		Cas favorables :	5
4	1	0,6	0,2	0,4	0		Fréquence :	0,250
5	1	0,49	0,22	0,26	0			
6	1	0,86	0,15	0,71	1			
7	1	0,45	0,97	0,52	1			
8	1	0,55	0,51	0,05	0			
9	1	0,62	0,13	0,49	0			
10	1	0,96	0,91	0,05	0			
11	1	0,18	0,84	0,66	1			
12	1	0,08	0,51	0,43	0			
13	1	0,45	0,31	0,13	0			
14	1	0,83	0,11	0,72	1			
15	1	0,86	0,35	0,5	1			
16	1	0,35	0,26	0,09	0			
17	1	0,21	0,51	0,29	0			
18	1	0,31	0,73	0,43	0			
19	1	0,15	0,44	0,29	0			
20	1	0,29	0,24	0,04	0			
21	1	0,35	0,74	0,39	0			
22								
23								
24								
25								

-the test of a positive outcome, here *y-x* greater than ½.

Figure 8. A spreadsheet file, used by the students

When the modelling with the spreadsheet is done, the students can do several successive simulations, with the same number of draws. They start with 10, then 20 draws. They record each time the frequency obtained. Then the number of draws is raised, and the students observe that the frequency stabilizes around 0.25.

The context of probability and statistics, and of the link between both, permits the implementation of investigation in class. Indeed mathematics teachers generally agree with the idea that an intuitive idea of the Great Numbers Law (the frequency tends towards the probability, for a large number of experiments) has to be built by the students.

Virtual Globes: example of a training path in geology

The “Virtual globes” paths (there are four such paths) have been elaborated by a team associating researchers and teachers (Sanchez 2009). They concern Earth sciences and Geography, and are addressed to secondary school teachers, and teacher trainers. The aim of these paths is to support the integration of geotechnologies, in particular virtual globes, like Google Earth. We focus here on the fourth, “Virtual globes 4”, which associates ICT and investigation.

Figure 9. Virtual globes 4, a training path

This path concerns the design of a field class, in Earth science or geology; it has two kinds of objectives.

First objective : field class and investigation

The first objective is linked with the nature of field classes in science or in geography. A study made in 2007 has shown that very often, field classes were in fact “traditional outdoor classes”. The outdoor aspect was used to provide a specific ‘atmosphere’, but in fact it was very difficult for the teachers to have the students make real use of their field observations.

Naturally, this was not surprising, because field situations are often very complex, and students often report that they find it difficult to draw relevant elements from their observations, in order to answer scientific questions.

For this reason a team of researchers and trainers (Eric Sanchez, INRP, Ludovic Delorme, Académie de Montpellier) decided to design a training activity showing the important elements needed to organize a field class, with the students leading investigations themselves.

Second objective: use of geotechnologies

The second objective of the path is the introduction of geotechnologies. Geotechnologies are all the digital means permitting to study geolocalised information. GPS, virtual globes like Google earth, etc. All these technologies are widely used in modern society, they are easily available in class, the corresponding software is not expensive, and it is sometimes free of charge.

Presentation of the path

The path starts with a face-to-face workshop. The trainees find out about the training, its principles, objectives and content, and the platform used. The teams of trainees are formed; they discuss and decide the objectives of the lesson they will elaborate. After this workshop, a phase of individual distance work begins.

The teachers work on a set of resources offered by the path. These resources are very diverse. There are, for example, research articles, videos of field classes, showing students before or during a field class, photographs taken in the field, audio files, etc. This set of documents will lead the teacher to reflect on didactical and pedagogical questions, and to reflect about the elements that must be taken into account to permit student autonomy during the field investigations.

The phase of individual distance work also has a second aspect: the technical training. The ICT tools are sometimes quite easy to use, but some tools are more specific. The path offers resources for this technical training. These resources are instructions for use, regularly updated. This means that, when a new version of a software package used in the path is published, the instructions for use are updated in the path, and the trainees can access this updated version. The designers of the path are aware of the quick evolution of the ICT tools used, which require frequent updating in the path.

A second distance phase follows, this time more collaborative. The teams of trainees design their lesson. They express their point of view, debate, sometimes in different domains, such as Earth science and geography. When this design phase is finished, and tested in class, each group presents its work, and tests its opinion against the opinion of the whole group. This phase is very rich, and it will enable, on the one hand, the discarding of some choices or, on the other hand, the identification of interesting innovations, which deserve to be better known.

Resources of the path

An interesting aspect of the resources of the path is that we have tried to articulate the work of researchers, who designed sequences and analysed field classes, with the work of practitioners. We have tried to help teachers benefit from the research results.

For example, it is suggested that videos or photographs of students are connected to transcripts of the students' audio recordings. These texts show that students have serious, in-depth debates, from a geological point of view, and that they are relatively autonomous. The teacher is invited to think about the elements that permit student autonomy. These elements are of two kinds. Firstly, ICT tools, such as digital cameras, enable the taking of pictures, which can then be localised on a virtual globe. The second element is the way the lesson has been designed. The field class has been prepared, and the students know exactly what they will have to collect in the field. These dimensions are very important,in order to support a real investigation by the students.

Conclusion

Pairform@nce is certainly a teacher training advanced method. Its "advanced" characteristics do not only correspond to the use of a distant platform. The global structure of the training, in particular the role attributed to teams of trainees is advanced.

Pairform@nce is not especially directed towards investigation in science. The two paths selected here, in different disciplines, are the most "inquiry-oriented", amongst the 34 published paths. New paths for investigation could be developed by other teams, in physics or biology for example.

Pairform@nce is a complex training system, organised in France. It uses a national platform in conjunction with local platforms. But similar training programs can be created, without the need for the whole system. A commercial platform (e.g. *moodle*[3]) is enough, so long as it allows downloading and uploading of files and discussion forums. Such a tool permits the collaborative design of classroom lessons, which is the most important principle of Pairform@nce.

[3] http://moodle.org/

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S-TEAM Product 4.6: Report on Teachers as Researchers

Workshop Report on action learning

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Background:

This report comprises firstly, a background paper describing in detail the author's experience of working with teachers as action researchers in Norway. It is followed by a discussion of mutual experiences of teacher-researcher activity at the workshop held during the S-TEAM conference in Glasgow, 13-15 October 2010. The aim of this research is to make teacher collaboration central to the process of implementing inquiry based science and mathematics teaching methods. It also reminds us that collaboration can produce interdisciplinary linkages within and outside the STEM subjects. This is increasingly necessary, particularly in working with scientific literacy, which, as the S-TEAM WP8 deliverables will confirm, involves educational dimensions beyond the traditional scope of science education.

Introduction

> We've learned that we have a high degree of competence which becomes more visible when we share it with others. We're so clever. We really are. When two persons observe your teaching, it does something to you, you think, you reflect on your own practice, you observe others, I think wow, there I got a tip. And we've discovered that when we get together, we become more visibly competent. We manage a lot, we know as much as we can read in books, we just have to let it come out and share it with the others. We've reflected on our own practice with the focus on learning strategies, and learning strategies have been well known in the whole team. It's much more salient during planning, and we think of learning strategies much more than before. It has been useful, we've got a lot of tips and "aha" experiences both during feedback from others, through observations and through reflection on our own practice, and not least when we worked across class teams. We've gained more insight into our colleagues and the pupils. We trust each other even more, and support each other. Very useful. It's we, the teachers, who are going to learn from this, but our action learning will also make the learning better for the pupils. Therefore we want to continue doing this next year, following the same plan.

The above statement comes from the team leader for teachers of students in the eighth, ninth and tenth grades. When she said this, the teachers at the whole school had gathered to exchange experiences. At that time the teachers and I, the researcher, had worked on a research and development (R&D) project for a whole year. At the beginning of the project the teachers and I jointly formed a research question to guide and frame the work. The question we arrived at was: *How can various work methods with the focus on learning strategies contribute to each pupil's subject and social development?* Both learning strategies and adapted education are key parts of the national curriculum, so the teachers could satisfy national requirements for learning and support for learning by choosing this research question as a framework for their teaching.

In her statement, the team leader points out that the development process, including observation and reflection, has made them more visibly competent. They have allowed their competence to emerge, and they have shared it with others. What she is saying is that they have been able to put their expertise into words and thus describe it to others. Thus, their personal competence emerged from its tacit form (Polanyi, 1967). This teacher also maintains that learning strategies have been more salient in the planning work, and that everybody in the team has learned about it. The team leader goes on to say that they have gained more insight into each other and the pupils than before, and this increases mutual trust, thus making the foundation for development even more solid (Krogh, Ichijo & Nonaka, 2000).

There are altogether 12 teachers in this team, named Team 3, and they also belong to their own class teams. The social climate between the teachers, and between the teachers and the pupils, is very good. The teachers are eagerly involved in their job, and have heated discussions about their pupils and their planning of the teaching processes. Krogh, Ichijo and Nonaka (2000) say that development has to be built on

confidence, trust, learning and dialogue, and according to Argyris (1990), an atmosphere that invites people to speak openly is a premise for progress in learning work. A teacher in the tenth grade says in the beginning of the project: "We can trust each other, we are loyal to each other, and we can allow ourselves to have a bad day, you never feel that someone is after you. We have a tolerant tone. You can be yourself". With the supportive and open atmosphere in Team 3 the foundation for development was present already from the start.

The selected school is situated in a suburban area and has pupils from the first to tenth grades. Forty teachers are working at the school, which has 500 pupils. The pupils are for the most part from middle-class families, and there are few immigrants at the school. The teachers are divided into three teams. I am, as mentioned, connected with Team 3 and therefore this micro society (Krogh et al., 2000) is the focus in this text. The purpose of this article is to show *what* and *how* teachers can learn during an R&D work project.

First I present theories on learning and development, which also became known to the teachers during a course in the first semester, before I discuss how a formalized plan for observations and reflections was developed. Next I describe how I collected material to describe and understand the processes underlying the R&D work, before I present an example on reflection from practice. Finally, I focus on the teachers' learning in the work, and end with a discussion about the teaching profession.

Theories on learning and development

Revans (1982; 1984) calls teachers' learning in development work 'action learning', and this implies looking forward as well as back. According to Revans, reflection means asking questions about one's own practice, and foreseeing possibilities for change and development. Thus, it is important for teachers to look ahead and not to get stuck on their experiences. Tiller (2006, p.51) states that:

> The strength of action research is that people in the organization can be aware of and utilize what is already there when it comes to knowledge and generate learning out of existing experiences by rethinking yesterday's experiences in the light of today's and tomorrow's [experience].[4]

In this way teachers can utilize knowledge they already have in their teaching community to look ahead and develop their practice.

In the same vein as Revans (1982; 1984), Engeström (1999, 2001) maintains that teachers have to see possibilities in their teaching and ask questions about it, with an overall goal in mind. Thus, they must have some ideas and foresee some consequences, as Dewey (1916) put it. Taking a look both back and forward is also shown in Engeström's (1999, 2001) expansive learning circle, as we can see in Figure 1 below.

[4] In this article the constructs action research and R&D work are used synonymously. In my opinion both research and learning based on actions are part of the action research construct. Learning based on actions often leads to development of practice and thus both research and development of practice are integrated processes in action research and R&D work.

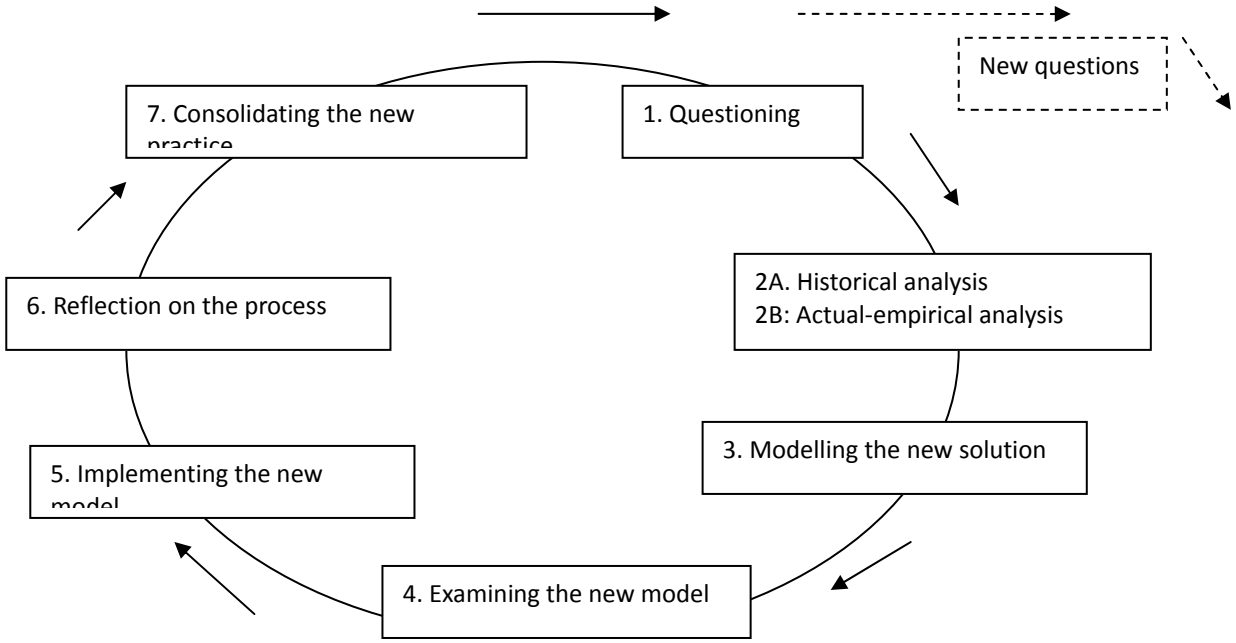

Figure 1: Engeström's expansive learning circle

The overall goal or vision for the teachers in Team 3 is to vary the work methods and focus on learning strategies to contribute to each and every child's academic and social development. Figure 1 shows how researchers and research participants ask questions about their current practice at the outset. There is some tension, there are some conflicts that have to be resolved and there are even possibilities that have to be striven for. These aspects are the basis for development in activity theory (Leont'ev, 1981), a theory that Engeström (1987, 1999, 2001) has developed graphically into the activity system. The activity system comprises a number of triadic relations. The minimum elements in this system are: subject, artefacts, object, rules, community and division of labour. All these factors have mutual effects on each other, and in the complete activity system we also find connecting lines across the different triangles. There are conflicts, tensions or possibilities between the factors visualized in the system that are the starting point for the development process shown in the expansive learning circle.

To make progress, Engeström (1999, 2001) suggests that both historical and actual empirical analyses should be conducted before a new solution is framed. The next step is to analyse the new model from various angles prior to implementing the new practice. After the implementation process, the involved parties, both teachers and researchers, reflect on the practice before the new practice is eventually consolidated. New thesis questions will again be directed on current practice to move it towards the vision for the work. In this way the expansive circle will be the foundation in spirals of development illustrating

constantly changing practices. The expansive circle became a thinking tool for the teachers when they planned lessons that should be observed and reflected on. In the following section I discuss how the teachers and I came to a formalized plan for observations of, and reflections on, practice.

Changing practice: a process in progress

The process leading to a formalized plan

When the project started, neither the teachers nor I could imagine how the process would continue. During the first semester the teachers tried hard to identify with the research question, even though they had taken part in the construction of it. The team leader stated that it would take some time before the teachers identified with the question and before it was rooted in their practice. And she was right. It took almost a semester before the teachers acted upon the research question as their own (Postholm, 2008a).

The school had allocated a whole day at the end of November in the first semester for the teachers and me to work on the project. The team leader planned the agenda for the day with me. The team leader had the last word when we drew up the schedule. Previously, I had been reminded by the teachers that this was their project, and I realized that my place was to observe, support and push them. The team leader was also the one who chaired this whole-day seminar. I was there, observing, commenting and asking questions.

During the day the teachers talked about their actual situation with respect to the focus of their work, and furthermore defined the overall goal that guided their teaching. In this way they could both develop a common understanding of their situation and what they should aim for. Furthermore, they discussed how they should arrange to share ideas on work methods and learning strategies amongst themselves. According to Senge (2006), a common understanding, a shared vision and the sharing of ideas in teams are decisive factors for development. During the planning day, the teachers decided that they wanted to share ideas in class-team meetings, in Team 3 and in meetings where only teachers of the same subject were present. The teachers wanted to use time on focused reflections to improve their teaching. The project was now moving forward and the teachers had really taken control. They perceived it as their own project.

The formalized plan

For the next meeting in Team 3 the following week I drew up a plan that formalized the teachers' wishes to observe each other's teaching, reflect on it afterwards and then share experiences and ideas. The plan became as shown in Figure 2 (below).

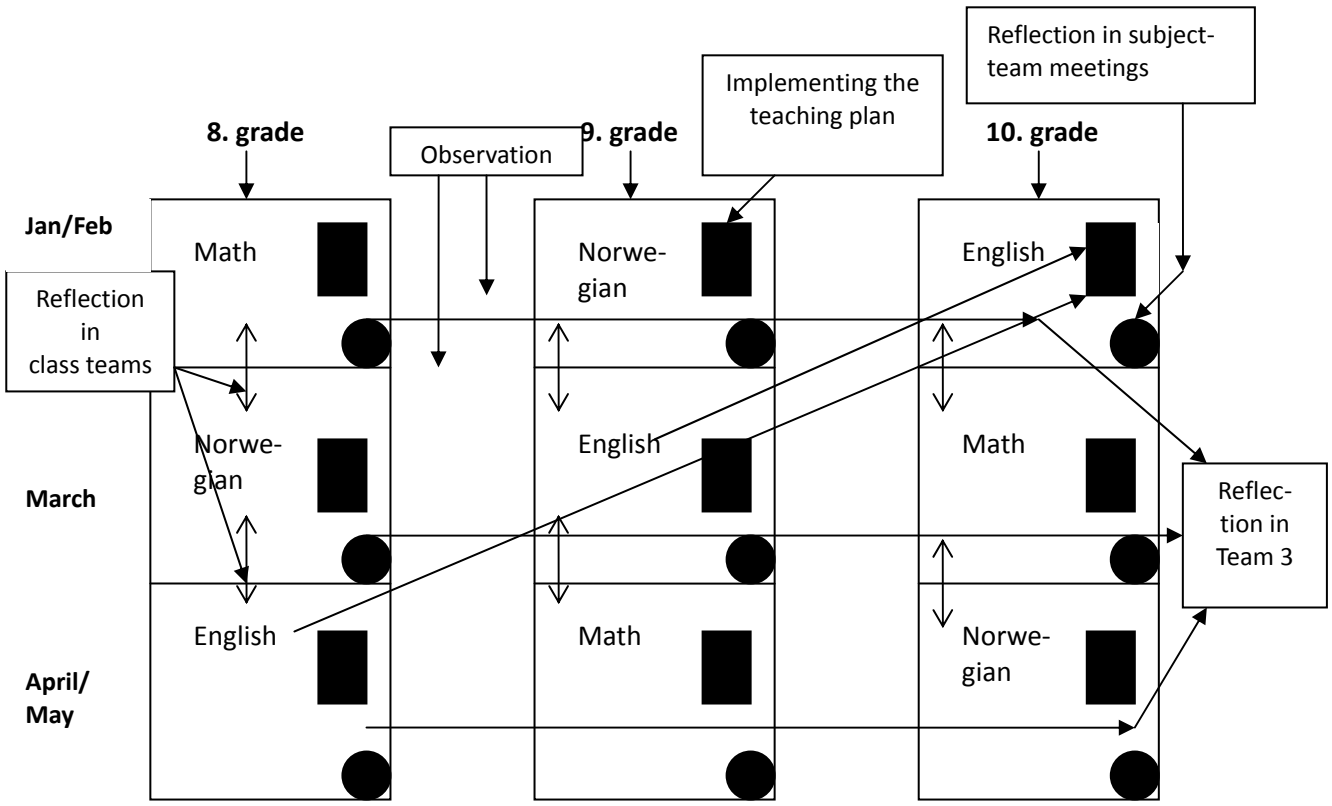

Figure 2: Formalized plan

Figure 2 shows that the teachers teaching the same subject should observe each other and afterwards reflect together on the observed activity. For instance, as shown, when the teacher in mathematics in the eighth grade teaches the pupils, the mathematics teachers in the ninth and tenth grades observe them (visualized by arrows from math in the ninth and tenth grade). Before teaching the class, the teacher sent a planning document (shown by the black squares) to the observing teachers and to me, as I was also taking part in the observation and reflection processes. This document described the subject/theme and the aims of the lesson, and the teacher wrote questions about his own planned practice and what he wanted feedback on. As we see from the figure, the intention was that the teachers should reflect together in their own class team after each observation (visualized by the vertical arrows combining the various subjects in the same grade) and in the team with all the teachers when one third of the process was completed (visualized by the horizontal arrows passing through the three different subjects observed and reflected on in the three grades). Additionally, the teachers teaching the same subject reflected on the observed activity on the same day as their meeting (visualized by black circles in the figure).

The reflection time after each observed teaching lesson lasted for about one hour, and this time represented work on top of what the teachers had to do. Therefore they were paid extra for the time they used on reflection after each observation session, from the school budget. The long-term intention was that the teachers would find this activity so useful that they would add it to their repertoire on a permanent basis in the time they already had at their disposal. As you can see in the citation at the very beginning of the text, the teachers wanted to follow the same plan the next year, meaning that they wanted to observe each other's teaching and reflect on it without any extra pay. In the following section, I provide a picture from a classroom based on observation of a lesson in mathematics and a glimpse from the reflection dialogue in the subject team following this lesson. Then I present the method used to capture and understand the process and how the teachers experienced the process and learned in their work.

The method used to capture the processes experienced by teachers

During the research process I wrote logbook entries, observation notes, transcriptions and preliminary analyses and interpretations. I observed the teachers during learning activities, and I also observed and reflected together with the teachers in class team meetings and in the meetings where all the Team 3 teachers came together. I also have observation notes from the seminar on action learning (Revans, 1982; 1984), and audio recordings from the whole day seminar. This material helped me to get an understanding of the processes during the observation and reflection activity, as illustrated in Figure 2.

The material gathered from the activity following the plan in figure 2 includes the teachers' planning documents for the lessons that were to be observed. I observed every lesson and took observation notes. I

actively took part in the joint reflections afterwards, which were tape-recorded. At the end of every semester the teachers at the school attended a meeting to present their experiences as participants in the project so far. These presentations were also tape-recorded, and all the audio recordings have been transcribed.

Throughout the process these texts helped me to distance myself from the ongoing activity (Riceour, 2004). The main features which had a decisive impact on the project and the learning and development that took place, were the start-up phase which lasted almost the whole of the first semester (Postholm, 2008a) and the observations and reflections following lessons and meetings (Postholm, 2008b). Next, I present a description of a lesson as an example of teaching practice and how it was reflected on.

An example from practice: observation and reflection

The story below is a short description of what was going on in a classroom when students in the eighth grade were having a mathematics lesson. The teacher had placed the students in groups, and the aims for the lesson were to give the students training in the use of mathematical words and concepts orally, to give them experience in formulating mathematical questions and to give the students training to understand and use logical argumentation. The ninth and tenth grade mathematics teachers and I were observing the lesson:

> The students are sitting in three groups or stations, as the teacher calls them, and they are going to do various things as they move from station to station. They have ten minutes at each of these stations. At the end of the lesson they are going to sum up all of the activities. It is the teacher that has established the groups in which the students get training in mathematical concepts. In one of the groups the students are working on a small board on which it is possible to make geometrical figures with a rubber band. When they have made a triangle without someone looking, they sit together in pairs, to explain the process to each other. One of the students tries to make the same figure as the other without saying a word, just listening. It is just the person who explains that does the talking. One of the students says during the summary dialogue afterwards that it was difficult to make the other understand, but all of them agree that the persons trying to be silent without talking, did it well. The teacher then asks the students if they know the names of various triangles, and they eagerly put up their hands.

Below I present an extract of the dialogue that took place after the accomplishment and observation of this lesson in mathematics. The teachers say:

Teacher 1:	(10th grade). Did the pupils learn anything?
Teacher 2:	(8th grade): Communication skills were developed, I think.
Teacher 3:	(9th grade): I think the pupils benefited a great deal from this lesson.
Teacher 1:	What do you mean by that?
Teacher 3:	I sat next to a group, I'm sure that they benefited from it.
Teacher 1:	They had the opportunity to repeat their concepts. And worked together to find solutions, thus the knowledge they already have was confirmed. They

didn't learn anything that was new to them.

Teacher 2: It's a communication training exercise. I feel that they also have to learn communication skills, that it's important to explain what you know. They need to have knowledge about this to manage to communicate. If it's completely new knowledge, it's hard to communicate. It's reproduction, but it could be that it sits better up here when they undertake such an exercise.

The teachers discuss back and forth whether or not the pupils have learned anything. In this dialogue they had a good opportunity to discuss Piaget's' concepts of assimilation and accommodation (Piaget, 1970), but they did not.

When I asked the teachers about the use of theory they have learned during their education, some of them said that it is in their bones. One of them stated: "And if you begin to consider why you do various things, why do I do it like this and like that, and then you have it, because you have substantiated it for yourself, not just put it into words". The teachers obviously thought that their knowledge is tacit (Polanyi 1967). One of the teachers said that she "has it", but she cannot put it into words. This means that the knowledge she is referring to is accessible, perhaps not being completely tacit but being "silent" knowledge that can be put into words. According to Dreyfus and Dreyfus (1986), people who act with proficiency think analytically about what to do. The teacher who said this has several years of experience as a teacher and could therefore be perceived as an expert. All the same, she plans and reflects on her actions. This means that experts also can reflect on their daily practice, and according to Dewey (1916) and Tiller (2006) this is what they should do if they are to continuously improve their teaching.

The reflection dialogues: content and form

But what tools can teachers use in this frame of reflection? At the outset I believed that my role was to push and support the teachers, and furthermore, connect theory to their experiences from practice. I had to change the appreciation of my role. The teachers had to first become acquainted with their own and others' practice, and the situation. After a whole semester with observations and reflections I felt that the discussions in the subject teams had to be given some impetus. Their reflections seemed to be going in circles, and it was time for theory to move the development forward in spirals of improvement. At this point, the teachers stated that they knew what was going on at the various levels in the three subjects. In a way, they had developed a collective actual development level (Vygotsky, 1978). It was time for theory to function as a development tool in the teachers' zone of proximal development (Vygotsky, 1978). As I will show, both the form and the content of the reflection dialogues changed during the process.

In the beginning, the form of the reflection dialogues was fairly strict. Everyone was to speak in turn during the first session. First, the teacher who had given the specific lesson spoke about his or her experience of it, focusing on the aim and content of the lesson. In their comments, the teachers were to pay attention to the aspects on which feedback was wanted, for instance how they perceived the slow learners' learning activity,

and how this activity could be developed for these pupils. In the first and opening session, the teachers who had observed were to give positive comments on the teaching, followed by good advice and tips.

During the first semester with observations and reflections, the teachers were not encouraged to challenge each other about the teaching situation, but just supported each other. The relations in the first conversations could therefore be called symmetrical (Bateson, 1972). Being in such a relationship means to give each other positive affirmation. It seemed necessary to have a semester in which the teachers were allowed to observe and reflect together so that they gained insight into each other's teaching. They said this also made them even more confident in each other, and the foundation for development became more solid (Krogh, Ichijo & Nonaka, 2000).

During the next two semesters the content of the reflection dialogues was expanded. In these dialogues the teachers challenged each other with questions connected to the observed practice. In the reflection dialogue presented above, we can see that one teacher challenged the observed teacher by asking about the students' learning. Being in relations where participants are challenging each other is called 'complementary relations' (Bateson, 1972). The teachers had at this point become familiar with the form of the dialogues and each other's practice, and it was time for questions, theory and theoretical concepts to be introduced into the reflections. Theories about learning and motivation were discussed to better understand and argue for the activity in the classroom. Such concepts as self-regulated learning, learning strategies and metacognition were also introduced. In this way a common understanding amongst colleagues was created through the concepts introduced in discussions. Hence, the teachers had learned a form of reflection whereby dialogues can take on a common understanding and meaning with respect to theories and connected concepts. Learning was obviously prevalent in the reflection dialogues based on the observations. In the following I elaborate on the teachers' learning throughout the R&D work.

The teachers' learning

Action learning is, as mentioned above, and according to Revans (1982; 1984), defined as an activity in which teachers learn on the basis of concrete actions. The teachers say they have learned that reflections on teaching practice are meaningful. This is specified more in the following statements made by the teachers. They say:

- It's nice to reflect on specific experiences
- You become more aware of substantiating your teaching
- It makes you more aware of what is good or not
- We help each other in a busy work situation

- Sharing ideas makes you more secure. Perhaps someone will use the plan you've made; others may use your ideas. It's good to know that others like what I do. And when we share ideas, we accomplish a lot together
- The reflection process becomes part of the planning work

The teachers prefer to reflect on specific practices and say that they become more aware of arguing for their teaching and what are good or bad learning activities. They perceive the reflection process as helpful in a busy work situation, and also appreciate that others like their ideas. Furthermore, the teachers experience the reflection dialogues as part of their planning work. Hence, the attention in the dialogues, directed both back and forward, helps the teachers in future actions.

During the project the teachers gained the possibility of focusing on various working methods and learning strategies over a long period of time, and they have learned that this is decisive when trying to improve their teaching practice. The teachers have also learned to ask questions about their own practice and to think ahead, not just to reflect on their teaching, but also to use these experiences to plan further teaching activities. Not only did they reflect that reflection stems from Latin (*re-flectio*) and means "to turn" (*flectio*) "back" (*re)*, but they also asked questions when thinking forward in time about something that should be done, in the direction of goals. *"Pro"* in Greek means *forward.* Proflection then means to turn forward. When preparing a plan to reach a new goal, the focus was then turned both forward and back. They we can say that "reproflection" was taking place, which means a dialectic relation between the past, present and future.

During the reflection processes the teachers developed their beliefs in theories, and after a while theories became a tool for development. The teachers got the opportunity to strengthen their learning when lecturing to student teachers about their project. During these lectures the teachers used theoretical concepts such as action learning, self-regulation, metacognition and learning strategies as if they have been included in their repertoire for a very long time. The teachers have obviously internalized these theoretical concepts, and used them as their own.

During the action-learning course the teachers learned how they could put their observations into writing. Before the project started, some of the teachers had made this part of their own practice, but all of them received training in jotting down what they saw, according to the focus of the observation, and what the teacher of the lesson wanted feedback on. When observing, the teachers also found it necessary to write. It helped them to remember what they saw, and then these notes became a helpful tool in the reflection processes when giving feedback. Hopefully the teachers continued to write down thoughts and reflections connected to their own teaching and daily practice, because such notes can help them to reflect systematically on their own teaching (Tiller, 2006).

Accordingly the teachers learned to find time for observations and reflections. They learned that this had to be planned at the beginning of each semester to make it possible. Furthermore, the teachers learned how reflection processes between teachers might be conducted, how tips and experiences can be exchanged, and also how to give each other advice or challenge each other by asking constructive questions. One of the teachers stated: "This is very useful. It is we, the teachers that are to learn from this, but our learning will also ensure that the students will learn more. In the final section of this paper I will elaborate on teachers' learning and what knowledge or competences could be part of their professionalism.

Concluding comments

In this text I have described what and how teachers can learn during an R&D project. The teachers got the opportunity to observe each other's teaching and reflect together, and thus learn from each other in their daily practice. The teachers had a problem formulation or a common object to act on. They, furthermore, asked questions about their particular lessons that were observed and reflected upon, in relation to various working methods and learning strategies to enhance the students' subject and social competence. In the Norwegian General Teacher Education Plan (2003) it is stated that continuing change and development competence should be part of teachers' professionalism. This means that teachers are expected to have a critical and focused gaze on their own practice to continuously change and improve it. In turn, teachers have to be active and responsible in their teaching processes, they should desire their own goals and furthermore strive to reach them. The project shows that if the drive for change and development comes from below and from within the teachers themselves, they will find development work meaningful. This does not mean that teachers work outside the national curriculum. It means that they can make their own decisions about the themes and competences listed in the plan, and fight for what they really believe in. In this way the drive can come from the teachers themselves, and really lay the foundations for learning and enduring development.

When the teachers decide what to work on themselves, it is more likely that they will find the work meaningful, and that they will continue to develop it without any external motivation or requirements. When this is not the case, development work most probably fades out when external pressure is removed. In the present R&D project the teachers developed the problem formulation on the basis of their interests at the same time as the national curriculum presented its chosen topics as central for teaching. I think that for the most part teachers find support and grounding for their teaching in this plan, but the content and arguments for teaching have to come primarily from within the teachers themselves. Then they can feel free to act as teachers, and the most important motivational factors with regard to teaching activities can be located within the teachers' daily practice and not outside it. And as previously stated, these two

perspectives do not necessarily collide.

The results from this project show that the teachers, one and a half years after the researcher has withdrawn, exchange knowledge between themselves, and the teachers feel that the atmosphere lays the ground for a more open dialogue. The teachers trust each other even more than before the project started. They have continued to reflect on daily practice in various teams, and learning strategies are still a focus for their reflections. This shows that when teachers experience a practice as meaningful, they will continue to do it, even though external pressures or, even more important, support mechanisms guided by the teachers' own motivation have faded out. Resource persons from teacher education can give this support in continuing education for in-service teachers in their practice, and R&D work taking the teachers' interests as its starting point provides a good basis for teachers developing their own practice.

Workshop Report: Introduction

During the S-TEAM conference the author, together with two participating teachers, presented experiences from a research and development (R&D) work project in Norway. This project was funded by the Norwegian Research Council, and was conducted in a school with about 400 students and 40 teachers. The selected school is situated in a suburban area and has students from the first to tenth grades. The teachers are divided into three teams. I was connected with Team 3, consisting of teachers teaching students in grades 8-10, and therefore this micro society (Krogh, Ichijo & Nonaka, 2000) was in focus in the presentation and in the discussions during the workshop. There are altogether 12 teachers in this team, to which the presenting teachers belong. Teachers from Glasgow and teacher educators from Glasgow, Turkey, Denmark and Sweden took part in this workshop.

Presentation and discussion

First I gave a presentation on how the R&D project was started up. I Informed the group that we, the teachers and I, in the beginning of the project jointly formed a research question to guide and frame the work. The question we arrived at was:

How can various work methods with the focus on learning strategies contribute to each student's subject and social development?

Furthermore, I descibed the start-up phase and how the teachers struggled with time, and how they developed a sense of belonging to the project during the first semester of cooperation. During a planning day in November, the teachers decided that they wanted to share ideas in class-team meetings, in Team 3 and in meetings where only teachers of the same subject were present. The teachers wanted to use time on focused reflections to improve their teaching. I described how the project now was moving forward and that the teachers had really taken control. They perceived it as their own project. I told the participants in the workshop that for the next meeting in Team 3, the week after this planning day, we drew up a plan that formalized the teachers' wishes to observe each other's teaching, reflect on it afterwards and then share experiences and ideas.

Next the presentation turned to action research in general. In this connection, activity theory (Leontév, 1981) and Engeström's (2001) expansive learning circle was introduced. I presented the main findings in the project as follows:

- Teachers have a lot of "tacit knowledge" that can be used in reflection dialogues to improve practice
- Reflection is an important activity in the planning of teaching

- Intentions have to be formalized/put into a plan if they are to be accomplished
- If teachers experience development work as meaningful they will use it their daily work.
- The appreciation of meaning is decisive
- It is important to identify with the work (from within , from below)

Furthermore I listed up for the participants what I, as a researcher, had learned during the project:

- It takes a long time for the teachers to identify with the research question.
- There can be an imbalance between the understandings that teachers and researchers have about theory.
- The researcher should try to understand the situation from the teachers' perspective, and adapt the process starting from their standpoint.
- The timing of the introduction of theory is significant.
- Theory in thinking processes represents the here and now situation with a view backwards and forwards at the same time.
- Development work has to be process driven.
- It takes some time before the teachers get to know their own and the other teachers' practice.
- Observations and reflections made them even more confident in each other.
- It is important that reflections on teaching take place on the same day as the teaching is accomplished.
- The researcher' s role: support and push the teachers.
- Challenge: Find this balance – support the teachers in their teaching and at the same time aim for development.

Next it was the teachers' turn to talk about the project, how it proceeded after the researcher had withdrawn from the practice field and what they had learned during the project. About their own learning they say:

- Experiences with focusing on one theme during a long period of time
- Experience in thinking ahead of practice
- Developed our view on theory
- Theory was helpful to analyse our teaching
- We learned how to write observation notes
- We saw how the researchers gathered data
- We still challenge each other with questions about practice

During the presentation the teachers also cited what one of the other teachers in the team had said. She had said: "This is very useful. It is we, the teachers, who are going to learn from this, but our action learning

will also make the learning better for the students". When commenting on what the situation is today one of the presenting teachers commented:

- The researchers have withdrawn
- Teachers and students still focus on learning strategies
- We cooperate in subject teams
- We share experiences daily and trust each other
- **There is a change in teachers' strategies towards inquiry based teaching**

The presenting teachers, one teaching English and the other science and mathematics, describe how students use learning strategies during their work. The teachers report that they have changed the way they teach so that their students are more active in their own learning because they use learning strategies. Thus the teaching has developed into a more inquiry-based activity where the students actively strive to solve their tasks and construct meaning and understanding during the teaching. The teacher in mathematics and science gives three examples of how his teaching has developed into an inquiry-based activity during the students' learning. These examples are about preparing for new topics, preparing for tests, and using column notes to systematize substances and shapes according to properties and form. He comments:

To prepare the students for a new topic, the science and mathematics teacher usually draws a mind map on the blackboard. The students decide the content of the mind map, using the knowledge they already have. When developing this content, they discuss it and make inquiries among themselves to create the mind map. This reflection refreshes the students' knowledge on the topic and gives the group accumulated knowledge. Moreover, this inquiry allows the students to refresh their knowledge and prepares them for new information on the topic.

The students are given the time to prepare for tests in these two subjects during class time. They can choose between different learning strategies to organize the topics. When they are organizing the topics, they are given the time to inquire about the process and the content so they can determine what is the important and relevant information for their purposes. This method gives the students time to make a deeper inquiry into the topic and refresh the content. Different test methods have been tried, where the students have had their notes with them (open-book) and where they have used a more conventional approach with no aids. On average, the best results have been achieved with the open-book test, and this test situation also functions as a learning situation for the students.

The students use column notes to systematize the information they compile on different substances and geometric shapes in mathematics. This means they have a system they themselves have produced that can be easily used later in other work. The system can also be used during tests or other activities. By using column notes, the students are also actively inquiring about the topic to collect more information.

The teacher reports that, all in all, using learning strategies seem to provide the students with a system that encourages them to actively search for and construct knowledge on various themes. This is reinforced by the fact that the students also use learning strategies voluntarily whilst doing their homework.

Discussion

The participants already during the presentation wanted to ask questions and discuss topics that came up in the presentation. “Time” tended to be a common challenge across the participating countries. The teachers obviously experienced that there was too little time to reflect together on teaching experiences. It was with pleasure that the teachers and I could tell of the struggle with time and the use of time throughout the project. This development was due to the meaningfulness they experienced, and that they felt ownership: it was really their project. Another topic that was discussed was the relationship between the teachers and the researchers, and what the researcher’s role in such projects should or could be. In this connection we all agreed that the topics that are to be worked on and the problem formulations that are used should be created on the basis of the teachers’ interests. We all agreed that the drive for change and development should come “from below” and “from within” the teachers themselves, and that they then would find development work meaningful, as in the present project. We also concluded that the researcher’s role in such projects is demanding. The researcher is to support the teachers in their development of practice at the same time as researching these processes. Another topic that was brought into focus during the discussion was about the research questions and how they emerged from the development processes.

During the presentation we agreed that each teacher has to have a will to develop, and that reflection processes on classroom activity wer the central activity during action learning, and thus an activity in which teachers can learn together and develop in their profession. We also discussed the importance of the formalization of plans at the school level, such as the plan I made, at the teachers request, on observation and reflection. In this connection a participant in the workshop described a research project about formative assessment and the factors that were important in managing to successfully accomplish such assessment work. He mentioned Personal and Professional Integrity and Systemic Integrity. This project was also published (Hayward, L. & Spencer, E., 2010). He obviously saw some similarities between our findings and the findings in the project he referred to. On the whole I, the researcher, experienced that challenges and possibilities in action learning and research on these processes are the same across countries, and that we therefore have a lot to learn from each other.

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