

Report on

The KUL-projects:
Learning Communities in Mathematics
and ICT in Mathematics Learning

by

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Preface

The following report is an interim evaluation of two research and development projects which have been carried out by scholars and didacticians at the Department of Mathematical Sciences at University of Agder in cooperation with teachers and staff at a number of schools in the Kristiansand region. The aims of the projects have been to establish close cooperation between a university department and schools, and to test and implement the ideas of developing mathematics teaching and learning through the principles of communities of inquiry and through the uses of information technology. As evaluators we want to thank the participants in the projects for their willingness to share their experiences of these activities with us, and to openly comment on what they perceived as successful and less successful elements. In particular, we want to thank the many representatives of the participating schools – teachers, headteachers and other school leaders – for the manner in which they generously contributed to this evaluation by commenting on how university-school collaborations of this kind appear from the perspectives of those who have the responsibility of teaching mathematics and making it relevant to new generations.

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1. Introduction

The following report is an interim evaluation of the projects that are referred to as *Kunnskap, utdanning og læring* (KUL) carried out between 2004 and 2007 at the University of Agder (UiA) at Kristiansand. The idea behind these projects has been to develop teaching and learning practices in mathematics in close cooperation with local schools. In this report we will first give a brief presentation of the KUL-projects, the ideas behind them and the activities pursued. Following this we will present the procedures of the evaluation and the data collected. After this we will report our findings and conclusions.

2. A short presentation of the KUL-projects

Kunnskap, utdanning og læring (KUL) includes two projects: *Learning Communities in Mathematics* (LCM) led by Barbara Jaworski and *ICT in Mathematics Learning* (ICTML) led by Anne Berit Fuglestad (ICT refers to Information and Communication Technologies). The LCM and ICTML projects are closely related. They share perspectives and approaches, and together they form what is locally referred to as the KUL-projects.

The aim of the LCM project is to “design and study mathematics teaching development for the improved learning of mathematics through inquiry communities between teachers and didacticians” (Jaworski, 2007a: page 1). On this basis, the specific mission of the LCM project is described as follows:

- “To study the processes involved in creating communication and collaboration between mathematics teachers and didacticians in which theoretical ideas and visions can be interpreted in practise
- To produce insight into key issues in developing inquiry communities to enhance mathematics teaching and learning
- To provide indications of sustainable practices in mathematics teaching development and learning improvements.” (Jaworski, 2007a: page 83)

The ICTML project takes its point of departure in the observation that “many teachers lack knowledge of how to utilise ICT in mathematics and ask for good examples of use” (Fuglestad, 2007: page 1). On this basis, the aim of the ICTML project is “to meet

this challenge” and “to be a research and developmental project where teachers and didacticians work together to inquire how ICT can support and improve teaching and learning of mathematics by focussing on inquiry community” (Fuglestad, 2007a: page 1).

The term didactician, which is not common in English (but more frequent in its Norwegian version), is used as an alternative to ‘educator’. ‘teacher educator’ or ‘researcher’ to point to the particular responsibility of professionals and researchers in this field of theorising teaching as an object of inquiry. This choice of term also gives an indication of how the members of the project staff at AUC wish to see their own role and responsibility in this activity.

To give an indication of the size of the projects, the LCM project involves 14 didacticians, including 5 doctoral students, from AUC, and 30 teachers from 8 schools (2 primary schools [barneskoler]; 3 secondary schools [ungdomskoler], 1 comprehensive school with grades 1-10; 2 upper-secondary schools [videregående skoler]). The ICTML project includes 3 didacticians and 12 teachers from 4 schools. Of course, these numbers have fluctuated somewhat during the course of the work, especially with respect to the number of teachers participating, as will be seen below. It should also be mentioned that colleagues from the LCM project contributed to ICTML workshops and other activities.

The KUL-projects have a duration of 4 years: from the beginning of 2004 until the end of 2007. They have been organised in the following phases:

1. Introductory Phase, January to July 2004: Creating possibilities for collaboration
2. Phase 1, August 2004 to July 2005): Community building
3. Phase 2, August 2005 to July 2006: What exactly do we mean by “inquiry”?
4. Phase 3, August 2006 to July 2007: Working towards school goals
5. Closing Phase, August to December 2007: Documenting and disseminating

During these phases there have been three principal sites for data collection, namely:

1. Workshops at AUC involving all participants in the projects. LCM has had 6 workshops each in Phases 1 and 2, and four workshops in Phase 3 (16 in all). ICTML has had four workshops in each phase (12 in all).
2. School activity involving teachers in a school working together (or sometimes singly) to develop mathematics teaching and learning. Visits from didacticians to meetings of the teacher team or to classrooms have resulted in the main sources of data for the projects.
3. A longitudinal study in which a selection of students has been tested with specially designed mathematical tests. The students were also surveyed on their attitudes to learning mathematics. Teachers have been interviewed. This research has also involved a number of master’s students

3. Inquiry communities and mathematics teaching and learning: An outline of the aims and ambitions of the projects

There is a considerable overlap in terms of theory and educational ambitions between the two projects, *Learning Communities in Mathematics* (LCM) and *ICT in Mathematics Learning* (ICTML). The main thrust of the theoretical background for the activities engaged in by the projects comes from the work on learning and communities of practice formulated by Jean Lave and Etienne Wenger during the 1990's. The basic ideas of the projects, both in terms of the perspectives on teaching and learning endorsed and the developmental activities engaged in, have been articulated in a number of publications (c.f., for instance, Jaworski, 2004a, b, 2007a, b; and Fuglestad, Jaworski & Goodchild, 2006). We will give a brief outline of how the work has been organised and its intellectual underpinnings.

In terms of the overall organisation of the project activities, the work has followed the logic of a developmental research paradigm, which has some similarities with what is currently known as design research. The notion of a design cycle with the following components has been used as a heuristic model for structuring the interventions:

1. Design
2. Action
3. Observation
4. Reflection
5. Feedback

The logic of this cyclic process is that teachers, in cooperation with didacticians, design teaching and learning activities in a particular area to be tried out in the classroom. The implementation of the ideas takes place during the action-phase, which is simultaneously what is observed. After the lesson, teachers reflect on the activities and compare what has happened with what was intended according to the theoretical ideas and assumptions guiding the intervention. During the feedback phase, the teachers and didacticians analyse the experiences and modify and develop the ideas on the basis of the experiences made. The design cycle is also intended as a learning cycle in which ideas and concrete educational experiences provide a basis for continued development. In comparison to most design research, the approach differs in one important respect: the heavy involvement of teachers during all phases of the work. Thus, there were no 'designers' who brought ready-made ideas and solutions to be tested into the classrooms. Instead, the design was a joint undertaking by the teachers and the didacticians.

An intellectual core of the activities is the notion of 'community'. Thus, at the outset the project work itself was organised as a community building exercise in which

sustainable partnerships between didacticians (i.e. the scholars from UiA) and the teachers were sought to be established and maintained. As an extension of the notion of community of practice, the concept of 'community of inquiry' was formulated. The norms of such a community imply that members engaged in activities such as teaching or research assume a stance of a critical and analytical questioning of their own practice. Thus, one seeks to approach one's practices with a critical perspective of continuous inquiry in which understanding will deepen and inform new modes of teaching and learning. The notion, or rather: activity, of inquiry is further specified as something that should characterise inquiry into mathematics, into mathematics teaching and learning, and into researching the activities of mathematics teaching and learning. These are related but in important manners different levels of inquiry. The discussions of the implications of seeking to establish 'communities of practice', and the experiences made in this respect, *per se* potentially constitute an important outcome of the projects.

4. The task of the evaluation

The evaluation of the projects has taken place during the period from May to August 2007. This means that the evaluation took place when Phase 3 was coming to an end and when the Closing Phase was about to start. In other words, the evaluation relates to documentation and dissemination of the KUL-projects by representing an external and critical look at the projects at this particular point in time. On this basis we see the aims of the evaluation as the following:

1. briefly reviewing the documentation (reports, articles etc.) produced within the projects, keeping in mind that the main part of the documentation and dissemination of findings will be appearing during the Closing Phase of the project. This is when the major results from the extensive empirical studies will be reported, and when the dissertations connected to the projects will be published. Thus, the evaluation has been carried out prior to the final reporting and this must be kept in mind.
2. scrutinizing the overall aims, perspectives and approaches of the projects by analysing formulated aims, missions and crucial notions.
3. Addressing and reflecting on the experiences of the teachers and didacticians involved in the developmental research and the community building.

It should be noted that the evaluation does not address the experiences of the students in the schools which participated.

The basis for the first and second tasks of the evaluation is the material which has already been produced, while the basis of the third task of the evaluation is a series of interviews.

5. The interviews

One set of interviews was conducted by Ole Skovsmose during the period 7-9 May 2007. A second set of interviews was conducted by Roger Säljö during the period of 30-31 May 2007. The interviews conducted by Ole Skovsmose were summarised in a written format during the interviewing, while the interviews conducted by Roger Säljö were audio-recorded and later summarised in writing. In all, the interviews lasted for slightly less than 15 hours. A general aim of these interviews was to address the following six issues:

1. Experiences of *education possibilities*. The guiding questions were: What new educational possibilities have you experienced through your participation in the project? Do they represent possibilities relevant for your own teaching practice? Could you exemplify?
2. Experiences of *collaboration*. The guiding questions were: How do you see collaboration and team-building as part of processes of educational innovations? How did you experience team building as part of the project? Could you exemplify?
3. Experiences of *inquiry processes*. The guiding questions were: Could almost all learning process be structured in terms of inquiry processes? What principal features are important for making an inquiry? Could you exemplify?
4. Experiences of *mathematics*. The guiding questions were: Do you see 'classic' mathematics classroom routines as necessary for learning mathematics? Has your conception of mathematics and of *matematisk faglighet* changed during the project? Could you exemplify?
5. Experiences of *uncertainty*. The guiding questions were: How do you see your possibilities for operating in a risk zone – so often associated with educational innovations? Do you experience specific uncertainties related to the uses of ICT? Could you exemplify?
6. Experiences of *doing research*. The guiding questions were: Do you experience conflicts between doing 'proper' research, which for instance could be included as part of a PhD dissertation, and doing developmental research as exemplified by the projects? Could you exemplify?

The interviews were organised partly as group interviews and partly as individual interviews. The overall concern was to get a picture of the participants' experiences of the six issues, where some of the issues were addressed primarily to teachers, others primarily to didacticians. The references to particular phases of the projects only appeared when the interviewees were asked to exemplify their experiences. Two aspects of the interviews were important: first the interviewees were asked to tell about their

experiences, and second they were asked to *exemplify* their experiences. They were also informed that they would stay anonymous.

This organisation of the interviews implies that we have met representatives of all the schools that participated and almost all of the didacticians who were deeply involved in the projects.

6. Some general impressions

It is obvious that the KUL-projects are very ambitious in terms of their aims and scopes. The idea of creating communities of inquiry that seek to challenge long-established traditions in mathematics teaching and learning in such a relatively short time as a few years is very demanding. The explicit ambition of involving teachers in all stages of the process of creating such communities of inquiry is a challenge in terms of time, but also when it comes to making the ideas concrete and viable for the teachers. This is not the standard model for developmental work in schools, and one must realistically assume that such an ambitious approach will have a slow start, and it may even initially be perceived as vague by some participants.

At a general level, all participants – teachers, school leaders and didacticians – give a positive view of the projects and the manner in which the work has progressed. It is obvious that the activities during the workshops, the school visits and the main conference in September of 2006 were perceived as productive and interesting. The atmosphere has been positive, and the representatives of the schools report that what they had to say counted as an important input to the activities. Thus, in terms of the relationships between the teachers and staff from UiA, there has been a reasonable balance and most commented favourably upon this.

Also in terms of the administration of the workshops and the other activities, almost all teachers and representatives of schools were positive. The workshops were perceived as very well prepared and well organised, as were the other activities. Thus, a conclusion at this general level is that it seems as if all the parties involved came out of the projects with positive experiences when it comes to being involved in this kind of university-school developmental activity.

7. Specific issues: A selection of observations

In the following sub-sections we will comment on some of the more specific issues that came up in the interviews.

7.1 Collaboration

Different forms of collaboration emerged as part of the KUL projects.

It was generally agreed among the participating teachers and school leaders that the KUL-projects had stimulated new forms of *collaboration among teachers within the participating schools*. In particular, the KUL-workshops had formulated issues which stimulated and facilitated collegial discussion and collaboration. Several teachers stressed that this was a unique and new experience for them linked to the activities of the KUL-projects.

Some teachers mentioned that the KUL-projects had brought about new forms of *collaboration between groups of teachers from different schools*. The KUL-workshops had served as an important meeting place, and some of the meetings had created new patterns of interactions between schools. It was also interesting for teachers at lower levels to hear the teachers at later stages commenting on issues of how prepared the students were for mathematics learning at more advanced stages. This is something which one rarely has any feedback on as a teacher. But, in general, these possibilities of inter-school exchange of experiences were seen as interesting and rewarding.

The teachers appreciated very much the *collaboration with didacticians from UiA*. This is very clearly and more or less unanimously expressed in the interviews. This collaboration was crucial for the ideology and the ambitions of the KUL-projects, and from the teachers' perspective the collaboration turned out to their satisfaction. Several teachers pointed out that they had never previously experienced such openness from researchers from the UiA, even though they had participated in different projects that had included researchers from UiA. The didacticians in the KUL-collaboration had demonstrated a genuine interest in their school practices. From the perspective of the teachers, there is no doubt that the collaboration with didacticians from UiA was a most valuable part of the KUL-project.

Some of the didacticians, in particular PhD students, found that the planning of the workshops had been very time consuming: was such an exaggerated carefulness concerning all possible details of a workshop really necessary? We must, however, add that judging from what the teachers say, the preparation of the workshops seems to have been a wise investment, not only for the specific organisation of a workshop, but also for achieving a productive interaction between theory and practice, and for establishing and maintaining an intense didacticians-teacher communication based on curiosity and mutual respect. Didacticians from UiA also reported that the KUL-projects had established new forms of collaboration among colleagues at UiA.

7.2 Conceptions of mathematics and mathematics teaching and learning

The KUL-projects attempted to establish *inquiry* as an important part of learning at various levels: about mathematics, about teaching and learning mathematics, and about developmental work. This meant that the traditional notion of mathematics (*matematisk faglighed*) was challenged in several senses. What has been referred to as the ‘school mathematics tradition’ builds on a conception of mathematics which includes priorities about what is important to learn in order to master mathematics. The school mathematics tradition puts a particular emphasis on: a) the teacher’s textbook-based presentation of new issues; b) the students’ activities of solving pre-formulated exercises; and c) the control of the correctness of the solutions presented by the students. The *matematiske faglighed* which is associated with the school mathematics tradition is an acted-out conception of what is important for obtaining mastery of mathematics. It is not an explicit, theoretically and philosophically elaborated conception; it is in immanent part of the institution of how to do mathematics in school.

The inquiry approach explicitly and radically breaks with this conception of learning mathematics. The power of the KUL-projects has to do with how the inquiry approach informs and comes to be a part of reformed classroom practices. It is beyond the scope of this evaluation to try to document the degree and nature of changes in classroom practices through classroom observations, but such changes were reflected in the teachers’ comments about their experiences of the impact of the project. Also, analysing such changes will be a significant part of the research agenda of the projects.

Some teachers argued that before participating in the projects, they were ready to experiment with non-traditional forms of mathematics teaching. It seems that several teachers got themselves involved in the KUL-projects because they felt a need to enter into processes of educational experimentation and innovation. They were ready to move beyond the institutionalised school mathematics tradition, and they had in fact already to some extent done so. However, they felt that one of the contributions of the KUL-projects is that they were able to make explicit ideas of teaching and learning which they had not formulated before. Several teachers referred to a particular formulation by Barbara Jaworski which indeed is central to the ideology of the KUL-projects: “Inquiry is a way of being”. This formulation, it was felt, symbolised and condensed many educational ideas and ideals which have been around for some time. But it was only through the KUL-projects that such implicit educational visions could be conceptualised, organised and turned into powerful and consistent guiding principles: inquiry processes could make up a defining part of teaching and learning mathematics.

We also asked the PhD students if, and to what extent, they found that their notions of mathematics and of learning mathematics had changed as a consequence of their participation in the project. The answers, on the whole, were in the affirmative. In fact, one PhD student stated that he found that his notions had changed radically. This is an interesting observation, since it indicates that not even all of those who participated in

the projects initially had very clear notions about the particular approach to developmental work and to mathematics learning that the projects represent.

7.3 Inquiry as a method vs. inquiry as an epistemological stance

From the point of view of didactics and educational philosophy, one of the most interesting features of the inquiry approach as articulated in the projects concerns to what extent the teachers' interpretations of what constitutes inquiry are consonant with what was intended. In the material collected for this evaluation, it is interesting to hear that this meta-issue was discussed by several teachers and didacticians, and there was a sense that the interpretations of what constitutes inquiry-based learning differed between participants throughout the projects.

Many remarked that some of the participants seemed to interpret inquiry approaches to mathematics as an extra activity on the fringes of the curriculum, something that one could engage in if there was time and which could be stimulating for the students. This is a kind of Mary Poppins' interpretation in the sense that inquiry may serve as a sweetener to make the mathematics to be learned a bit more tasty.

Others saw it as a more or less radical break with the conventional tradition of mathematics teaching described above. This implies that inquiry learning appeared as a new, more student centred, approach to teaching. In this interpretation, learning was seen to follow from the kind of engagement with mathematical reasoning that the inquiry model implies, and this kind of engagement would lead to gains in learning as well as, and equally importantly, more positive attitudes to the subject. It seems as if the positive attitudes that most teachers expressed to inquiry learning had to do with the experience that inquiry learning concretised for them what they had intuitively felt: this is a more productive, student-active way of organising mathematics learning.

However, when reading the documentation there is a third interpretation which represents an even more ambitious goal, namely the idea of seeing inquiry as an epistemological stance that would characterise not just mathematics learning among the students but also school development, and perhaps learning, in general. This is the idea that inquiry encapsulates a conception of the process of how we come to know the world through interaction in communities of practice, and this applies equally to students learning mathematics and to teachers trying to develop teaching and learning practices. In other words, inquiry is a model for how we come to know the world around us. To what extent and in what sense this idea became clear to the participants is an interesting topic that should be explored when analysing the material collected from the workshops and other sessions. There are signs in the interviews that reflect this idea among the participants. It is our impression that the notion of communities of inquiry and the debates about the concept provoked interesting and generative discussions.

7.4 The impact on students

The impact of the KUL-projects for classroom practices and for the students' experiences of learning mathematics was not addressed as part of the evaluation through any direct observation. The impact on the classroom practices was evaluated through the teachers' experiences and through their reports about changes of practices. Several teachers commented on these issues, and they argued that they had noticed such changes in terms of how they and their colleagues talked about and organised classroom activities. Also, there is further documentation of initiatives taken in the many publications produced from the projects. Further documentation of what has taken place in classroom is also included in the extensive KUL Data Bank.

7.5 Data management in KUL projects

During the KUL projects, data from many different situations have been collected, for instance from workshops, seminars, school meetings, classroom visits, interviews, briefing papers, longitudinal tests, exchange of e-mails and other correspondence. The data exist in many forms: as video and audio recordings, word and text documents including data reductions (factual summaries of the content of video and audio recordings) and transcriptions of recordings, PowerPoint presentations, copies of texts produced by pupils and teachers, Excel sheets, and objects from software such as Cabri and Geogebra. The data have been collected by all didacticians.

The fundamental principle is that the data are owned by the project as a whole, not by individuals. Thus, didacticians share a common data base. All data exist in digital format and are stored on the UiA main file server using a standard windows-based filing system. A set of file names has been developed that identifies each document by the type of event from which the specific data were collected, the date of the event, the location of the event in the case of schools, the type of data, the person responsible for collecting the data, and in some cases a date on which the data corpus was actually produced if this differs from the date of the event. Data objects are then filed by type of event as sub-files belonging to either schools or UiA as appropriate.

'Event Calendars' exist for each school and UiA. These provide a historical list of events that took place (and are planned) at each location. Data items relating to each event are then hyperlinked from the Event Calendar. It is thus possible to locate documents or data by direct access to the data or via the Event Calendar. 'Event Memos' which are linked to the Event Calendar provide a means of communicating between didacticians about who is using data from a particular event. The Event Memos provide a

means by which didacticians can share the work of data reduction and avoid duplication of effort.

Analysis, as part of the scientific work of the KUL-projects, is performed in the language of the original data. Translation is only done for the purpose of publication and when necessary. It is an ambition of the KUL-projects that if any transcript forms part of more than one published work, it should be identical even if different authors/didacticians use it. A common set of pseudonyms, one for each participant and school in the project, is used by all didacticians. ATLAS.ti is used as the software to support analysis; this was chosen because of the possibility of coding directly video, audio and image data, in addition to text.

The data base created from the KUL-projects is impressive and must be seen as an important resource for research also beyond the current projects. The data sets are unusually rich and refer to many different levels of activity, all the way from mathematics performance by the students via the discussions between teachers and didacticians to the collective activities at workshops and at the conference. The latter data should be possible to use for in-depth analyses of the concrete conditions and circumstances of school development.

7.6 Handling tensions and conflicts

Tensions and conflicts make up a necessary and constitutive part of projects of the kind KUL represents. Fundamental assumptions about teaching and learning are challenged, and this inevitably will create friction in the organization. Here we will address two of them. Our point is not that such tensions and conflicts should be avoided. In fact, this would be contra-productive. However, they can be addressed in different ways, and we will comment on that.

One tension concerns the relationship between the teaching of primary and secondary schools (the comprehensive school) and the upper secondary schools (*videregående skoler*). The two levels represent different conceptions of mathematics education, and this can also be easily seen in the case of the schools of the KUL-projects. The education at the two different levels of the school systems is guided by different ideas about both mathematics and the teaching and learning of mathematics. The curricula are structured according to different principles, and the systems of tests and examinations differ as well. An important factor may also be that the identities of the teachers are different: at the upper secondary level the subject matter of mathematics is more formative for the teachers' conception of their role, while at in primary and secondary schools the more general educational ambitions of taking a broader responsibility for children's development are more prominent. These different educational paradigms also imply different views on mathematics, and a concrete

consequence for projects of the kind that KUL represent is that one has to take into account and accommodate to different attitudes and approaches with respect to how one develops an inquiry approach in mathematics education.

In upper secondary school processes of inquiry could be experienced as too time consuming, hampering the possibilities of coping with the prescribed curriculum in an efficient manner; while in primary and secondary schools, the inquiry processes could much more easily be perceived as fitting into what is prescribed in the curriculum of promoting the development of general problem solving skills. From the perspective of the upper secondary teachers, the examples presented at the KUL-workshops were not clear and convincing enough to clarify to what extent it is possible to develop an inquiry based approach to mathematics learning with respect to issues and topics within the prescribed curriculum such as differential and integral calculus, vector calculus, analytic geometry, theory of functions, etc. Some of these teachers experienced that their reservations against a broader application of an inquiry approach were seen by the didacticians as expressions of a certain degree of educational conservatism. For the teachers at the lower levels, these problems did not appear. They saw the inquiry concept as pointing in the direction of presenting mathematics in a manner which accords with young children's natural approaches and attitudes to learning.

This difference in implicit assumptions about how mathematics teaching and learning should be organized was commented upon in the interviews by teachers and didacticians, which indicates that it played a role during the activities.

A second conflict relates to the idea of developmental research. One attitude towards research is that the researcher should not interact with what is researched, and that he or she should operate as 'a fly on the wall'. However, it is clear from the teachers' perspective that they do not have any particular interest in having didacticians sitting on the wall. They are interested in didacticians interacting with what is taking place in the classroom. In this sense, some forms of action research seem to be in line with the ideas of developmental research. The teachers involved in the KUL-projects were in fact very happy with how the didacticians were involved in classroom activities. This is clear from the interviews.

However, and this is interesting, some of the PhD students did not find that their interaction with teachers was sufficiently clear in terms of its consequences for research and research methodology. This implies that the very interaction between PhD students and teachers was to a great extent excluded from their research agenda. This interaction was seen as interesting but at the same time as somewhat disturbing for the research activity. The participation in classroom practices was somehow 'put in parenthesis' by PhD students. Instead, what was defined through the 'objectified' data as registered in the KUL Data Bank was perceived as serving as the proper data material. There might have been a need in for engaging in more methodological reflections of what it means to do

developmental research of this kind. This is not a research approach for which researchers generally are well prepared, and it is a very demanding way of studying social activities.

A third point, which is perhaps not a conflict but still a thing to be noted, concerns the general readiness of a school to be involved in activities of this kind. One of the participating schools was new. When first invited, the staff of this school turned down the offer to participate. This was done not because of lack of interest but because the working routines were not in place, and new members of staff were coming in. However, the staff reconsidered and decided to join. Participation in the KUL activities from this school decreased, and towards the end of the project time only a few teachers participated regularly. This development was not the result of negative experiences with the project as such; rather the demands of getting the regular school work running was quite taxing, and this meant that the project activities were not attended to in the manner they should have been. The staff of this school who did participate felt that this was unfortunate, but maybe there is a lesson to be learned here in the sense that the starting of a new school with members of staff who do not know each other, and who have no common history, is a heavy undertaking. Developmental work of the kind the projects represent may be perceived as less of a priority under such circumstances.

7.7 The dissemination of the findings of the KUL-projects

The KUL-projects have had a powerful impact for as long as they have been going on. This is well-documented, and all those involved have felt that this has been significant. Here we will discuss their possible impact beyond the duration of the project period. Naturally, one can claim that a proper evaluation of long term effects has to be performed after a substantial period of time, and not in parallel with the final phase of the project which in fact includes the dissemination phase. However, we want to make four observations about the sustainability of the educational innovations.

A first important aspect of achieving educational change is to construct examples and materials which make alternative educational practices concrete and possible to assess – not only in experimental situations which normally are characterised by an overflow of resources, time and attention, not only from teachers but also from didacticians – but also in the daily practices of the teachers. We find that the KUL-projects have been successful in providing useful examples, but, of course, there will always be a wish for more of this from the participants, since this is what takes the model into the teaching and learning process.

Second, it is important that teachers develop new competences, for instance in operating with ICT in such a manner that a reasonable range of such resources can be integrated in a productive manner into the classroom practices by the teachers

themselves. In order to organise inquiry processes, a new teacher professionalism has to be developed. We have noticed that there might be some lack of opportunities for in-service training with respect to how to turn topics from the upper secondary school into productive scenarios for inquiry processes. However, in general we find that the KUL-projects have been successful with respect to contributing to the development of teacher professionalism in the sense that teachers have become familiar not only with some of the principles of inquiry processes, but they have also become aware of how to organise and talk about developmental activities. This is an important step in the process of developing teacher professionalism.

Along the same lines, a third important element for providing a sustainable educational changes has to do with a change of view of educational processes, and in this case the adoption of new perspectives on the learning of mathematics. The notion of *inquiry* launched by the projects epitomized some ideas and priorities held by the teachers, maybe for different reasons and in a variety of intuitive forms. Furthermore, the notion of inquiry symbolised a turning away from the school mathematics tradition and into a new space of educational possibilities. The notion no doubt provided an inspiring and reasonably solid conceptual footing for the ideas and wishes for development of their own activities that the teachers held at the time when joining the project. From the perspective of sustainability of educational innovations, a consistent change in teachers' view of educational priorities is important, and this issue will hopefully be further explored in some of the research documentation to follow from the projects.

We find that these considerations for ensuring sustainable educational changes have been well taken care of by the KUL-projects. However, it is important to point out that a fourth element is important as well. Educational change has to be ensured through school organisational initiatives. For instance, it was emphasised by different teachers that one hour per week, put into the weekly schedule, would make a tremendous difference in the continuation of didactic discussions, exchange of experiences, and the further development of educational innovation. However, it is obvious that the sustainability of the project has not been consistently taken care of from this organisational point of view. It is important to consider who is responsible for the fulfilment of this fourth condition necessary for securing the continuation and development of innovations. We do not think of this as a criticism of the KUL-projects. On the contrary, this has to do with a much broader organisational problem, too often accompanying the political need to demonstrate the immediate success of a new initiative in educational innovation. In other words, it appears more efficient to invest in new projects instead of investing in the sustainability of already established or completed projects. We have to do with a problem in educational investment policy, which also may obstruct educational innovations in a Norwegian context.

7.8 Contributions to research

An important part of the dissemination of the experiences of the KUL-projects will be the research publications to appear. The team members have already been very active in publishing in various contexts. The list of publications in its current state (August, 2007) includes about 55 items. Thus, we find many conference contributions to the most important international and Scandinavian meetings in the field of mathematics education research, book chapters, journal articles and technical reports. Many of these make interesting reading about various aspects of the work, in particular about the basic, programmatic and theoretical ideas of the projects. Furthermore, some publications articulate and illustrate findings based on data from the projects. The publishing activities so far must be considered as very satisfactory, and it is also interesting to observe that so many authors have contributed. This indicates that the projects have been central in the department and provided opportunities for many scholars at various stages of their careers to contribute. As yet, however, the main part of the publishing of project results is still to come, and the upcoming dissertations will also be an important output from the projects.

It is very important for the projects that there will be a range of publications that satisfy the diverse expectations and needs of practitioners and scholars. We would also like to point out that owing to the character of the projects of combining an interventionist agenda with a research dimension, it is important that the publication profile will be such that it represents the mix of the interests relevant: mathematics teaching and learning on the one hand, and school development, on the other. It is by satisfying the expectations of both these research agendas that the KUL-projects will be able to make a lasting contribution.

8. General conclusion

It is our opinion that the KUL-projects represent an unusually interesting research and developmental activity in school settings. There are not too many projects of this kind in the context of mathematics learning, or, indeed, in educational development in any area, which combine an interesting and clearly articulated theoretical idea about teaching and learning with a systematic intervention of the kind that the projects represent. The approach to the issue of educational development is bold; the project members have been focussed on interacting with teachers and schools, and the idea has been one of cooperating on issues of changing school practices in a subject that is central to schooling. This implies that the project results will be of interest also outside the specific community of mathematics learning.

We also find the project very substantive in terms of its approach and organisation. What we see in the interaction between UiA and the schools can be interpreted as the beginning of the establishment of a long-standing relationship in developmental work. A clear majority of the teachers and school-leaders perceived the project activities as positive, and, thus, their interest for this kind of cooperation has increased. It is quite possible that these positive experiences will increase the pressure on school authorities to provide space in the time-table for developmental activities.

Appendix A: List of publications from the KUL-projects

- Andreassen, I. S. (2005). *Innsikt i elevers kompetanser som vises i skriftlige matematikktester*. (Insights into pupils' competencies as shown in written mathematics tests.) Mastersoppgave. Høgskolen i Agder, Kristiansand.
- Andreassen, I. S., Breiteig, T., & Grevholm, B. (2005). Innsikt i elevers prestasjoner innenfor tall og algebra. (Insights into pupils' performance in number and algebra). I I. M. Stedøy (Ed.), *Vurdering i matematikk – Hvorfor og hvordan? Fra småskole til voksenopplæring*. Konferenserapport no 3 – 2005. (pp.113-128). Trondheim: Nasjonal Senter for Matematikk i Opplæringen.
- Bjuland, R., Cestari, M. L. & Borgersen, H. E. (2007). Pupils' mathematical reasoning expressed through gesture and discourse: A case-study from a sixth-grade lesson. Larnaca, Cyprus: CERME 5 (in press)
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- Fuglestad, A. B. (2005). Hva de velger og hva de liker - elevers bruk av IKT verktøy. *Tangenten*, 16 (2), 23-29.

- Fuglestad, A. B. (2005). Students' choice of ICT tools in mathematics - and their reasons. In H.L.Chick & J. Vincent (Eds.), *Proceedings of the 29th Conference for the International Group for the Psychology of Mathematics Education* (pp. 1-310). Melbourne: Department of Science and Mathematics Education, University of Melbourne. (poster)
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Appendix B: A short CV - Roger Säljö

Dr Säljö (born 1948) is professor of education and psychology of education at Göteborg University. He is the Director of LinCS – The Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society – a national centre of excellence in research funded by the Swedish Research Council (2006-cont.). He was educated in Goteborg, and received his Ph. D. in 1975 on a dissertation in the area of psychology of learning. In 1983 he was appointed to the Chair of Behavioural Sciences at the Department (Graduate School) of Communication Studies, Linköping University. He has served as dean of faculty at Linköping University, as vice-rector at Göteborg University and as member of many Scandinavian funding agencies. He has been a visiting scholar/professor at several universities in different countries, including a Universität Konstanz (where he was an Alexander von Humboldt-Fellow), University of California San Diego, Rijksuniversiteit Utrecht, Georg-Augustus-Universität, Göttingen, Université de Neuchâtel, Oslo University, University of Agder and the University of Turku. In 1995 he was a scholar at the Swedish Collegium for Advanced Study in the Social Sciences (SCASS) at Uppsala. He served as the president of the European Association for Research on Learning and Instruction (EARLI) between 2005 and 2007.

Dr. Säljö specialises in research on learning, interaction and human development in a sociocultural perspective, where he has published extensively (over 290 publications). Much of his work is related to issues of literacy and numeracy, and to how people through interaction acquire competences and skills that are foundational to learning in a socially and technologically complex society. In recent years, he has worked extensively with issues that concern how the so-called new technologies transform human learning practices inside and outside formal schooling. Dr. Säljö has supervised 29 Ph. D. students to their degrees in different faculties. He is the member of the editorial board of about 15 international journals, including *Culture & Psychology* (Sage), *Journal of Applied Linguistics*, *Instructional Science* (Elsevier), *International Journal of Educational Research*, and *Learning and Instruction* (Elsevier). He served as an editor of *Learning and Instruction* for six years. Dr. Säljö has also received various awards including The Sweden-American Foundation Scholarship for Advanced Studies in The United States, 1988, the EARLI Oeuvre Award for scientific contributions to the field of learning and instruction, 1999. In 2006 he was awarded the distinction of Finland Distinguished Professor.

Appendix C: A short CV - Ole Skovsmose

Academic degrees: Master's Degree 1975 from the University of Copenhagen (mathematics and philosophy). Ph.D 1982 from the Royal Danish School of Educational Studies (mathematics education). Dr.scient 1995 from Aalborg University.

Positions: From 1982 associate professor at Aalborg University. From 1996 professor in mathematics education at The Royal Danish School of Educational Studies. During the period 1998-2004, appointed special professor at Nottingham University. From August 1999, professor at Aalborg University.

Member of the committee directing the projects "Mathematics Education and Democracy" (1988-1993). Together with Celia Hoyles and Jeremy Kilpatrick, director for BACOMET-4 project. Co-director of the research programme: Curriculum, Learning and 'Bildung' for the 21st Century, Royal Danish School of Educational Studies. Co-director of The Centre for Research of Learning Mathematics, a co-operative project between Roskilde University Centre, Aalborg University and The Danish University of Education. Organiser of the "South Africa project" (1994-2000), which included co-operation between universities in Denmark and in South Africa. Research director for the Centre for Educational Development in University Science, which included co-operation between seven universities in Denmark. Director of the Ph.D programme "Science and Technology" at the Doctoral School at Aalborg University. Member of the editorial board of *Nordic Studies in Mathematics Education*, *Bolema* (a Brazilian journal in Portuguese), *For the Learning of Mathematics*, *Mathematics Education Research Journal*, *African Journal of Mathematics*, *Science and Technology Education*, *Adults Learning Mathematics Journal*, *Mathematics Education Library* (previous Kluwer Academic Publishers, now Springer). Together with Alan Bishop and Thomas Popkewitz editor of *Critical Essays in Education* (Sense Publisher).

Participated in conferences and given lectures about mathematics education in many different countries, including Australia, Austria, Brazil, Canada, Colombia, Germany, Norway, Sweden, USA, England, Hungary, Iceland, South Africa, Greece, Portugal, Spain, and (naturally) Denmark. Have published books and articles in Danish, English, Greek, Portuguese and Spanish.