In researching the therapeutic treatment of mathematics anxiety there is also the challenge of the validity of the data. Although this is not a dilemma unique to this research domain it is a dilemma that is particularly prevalent here. Each of the aforementioned treatments requires a great amount of reliance on student teachers’ outputs as data – either in the form of written reflections or mind maps. This elevates the chances that the data can be corrupted by student teachers efforts to present ‘correct’ responses rather than ‘true’ responses. However, because the data is first and foremost seen as an integral part of the treatment of mathematics anxiety, both by the student teachers and the researchers, there have been few occurrences of such problems. In fact, in Liljedahl, Rolka, & Rösken (in press a) the authors guarded against occurrences of denial or rhetoric, yet found few occurrences of either.

Finally, there is a challenge pertaining to the deeply personal nature of the data collected. By the very nature of the context, the participants are revealing something about themselves that they are likely view as a weakness. As such, both the collection of the data, and the reporting of the data, need to be treated with great sensitivity. One way to avoid this problem is to report on general categories instead of in-depth case studies. However, in doing this we lose some of the power of qualitative reporting. Another possibility is to create evidence-based fictional stories (Hannula, 2003; Richardson, 1997) that combine experiences of several students.

TEACHERS’ LEARNING FROM LEARNING STUDIES:
AN EXAMPLE OF TEACHING AND LEARNING FRACTIONS IN PRIMARY FOUR

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In this paper, we suggest an effective model for teachers’ professional development – Learning Study. A Learning Study combines students’ and teachers’ learning. Through a Learning Study, teachers improve their teaching by learning how their students learn. In a Learning Study, a group of teachers explore the relationship between teaching and learning with the aim to improve students’ learning in a cyclic process of planning and revising their lessons. An example of a Learning Study about teaching fractions in Primary 4 in a Hong Kong school is given.

INTRODUCTION

Schools have often been blamed for not being able to achieve the educational goals valued by society. Thus, large-scale systemic educational reforms emerged, orchestrated by provincial, state, or national governments (Fullan, 2000). All these reform efforts were found to be futile because they neglected one important factor for the improvement of student learning outcomes - teachers. Recently, more and more
researchers have pointed to the fact that teachers are the most important change agent in curriculum reforms. It is now recognized that systematic effort would be of paramount importance to foster teachers’ professional development, which will greatly contribute to the success of education reforms. (Darling-Hammond, 2006). Learning Study therefore provides such an opportunity and environment for the professional learning of teachers.

**LEARNING STUDIES**

A Learning Study is similar to the Japanese lesson study (Yoshida, 1999; Stigler & Hiebert, 1999) in which a group of teachers work collaboratively to explore and develop their teaching practice in a cyclic process of planning, observing and revising lessons. However, the aim of a Learning Study is not to improve the lessons in a general way, (e.g., implementing new methods or new technology) but to enhance students’ learning of a specific object of learning. In a Learning Study, recognizing the variation in students’ ways of seeing plays a central role in teachers’ decision making. Before and after the lessons the students are tested and/or interviewed to obtain information about what is problematic for them to learn a particular concept or skill. This also provides insights into what is critical for students’ learning, based on which lessons are subsequently planned. After the lessons, the students are tested and/or interviewed again. Information from the post-test gives immediate feedback to the teachers and enables them to analyse and reflect on the lesson (already video taped) from the point of view of why the students have been able to or fail to learn. Hence, teachers inquire about and explore the lessons from the perspective of possibilities for learning; whether the necessary conditions for learning are met in the lessons or not. In a Learning Study, the capability we want the students to develop is the very focus. Therefore, how the object of learning is handled in a lesson becomes the object of study for the teachers (as well as for the researchers). After identifying an object of learning they further specify explicitly the critical aspects that need to be handled in the lesson, they plan the lesson and teach it. After the first cycle, they revise the lesson plan according to their post-test findings from the post-test, student interviews and classroom observations. Then, in the second cycle, a new teacher teaches the revised lesson to her students. A post-test is given and the recorded lesson is observed and – in some cases – the lesson plan would be further revised.

The main purpose of LS is to find the relationship between teaching and student learning outcomes. The theory of Variation (Marton, Runesson, & Tsui, 1997) forms the basis of the theoretical framework of Learning Study. According to this theory, in order to learn something, one must be able to discern its critical aspects. And, in order to discern an aspect, one must experience variation in the aspect. The failure to learn something can be interpreted as the inability to discern all the aspects that are necessary to be discerned for a particular way of understanding. For example, it is necessary to discern simultaneously, concepts like equal shares, part-whole comparison, as well as unit and unitizing in order to understand the concept of fractions. The theoretical framework, however, does not prescribe any particular
teaching method or arrangements; instead it serves as a guiding principle when investigating students’ learning and their learning possibilities in the classroom.

LEARNING STUDIES IN HONG KONG AND IN SWEDEN

Learning studies have been tried out in a connected project in Hong Kong and Sweden. In Swedish schools, teachers cooperating in working teams is common. Although teams meet regularly to discuss issues related to their teaching, they seldom come together over an extended time to intensely discuss how to teach a particular concept. It is uncommon that they get an opportunity to observe a colleague’s teaching; and even less common for them to be able to observe teachers’ teaching the same topic. In the Swedish project, 18 Learning Studies were carried out in different subjects.

In Hong Kong, the situation is somewhat similar. Peer observation and collaborative lesson planning have become a normal routine in the majority of schools in Hong Kong now. The first attempt at introducing a systemic procedure and learning theory to enhance the effectiveness of such teacher collaboration towards teaching and learning through Learning Study was made in a three-year project in 2000 (Lo, Pong, & Chik, 2005) with only two primary schools. Then in the following six years, over 200 Learning Studies have been developed involving both primary and secondary schools, covering almost every subject in the school curriculum.

ONE EXAMPLE OF TEACHERS’ LEARNING IN LEARNING STUDIES

This Learning Study at Primary 4 level was in the area of ‘fractions’ (Lo, 2001), developed by a Learning Study team of five teachers from a primary school and 3 researchers from the University of Hong Kong. The entire study took nine meetings, which were held in the school at after school hours over a period of six months.

The Learning Study group planned to do a study on fractions because the teachers perceived that ‘fraction’ was most difficult for school children at this level. As the textbook they used made use of the following diagram to illustrate $8/8 + 6/8 = 14/8$:

![Diagram of fractions](image)

The teachers complained that some students would just add the numerator and the denominator together and come up with the idea that $8/8 + 6/8$ is $14/16$. Through the discussions, the teachers began to realize that they had been insensitive to students’ ways of seeing which contributed to difficulties in learning. While teachers took for granted that the unit was one circle and expected the answer to be $14/8$, some students actually took the whole as two circles and saw it as $14/16$. The problem in students’ learning arose because the ‘unit’ under consideration had never been given enough emphasis by the teachers in their teaching. After some discussion, the
teachers realized that their previous practice, in which they mainly drilled students on arithmetical operations of fractions in their ‘pure form’ without any reference to the whole that the fraction relates, may be contributing to the students’ habit of ignoring the ‘unit’ or the whole to which fractions refer. The literature also supports the teachers’ views, as Lamon (1999) suggests: there are two aspects of fractions, that are vital but students often fail to grasp, namely, unit and unitising, and part-whole comparison. As a result, the teachers decided that the research lesson should be focused on ‘unit’ and ‘unitising’.

The teachers then designed a pre-lesson diagnostic test to collect information for planning of the research lesson. The test items were designed to find out students’ understanding. Such an exercise further sensitised the teachers to the differences in students’ understanding. The teachers then worked collaboratively to plan their lessons to address the critical aspects identified, taking into account students’ difficulties as revealed by the results of the pre-test. The Theory of Variation was also used to guide the planning. A number of activities were designed to help students discern the importance of the unit. For example, students were asked to compare the size of the fractions when the units varied and the fraction remained constant. This pattern of variation helped to bring into focus the significance of the unit. There was also an activity to bring about fusion of all the parts to result in better understanding of the whole. In this activity, students were told that TWGH held its yearly fund-raising event. Li Ka Shing (a well known multi-billionaire in Hong Kong) donated five million dollars to help TWGH; Chan Siu Ming took out half of what he had saved, and donated 50 dollars; Wong Tai Yung donated all the 5 dollars that he had. Students were asked to discuss two key questions: ‘who has donated the most?’ and ‘Who was the most generous?’ In this case, the unit (the whole), the size of the fraction (the part) and fraction varied simultaneously. This problem-solving exercise motivated students to integrate what they have learned in the first part of the lesson and served the function of fusion.

The research lesson was then taught by the teachers to their own classes in cycles. Permissions were obtained from the school, teachers involved and parents of students for the lessons to be video taped. Both teachers and researchers studied the video recorded lessons and made suggestions for further improvements after each cycle.

After the research lesson, the teachers realized that in the past they had over estimated the students’ ability to learn this difficult topic while under estimated the time that the students needed to spend on learning it. In fact, one teacher who appeared to be indifferent at the beginning of the Learning Study said this during one of the meetings: “I really felt ashamed of myself. I’d never realized that ‘fraction’ could be taught in this way!” This teacher is still leading Learning Studies in his school and has also offered his support to Learning Studies in other schools.
CONCLUSION

A Learning Study aims at enhancing both students’ and teachers’ learning at the same time. In our interpretation the Learning Study was successful as far as pupils’ learning is concerned. Our experience with this and other Learning Studies tell us that it is quite common that some aspects of the object of learning are taken-for-granted or overlooked by the teachers. This happens because such aspects are usually too familiar or well known to the teachers, such that they are considered self-evident and thus failed to take it into consideration when planning the lesson. However, this may contribute to an obstacle for students’ learning. Failing to bring out certain aspects of a concept that are critical for learning can result in unsuccessful learning outcomes. It is suggested that through the Learning Study process, teachers dig out what is taken-for-granted or reveal the difficulties that are encountered by students but unknown to them. The teachers can then change their teaching in a way that enhances students’ learning. This is, from our point of view, one of the most important learning outcomes for the teachers in a Learning study.

One of the specifics and advantages of a Learning study is the immediate feedback the teachers can get about their teaching from the results of the post-test. Normally, in order to evaluate a single lesson, teachers trust their own intuitions as to how successful the lesson is and what pupils have actually learned. Nevertheless, testing or interviewing the pupils about what has been taught immediately after the lesson, provides a more direct and reliable account of how the teaching enactment had opened up opportunities or made it possible for students to learn what was intended. We also think that the opportunity to observe colleagues teaching the same topic, offers specific learning possibilities for the collective discovery of what is critical for pupils’ learning.

Pupils’ learning progress can more or less be effectively tested. But what about what teachers were learning? In what way is it possible to identify their progress apart from more general reflections and expressed insights reported by the teachers? Since all the meetings were audio-recorded, and the lessons were video-recorded, this made it possible for the changes in individual teachers to be traced. One indication for teachers’ learning is the contributions they made when engaged in pre- and post-lesson meetings. As teachers jointly and systematically enquired about their own practice, their professional learning can be manifested in the way they enhanced and contributed to a collective development. The lesson plan that the teachers came up with is another indicator, as it showed whether the teachers managed to identify critical aspects necessary for learning. The enacted lessons reflect the teachers’ considerations about pupils’ understanding and whether they were able to change their plan during the enactment to take this into account. Of course, the pupils’ learning outcomes gave very useful feedback about the effectiveness of the teaching.

From the results of several Learning studies we have noticed that the teachers are much more confident and have a better grasp of what they usually considered