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Working with Mathematics and Science teachers on inquiry-based learning (IBL) approaches: Teacher beliefs

Abstract
This paper reports on mathematics and science teachers' beliefs about the use of inquiry-based teaching strategies. Two different surveys were conducted: one with 24 teachers who were to become future instructional leaders; and one with 75 teachers as part of an international baseline study. We found that teachers in Norway would like to use more IBL strategies in their day-to-day teaching. They were also asking for more, and more relevant, professional development courses. Textbooks were not seen as a main hindrance to the use of IBL, but these would need to include more IBL approaches. Even if the curriculum, particularly in the natural sciences, did not represent an important hindrance, in their view it would need to advocate IBL more explicitly. The results provide deeper insights into teacher beliefs related to IBL, in particular the constraints that prevent the teachers from working in such a manner, and into potential 'openings' for using IBL to enhance pupil engagement and deeper learning. Methodologically, the study uses a quantitative approach to investigate teacher beliefs related to IBL that adds to the literature in the field.

Introduction

The present study was as part of the European Union project Promoting Inquiry in Mathematics and Science Education Across Europe (PRIMAS 2010), which is intended to effect change of teacher beliefs and pedagogic practices with regard to Inquiry Based Learning (IBL) in mathematics and science classrooms of 12 European countries. The data which provide the basis for analysis for this paper were from the early phase of the PRIMAS project in Norway.

There is a growing concern at European level about the alarming decline in young people's interest in mathematics and science (Academia Europaea, 2007). Students' declining interest in these key subjects has been linked to the ways they are taught from the earliest age. Several national and international reports point to the growing need for sustainable professional development for mathe-

matics and science teachers. The strategy document "Science Education Now – A Renewed Pedagogy for the Future of Europe" (Rocard et al., 2007) recommends that "improvements in science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools" (p. 3).

A recent study by The Gallup Organisation (2008) that surveyed almost 25 000 people aged between 15 and 25 showed that only a small number of young citizens considered natural science relevant for their university studies. Interestingly, the same study showed that young Europeans had a positive view of science and technology. For instance, more than one-third (35%) of the respondents agreed *strongly* that science brings more benefits than harm (The Gallup Organisation, 2008). So, even if young people regard the benefits of science and technology as positive, most do not consider these subjects as a relevant career path for themselves. To address this worrying trend European governments have decided to give priority to the professional development (PD) of teachers of science and mathematics at all school levels, and there are currently several European Union 7th Framework projects focussing on mathematics and science education. One of these projects is the PRIMAS project: Promoting Inquiry in Mathematics and Science Education Across Europe.

Research in mathematics education has shown that teacher attitudes and beliefs affect their pedagogic practice and play an important role for the development of student attitudes towards mathematics and science (Peressini et al., 2004; Fang, 1996; Thompson, 1984, 1992; Ernest, 1989; Kagan, 1992). Pehkonen (2003) contended that beliefs are a very important factor in terms of student and teacher performance in the teaching and learning of mathematics. If the teacher regards mathematics as being solely about computations, the students will spend most of their lessons performing computations. This, in turn, is said to influence students' beliefs about what mathematics is and what it means 'to do mathematics'. For example, in his study of a novice teacher Skott (2001) showed how a teacher's beliefs and images of school mathematics influenced his pedagogic practice in terms of supporting investigative activities and inspiring independent student work. Staub and Stern (2002) found that students with teachers who claim to have constructivist beliefs were able to do better on demanding mathematical tasks than students with teachers with a more transmissionist view.

Maaß and Dorier (2010) claimed that primary school teachers typically have weaknesses in mathematics and science content knowledge; and secondary school teachers have weaknesses in pedagogical content knowledge. This calls for an 'integrated approach' to teacher professional development, where primary school teachers can develop their subject content knowledge and secondary school teachers their pedagogical knowledge of mathematics and science. In a recent PRIMAS report analysing the national contexts of the twelve PRIMAS

partner countries (Maaß & Dorier, 2010) the authors pointed out that in all 12 countries there have been developments towards IBL orientated teaching. It is claimed that most countries' curricula contain IBL orientations, but that commonly used classroom resources, such as textbooks, do not often reflect this development.

Thus, there are several problems that need to be addressed to enhance student attitudes towards mathematics and science education. In this paper we concentrate on the 'under-use' of IBL in spite of strong advocacy by the science and mathematics education communities. Our research question is the following: What do Norwegian mathematics and science teachers regard as the main obstacles and possible incentives for the use of IBL pedagogies in their day-to-day teaching?

Inquiry Based Learning and the Norwegian context

What is IBL?

Even though IBL, and more generally inquiry as a method for teaching and learning has gained popularity in the science and mathematics education community, there appears to be no consensus on a common clear-cut definition of the term.

More 'traditional' mathematics teaching regards the subject as fixed and static, with a set of algorithms and rules that yield to a correct, and single answer when applied. In contrast, inquiry-oriented mathematics educators hold a more dynamic view where the student engagement in activities is important, activities that will provide opportunities for the construction of knowledge of mathematical/scientific concepts and ideas. This is seen to be achieved by using active communication, e.g. about multiple solutions; 'creative' reasoning; experimentation and discovery. The role of the teacher is then to facilitate and support student active learning and not to transmit static knowledge (Stipek, Givvin, Salmon, & MacGyvers, 2001). Welch, Klopfer, Aikenhead, and Robinson (1981) consider "inquiry to be a general process by which human beings seek information or understanding. Broadly conceived, inquiry is a way of thought" (p. 33).

Wells (1999) emphasised that "inquiry does not refer to a method […and …] still less to a generic set of procedures for carrying out activities" (p. 121). According to Wells, inquiry means "a willingness to wonder, ask questions and collaborate with others in an attempt to find answers" (p. 121). This view is also held by Carlsen and Fuglestad (2010) who contended that inquiry is not to be regarded as a method, nor a procedure or a set of rules, but that it is an attitude towards learning, that one should have a willingness to wonder and explore when facing new situations and new challenges. Jaworski (2010), reporting on the Learning Communities in Mathematics project in Norway, declared that to inquire means "to question, probe, investigate, and wonder; to identify problems

and seek solutions; and to look critically at whatever we are inquiring into" (p. 77). In the mathematics classroom this implies that the participants "work on mathematical tasks or problems in a mode of open questioning that allows conjectures to be addressed and generalizations to be established" (p. 77). Hundeland (2011) emphasised "the working (together) with new challenges in an inquiring and explorative mode" (p. 34) in the classrooms and workshops. The Rocard-report (Rocard et al., 2007) sited Linn, Davis, and Bell (2004) who claimed that "inquiry is the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" (p. 4).

The PRIMAS project identified several aspects that are likely to be part of a definition of IBL. By IBL the PRIMAS project advocates the following: IBL involves developing an inquiring mind and a scientific attitude. IBL is based on students adopting an active and questioning approach where students pose questions, explore and evaluate, and where the problems they address seem relevant to them. Teachers are expected to be proactive, to support individual students' needs, and to differentiate by using carefully chosen questions. They value students' contributions, welcome students' misconceptions as sites for learning, and scaffold learning using students' reasoning and experience. In the classroom there is a shared sense of purpose and ownership (Maaß & Euler, 2011). Not all these aspects of IBL may be present all the time, and the different aspects of the definition should not be seen as limiting factors.

The situation in Norway

The Norwegian government regards the professional development of mathematics and science teachers as one of their main priorities. In their report *Science for the future* (KD, 2010) the Norwegian government stated that

> [...] it is a primary assignment to increase teachers' qualifications in science subjects. […] Because so many teachers lack the necessary competence in science subjects, it will be necessary (to develop) a systematic enhancement of competence through continuing and further education and training for teachers. (p. 32)

Further, the development of teacher competence is regarded as crucial for enhancing pupil learning of mathematics and science. "Highly professional and pedagogically skilled teachers are an important precondition for the pupils' learning and contribute to good results for the pupils." (KD, 2010, p. 20) In line with the new teacher education reforms the government has pointed out that more research is needed that is relevant for primary/lower secondary schools and teacher education (KD, 2009). Moreover, the evaluation of the National initiative of developing competence in 'grunnopplæring' (Hagen & Nyen, 2009) and the TALIS report on teacher professional and competence development (Vibe, Aamodt, & Carlsten, 2009) have painted a bleak picture of teacher

competence and professional development (PD) in Norway. In this situation it is important that politicians and decision makers are given access to empirically valid information about current educational reality, its challenges and potential 'remedies'. The literature (e.g. the National Council of Teachers of Mathematics (NCTM) 2010) is clear that the ultimate aim of teacher professional development is enhancing student learning, through the mechanism of improving instruction. In mathematics and science education there is ample evidence that sustained support and structured learning opportunities for teachers can lead to enhanced student achievement (e.g. Ball, Thames, & Phelps 2008).

The present curriculum in Norway LK06 (KD 2006) does not specify working methods or ways to organize teacher pedagogic practice. However, 'problem-solving' is emphasised and explorative activities and creativity are encouraged. Inquiry Based Science Teaching (IBST) is an explicit aim and element of the science curriculum LK06 through the theme of "the budding researcher". This theme deals with natural science methodologies for developing knowledge involving the formulation of hypotheses, experimentation, systematic observation, openness, discussions, critical assessment, argumentation, grounds for conclusion and presentation. However, it has been found that IBL pedagogies have only to a limited extent been implemented in day-to-day classroom teaching (Lipowski & Seidel 2009). The Norwegian PISA+ study (Ødegaard & Arnesen, 2010) also reported few observations of science lessons that included inquiry elements. Moreover, the chapter on mathematics teaching in the TIMSS 2007 report (Bergem & Grønmo, 2009) claimed that solving exercises on one's own is the most common pupil activity in Norwegian mathematics classrooms (p. 123, p. 125).

Teacher beliefs and IBL

Cohen and Ball (1990) claimed that teachers align new practices with their more traditional beliefs about mathematics education, and hence the effect of professional development programs designed to help teachers implement inquiry-oriented teaching typically have little effect. Welch et al. (1981) also argued that whilst the science education community had advocated inquiry-based learning, "the optimistic expectations for students becoming inquirers have seldom been fulfilled" (p. 33). Colburn (2000) listed several reasons why science teachers may not use inquiry-based learning more often:

- confusion about the meaning of inquiry,
- the belief that inquiry instruction only works well with high-ability students,
- teachers feeling inadequately prepared for inquiry-based instruction,
- inquiry being viewed as difficult to manage,
- an allegiance to teaching facts, and
- the purpose of a course being seen as preparing students for the next level (p. 42)

Stipek et al. (2001) examined teacher beliefs and practices, which appeared directly related to inquiry-oriented mathematics instruction. They found that "more traditional beliefs were associated with more traditional practices" (p. 223), and that teachers who held these beliefs tended to enjoy mathematics less and show less enthusiasm in their classroom teaching. Further, they stated that "teachers' self-confidence as mathematics teachers correlated with students' perceptions of their own competence as mathematics learners" (p. 224). Kleve (2007) found that both students and parents preferred the teacher to teach 'from the board' explaining the mathematics to the students, and that time pressure was an important hindrance to more process and inquiry oriented work. In his study of three teachers at upper secondary school in Norway, Hundeland (2011) concluded that "the teachers are positive towards elements of inquiry in their teaching, but they problematize the use of inquiry with respect to the limitations set by the school framework" (p. 211). The teachers Hundeland examined felt obliged to teach in a way that would ensure that all knowledge content elements for the forthcoming exam were covered. (p. 213). In a qualitative study of six teachers doing a professional development course on modelling, Maaß (2011) identified three contextual conditions that were considered problematic by German lower secondary mathematics teachers: (1) time is too short to do modelling in class; (2) assessment is problematic; and (3) students do not like modelling or are not capable of solving modelling tasks.

Research methodology and design

As mentioned above, in this paper we investigate Norwegian teachers' beliefs with respect to IBL, in particular what they see as the main obstacles and possible incentives to use IBL pedagogies in their day-to-day teaching.

The analyses in this paper are anchored in data taken during the early phase of the PRIMAS project in Norway. Two different surveys were conducted, one with 24 teachers to become future IBL instructional leaders; and one survey with 75 teachers as part of an international baseline study. The teachers were surveyed concerning their IBL related beliefs, and what they see as hindrances and incentives for the increased use of IBL pedagogies. In a recent paper (Lyngved, Pepin, & Sikko, 2012) drawing on teacher evaluation of an early session, we reported on teachers' perceptions of particular mathematics and science task features, and we analysed how teachers developed an awareness of and criticality towards their work with mathematics and science tasks.

At the start of the professional development period two different surveys were conducted in all PRIMAS participating countries. One survey (Survey 1, S1) was given to the teachers taking part in the professional training to become instructional leaders (or 'multipliers') in their localities. In Norway these instructional leaders-to-be are ordinary teachers who volunteered to take part in the PRIMAS PD course, in order to develop their pedagogical knowledge about the use of inquiry in their day-to-day classroom practices. At this stage of the

study the first survey was conducted with 24 teachers, most of them working in local lower secondary schools (19 teachers), three teachers in local primary schools, and two in a local upper secondary school. The questionnaire was developed by the PRIMAS partners and used in the different countries in their respective languages. The teachers were asked to respond to 17 statements about IBL on a four part Likert type scale, and to choose which of 8 statements that best described their present engagement with IBL. Survey 1 cannot be regarded as a representative sample of Norwegian teachers, with the limitations concerning external validity this entails. Firstly, because the 24 respondents were teachers who volunteered to take part in a PD course focusing on IBL, and it is therefore reasonable to suggest that they hold a more positive view towards IBL than a randomly selected group of teachers would. Secondly, all teachers worked in a particular region of Norway, thus the sample is region-specific.

A baseline study (Survey 2, S2) amongst a more general population of teachers (in local schools) was conducted in all PRIMAS participating countries to obtain information about the situation of IBL teaching/strategies in schools. This questionnaire, developed by the PRIMAS consortium, was used in all PRIMAS partner countries, and translated into the local languages. The questionnaire had 17 question items: seven questions on personal data and background information; three questions on experiences with continuous professional development courses; five questions on present practice; and two questions on IBL in particular. Each question, apart from those on personal data and background information, consisted of several statements which the teachers had to respond to on a four part Likert type scale.

All together 925 respondents from the 12 PRIMAS countries contributed to this survey. It is important to note that this was also not a random or representative sample, in none of the 12 countries, but an opportunity sample, and therefore limited with regard to external validity. The Norwegian respondents were from the PRIMAS multiplier schools and teachers attending other PD courses at the local university or university college. Although the quantitative results from the Norwegian sample are not generalizable to the Norwegian teacher population, the results nonetheless highlight some views concerning IBL that are present among Norwegian teachers. The Norwegian sample size is 75, but as some of the questionnaires were conducted after the international deadline, only 61 went into the international study. A more thorough analysis of the international data from all partners can be found in Maaß and Euler (2011). One of the potential methodological weaknesses of this design is due to the fact that the researchers had predetermined the categories that were investigated, and as a consequence it is likely that the study did not catch all important aspects of the teachers' beliefs concerning IBL. However, this is a methodological weakness that may need to be accepted and which future studies could address. Both the multiplier questionnaire and the baseline

questionnaire were completed using paper and pencil. The data from the questionnaires were put into Excel, and subsequently analysed using SPSS.

Results and discussion

Survey 1 (S1), which was conducted at the beginning of the training of the Norwegian multipliers, shows that the main area of concern for teachers was the lack of time for lesson preparation and the extra time and energy they believed was required to implement IBL. 33 % of the respondents agreed or strongly agreed that they were concerned about the time and energy required to implement IBL; and 41 % expressed concerns about the extra time they believed preparing IBL lessons would take (Figure 1). This corresponds to findings by Kleve (2007) who also asserted that teachers felt time pressure as one of the main constraints for doing more process work in their mathematics lessons. It should, however, be noted that our results also imply that the majority of the surveyed future multipliers did not have serious concerns about IBL taking extra time.

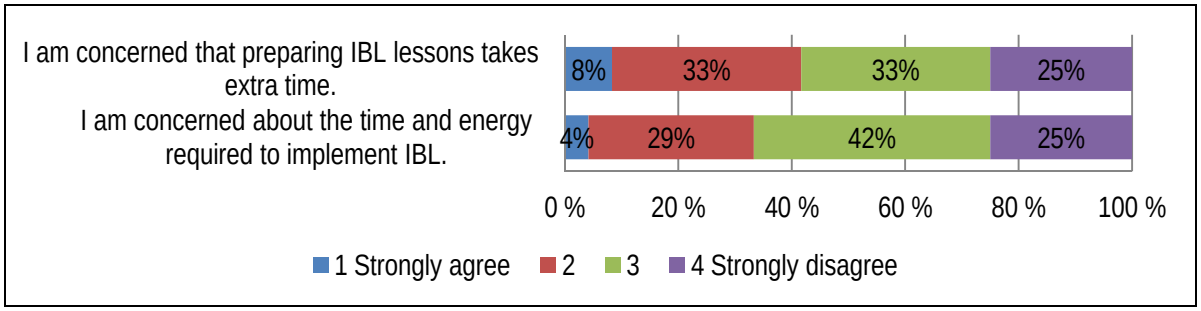


Figure 1: Main concerns of Norwegian multipliers about the use of IBL (S1). N = 24

Similarly, the results from the baseline survey (S2) show that a main hindrance for the uptake of IBL seemed to be time (see Figure 2). Teachers felt that they did not have sufficient time to prepare IBL lessons, and almost two thirds claimed that there was not enough time in the curriculum to work with IBL approaches. This is in line with Hundeland's (2011) and Jaworski's (2010) findings. Jaworski contended that one reason for teachers not engaging more with inquiry-based tasks was the shortage of time; that working inquiry-based would take up too much of their classroom time (Jaworski, 2010, p. 75).

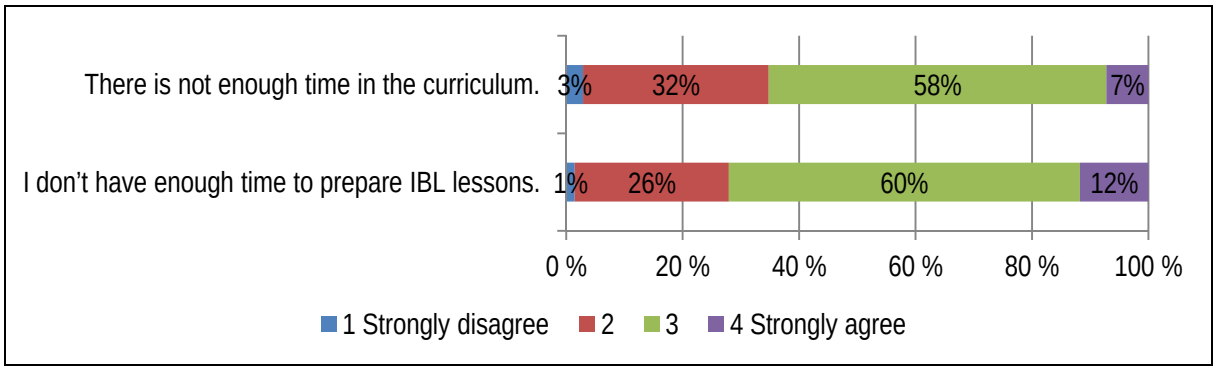


Figure 2: Time as obstacle for increased use of IBL approaches (S2). N = 75

However, our findings from S1 show that the Norwegian multipliers did not have serious concerns about their potentially new teacher role when using IBL pedagogies (96% disagree or strongly disagree, Figure 3), nor were they concerned about receiving criticism from their colleagues when trying to implement IBL (92 % disagree or strongly disagree). They were somewhat, but not overly, concerned about student attitudes toward IBL lessons (21 % expressed some concern), and about the potential tension between IBL and effective student preparation for examinations (25 % expressed some concern). These findings differ from results by Colburn (2001) who claimed that teachers did not use IBL because "the purpose of a course [was …] seen as preparing students for the next level", and these concur with Hundeland's (2011) findings, who stated that teachers saw it as their main responsibility 'to drill' students for the national examinations.

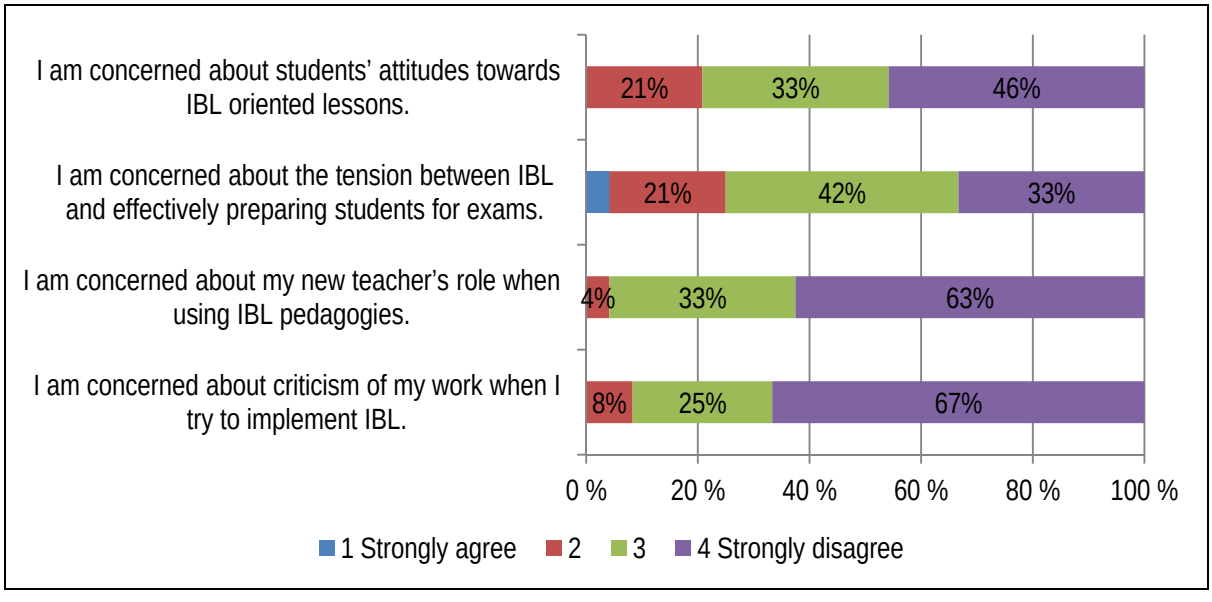


Figure 3: Further concerns of Norwegian multipliers about the use of IBL (S1). N = 24

A large percentage of the multipliers wanted to be part of a more coordinated approach to IBL, almost all wanted to work more closely with colleagues using IBL pedagogies, and almost all wanted their students to be motivated by IBL

(Figure 4). These positive results in terms of teacher belief in IBL are interesting and emphasise that teachers regarded IBL as an important part of mathematics and science teaching, and as something that they would like to implement more in their day-to-day classroom teaching when collaborating with colleagues.

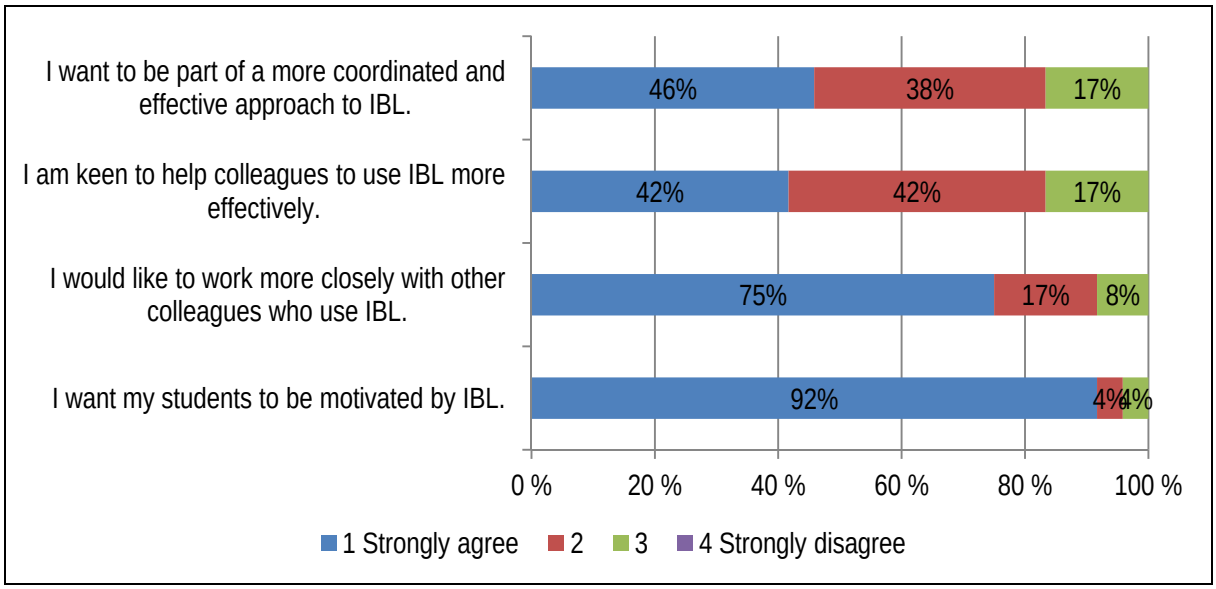


Figure 4: Norwegian multipliers' view concerning more the use of IBL (S1). N = 24

These results clearly show that there was a strong wish amongst teachers that their students should be motivated by IBL approaches (92 % strongly agree, 4 % agree). This in many ways was not surprising given that these teachers had volunteered to take part in a PD program which sought to enhance IBL strategies in mathematics and science classrooms. 92 % of the multipliers wanted to work more closely with other colleagues who used IBL, and 84 % were keen to help colleagues to use IBL more effectively. This means that the motivation to use IBL was evident and that teachers believed that the use of IBL was likely to motivate students in their science and mathematics learning.

The Norwegian baseline study (S2) showed that about one third of the surveyed teachers considered IBL to already be an important part of their daily teaching. As most teachers taught both mathematics and science, it was not possible to extract from the survey whether this was equally true for mathematics and science. Other studies (e.g. Maaß & Euler, 2011) contend that whereas IBL approaches have already been partly implemented in science education, in Norway not least through the "budding scientist" approach, IBL strategies were less used in mathematics education.

As did the multipliers (S1), the teachers surveyed in the baseline study (S2) almost unanimously expressed their wish to use more IBL pedagogies. These results support the claim that Norwegian teachers had a positive attitude towards IBL oriented pedagogies, that they found them important and a sensible strategy to follow. Moreover, almost all teachers wanted to have more support for

implementation of IBL in their lessons (see Figure 5). These findings are in line with the literature, e.g. Kazemi and Franke (2004) and Jaworski (1998, 2006, 2010), who point out the importance of colleagues working collaboratively to enhance their competences and pedagogical skills.

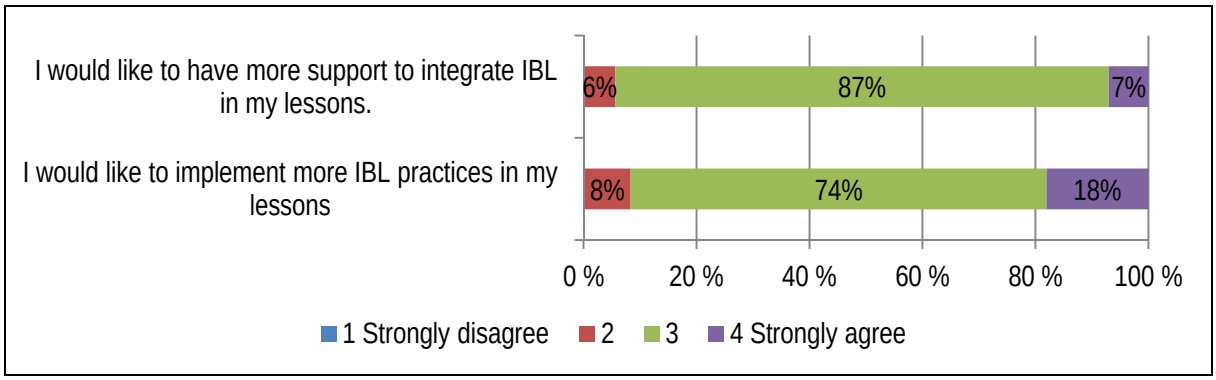
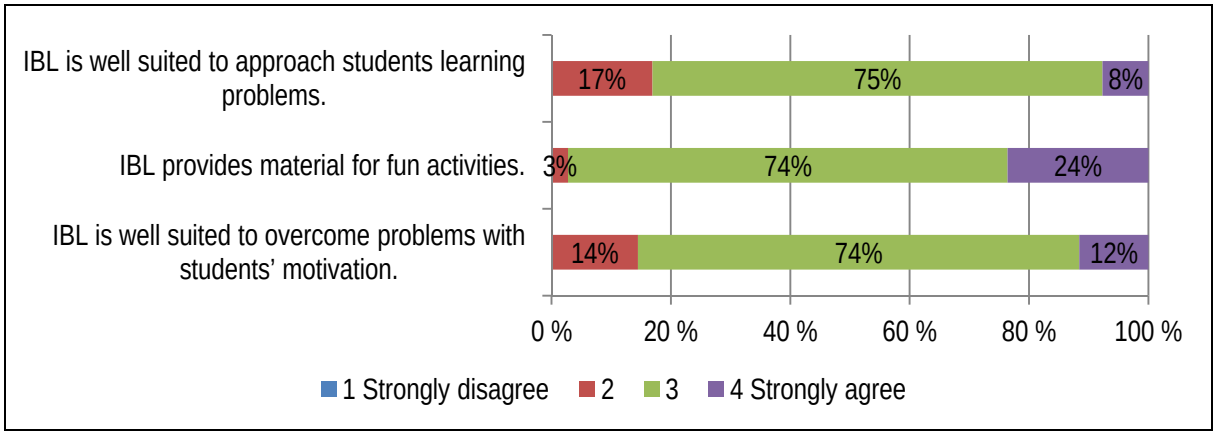


Figure 5: Implementation of more IBL in teachers' lessons (S2). N = 75

The surveyed teachers in S2 were unanimous in claiming that IBL provided possibilities for "fun activities" (see Figure 6). Note that the term "fun activities" was not defined in the questionnaire, so the response to this statement relied to a large extend on the individual's interpretation of what "fun activities" may constitute for him/her.

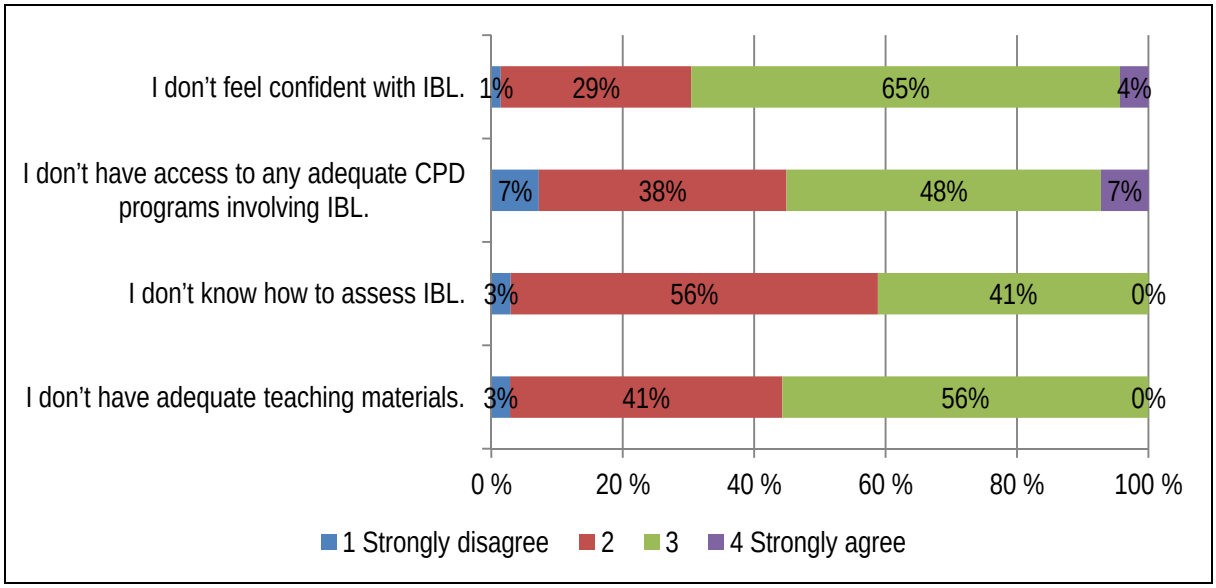
A large percentage of teachers saw IBL as well-suited to overcoming problems with student motivation and also as appropriate for work with students with learning difficulties. This may be seen in contrast to Colburn's (2000) second point, i.e. the teachers' belief that inquiry instruction only works well with high-ability students.



Figur 6: Factors teachers see as incentives to more use of IBL (S2). N = 75

As is evident from Figure 7, more than two thirds of the surveyed teachers said that they did not feel confident with IBL, which is in line with Colburn's (2000) first and third points. 55 % agreed or strongly agreed with the statement that they did not have access to adequate CPD programs involving IBL. This

supports the government's goal to enhance teacher competence through continuing and further education programmes as outlined in the report "Science for the future" (KD, 2010). There was also uneasiness about the assessment of IBL tasks, as 41 % claimed that they did not know how to assess IBL. The lack of adequate teaching materials were also seen as an important hindrance, as around 56 % agree or strongly agree that this factor was an important obstacle.



Figur 7: Important hindrances for the implementation of IBL (S2). N = 75

Comparing the results presented in Figures 4, 5, 6 and 7, it appears that teachers had a positive attitude towards IBL; that they believed in working with their students on the basis of IBL approaches in order to enhance student competences in mathematics and science, but that they needed more support to do so. The support they asked for was in particular linked to the need for more time, and more collaboration with colleagues and more CPD programs focused on IBL.

In Norway textbooks play an important part in the shaping of lesson content, both in science and mathematics classrooms (e.g. Alseth, Breiteig, & Brekke, 2003). Looking at the statement "IBL is not included in textbooks I use", the mean score was 2.54 with a standard deviation of 0.555 (see Table 1). Indeed, very few of the respondents answered this question at the extreme ends of the scale, as only 1 strongly agreed and 1 strongly disagreed. This may indicate that while textbooks were important, they were not seen by teachers as a main obstacle to the implementation of IBL.

	Mean	Std. deviation
IBL is not included in textbooks I use	2.54	0.555

Table 1: Mean score and standard deviation on the statement IBL is not included in textbooks I use. (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree) (S2). N = 75

Discussion of the Norwegian findings and comparison with the European study

The questionnaires used in the two surveys were developed by the PRIMAS team and then translated into the local languages. Thus, teachers in the different countries were asked the same questions and hence it makes sense to compare the Norwegian results with the international ones.

Overall, despite the limitations with regard to external validity, the Norwegian results do not significantly differ from the international mean. Norwegian teachers' orientation towards IBL (measured with the statements "I would like to implement more IBL practices in my lessons" and "I would like to have more support to integrate IBL in my lessons") is close to identical to the international mean (Figure 8). Furthermore, their views on how IBL might motivate students (measured with the statements "IBL is well suited to overcome problems with students' motivation" and "IBL is well suited to approach students learning problems") are close to identical with the international mean. The Norwegian results concerning the routine use of IBL and concerning teachers' view that IBL required extensive content knowledge are slightly lower than the international mean. The routine use of IBL was measured with the questions "I already use IBL a great deal" and "I regularly do projects with my students using IBL". The content knowledge measure was developed from the statements "successful IBL requires students to have extensive content knowledge" and "IBL is not effective with lower-achieving students". These results suggest that the Norwegian teachers in the present study used IBL pedagogies as much as their European colleagues, but also that teachers in Norway did not consider the lack of extensive content knowledge as a serious obstacle to the use of IBL.

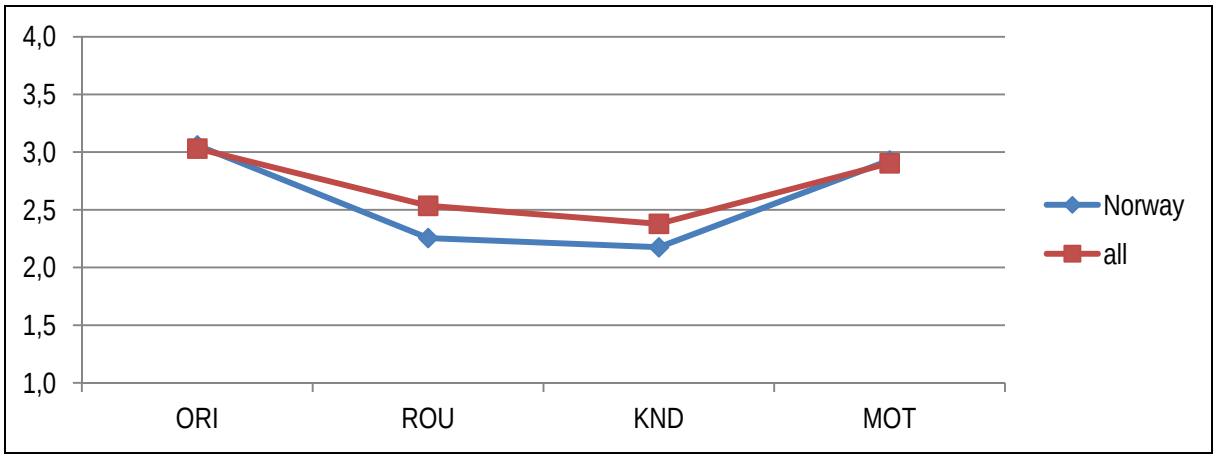


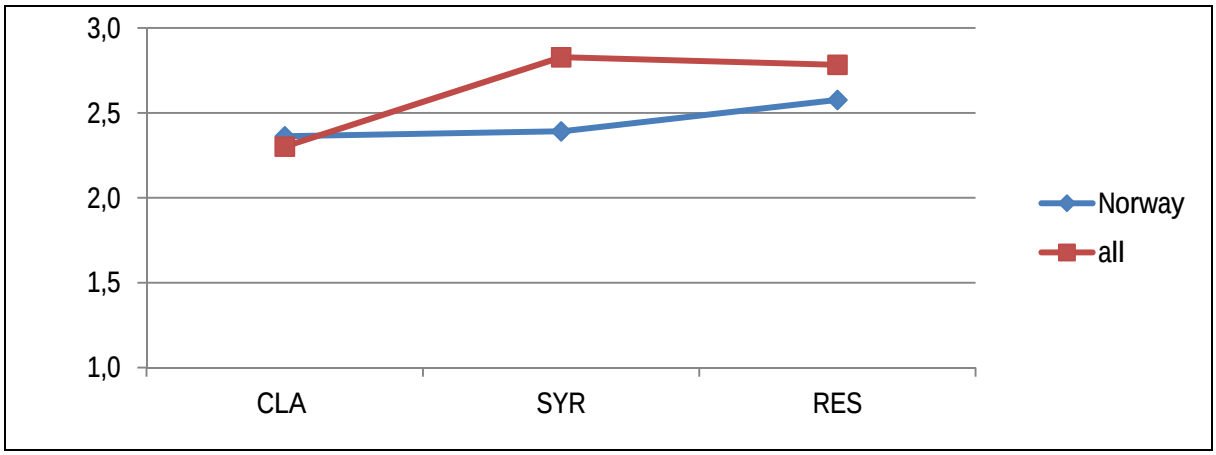
Figure 8: Mean scores of Norwegian S2 respondents compared with the international mean. Preconception of IBL compared with use of IBL, ORI: orientation towards IBL, ROU: routine use of IBL, KND: IBL requires extensive content knowledge,
MOT: IBL motivates student,
(1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree). N (international) = 925, N (Norway) = 61

The Norwegian results are also quite close to the international mean on the questions about liking to implement more IBL and the wish for more support to integrate IBL in the day-to-day lessons, as can be seen from Table 2 below. To the statement "I would like to implement more IBL practices in my lessons" the Norwegian mean score is slightly, but not significantly, higher than the mean of all partner countries, the Norwegian being 3.10 as compared to 3.06 when all PRIMAS countries are included. To the statement "I would like to have more support to integrate IBL in my lessons" the difference is even less, the Norwegian score being 3.02 compared to 3.00.

	I would like to implement more IBL practices in my lessons	I would like to have more support to integrate IBL in my lessons.
Norway	3.10	3.02
all	3.06	3.00

Table 2: Norwegian and international mean score (S2). (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree). N (international) = 925, N (Norway) = 61

Other countries seemed to suffer more from lack of adequate resources, and Maaß & Euler (2011) suggested that "in some countries especially in the Eastern European ones, this problem is regarded as more severe" (p. 31). System-immanent problems, like the curriculum, assessment practice and also class size, were not so obvious in Norway (p. 16). Comparing Norway to the other PRIMAS participating countries (see Figure 9) the results show that classroom management was regarded as equally difficult. At the same time classroom management was not considered a significant obstacle to working with IBL pedagogies, as the mean score both internationally and in Norway is below 2.5 (Norway 2.36, all 2.30). System restrictions and resources, however, were seen as less obstructive by the surveyed teachers in Norway than the mean score across Europe.



Figur 9: Mean scores of Norwegian S2 respondents compared with the international mean. Problems with implementation of IBL: *classroom management (CLA), resources (RES)* and *system restrictions (SYR)* (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree). N (international) = 925, N (Norway) = 61

Conclusion

The results presented show that the Norwegian teachers surveyed believed that IBL pedagogies were sensible approaches in their day-to-day teaching in mathematics and science classrooms. Our findings also show that the Norwegian teachers would have liked to implement IBL strategies more than they already did. Working more inquiry-oriented also means working in a more scientific-like way, hence bringing the classroom experiences closer to the way mathematicians and scientists work. This may lead to a more positive attitude towards mathematics and science, thus meeting the goals of both the European and Norwegian authorities. To facilitate the increased use of IBL strategies, teachers believed that they needed more, and more relevant, continuous professional development courses. As the Norwegian government has singled out the professional development of mathematics and science teachers as their priorities, this opens up great possibilities for future PD developments. Future PD courses need to be geared towards IBL, both to meet the demands of the teachers, and also the demands of the mathematics and science communities.

According to our results, teachers need to be given more time to implement IBL in their classrooms and more time to collaborate with their colleagues. Research (e.g. NCTM, 2010), has emphasised the value of collaboration for teacher learning and the central role that professional learning communities can play in enhancing teachers' professional knowledge development and practice. Working with colleagues, it is said, helps teachers to critically analyse and explain their practices, and articulate rationales for instructional decisions, which not only makes their principles and beliefs visible and 'sharable' with their peers, but in turn is likely to help them to develop deeper and more widely shared understandings of student learning. Teachers also believe that more time needs to be allocated for IBL in the curriculum. These time constraints have to be solved at different levels. The national authorities need to respond to the demand for more explicit mention of IBL in the curriculum and IBL oriented national exams. The local authorities need to encourage schools to take part in PD courses and rectors need to encourage the building of collegial communities in their schools geared towards IBL.

Textbooks are not seen as a main hindrance to the uptake of IBL. However, in Norway most teachers use textbooks in and for their lessons. It would therefore be helpful if textbooks were more geared towards IBL, and furthermore if teachers learnt how to work with resources, such as textbooks, learnt how to use them in their desire to implement more IBL oriented approaches.

Methodologically, the quantitative approach to investigating teacher beliefs on IBL offered in this study complements previous investigations. To get a more comprehensive picture of Norwegian teacher beliefs and IBL practices, similar studies to ours could be conducted on a larger scale across different parts of Norway.

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