New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
5th Edition

Enhancing Teachers' Professional Knowledge in Connecting the World of Work to Inquiry Based Science Teaching: Case of Norway

Maria Immaculata Maya Febri[1], Svein Arne Sikko[2], Heidi Dahl[3], Ragnhild Lyngved Staberg[4]
[1, 2, 3, 4]Norwegian University of Science and Technology (Norway)
[1] maria.i.febri@ntnu.no, [2]svein.a.sikko@ntnu.no, [3]heidi.dahl@ntnu.no, [4]ragnhild.l.staberg@ntnu.no

Abstract
European policy documents highlight the importance of inquiry-based learning (IBL). Norwegian whitepapers and curricula also strongly recommend and support the inquiry approach. The EU-project mascil (mathematics and science for life) seeks to promote a widespread use of inquiry-based science teaching in primary and secondary schools across Europe. One major innovation in mascil is to connect IBL in school with the world of work, making science more meaningful for young European students and motivating their interest in careers in science. Through the participation in mascil, and by using the mascil approach, i.e. based on the cascade model and spiral model, we have educated in-service science and math teachers as multipliers in Norway. Having gone through the professional development (PD) courses with us, these multipliers are now arranging workshops for their colleagues, and thus a high number of teachers are involved. In this paper, we present experiences from multipliers. In particular, we look closely at how the multipliers have developed themselves in terms of their beliefs, efficacy and motivation in implementing the mascil's ideas, and in spreading the ideas in the workshops with their colleagues. Based on case studies involving four multipliers, we found that the multipliers, despite their different background, have significantly benefitted from the PD-courses. Results from interviews and observations of workshop sessions, show that they have become enthusiastic about implementing IBL and the world of work, and has proven to be capable of conducting lessons that inquiry-based and with close connection to the world of work. They have also become highly engaged in spreading the pedagogy to their colleagues in own school, resulting in fruitful development of teacher professional knowledge in their community of practice.

1. Introduction
Inquiry-based learning (IBL) generally refers to student-centered ways of teaching in which students raise questions, explore situations, and develop their own ways towards solutions [1]. On European level, most educational policy documents clearly support and require an introduction of IBL to school subjects [2, 3]. The status of IBL in Europe depends significantly on the country and also the subject [4] but apparently IBL is not implemented as widespread as expected [1]. Thus, many projects focus on further implementation, among them is the EU-project *mascil* (mathematics and science for life) in which Norway participates.

In Norway, the latest policy reform in the 10-year compulsory school and in upper secondary education [5] embeds a new main subject area in the science curricula: *the budding researcher*, which caters the process dimension of the Nature of Science and clearly features inquiry-based learning (IBL). Norwegian whitepapers indeed strongly recommend and support the inquiry approach [6]. However, the classroom study PISA+ reports few enactments of the budding researcher in Norwegian schools [7].

The *mascil* project has to foci: (1) promoting a widespread dissemination and implementation of IBL in primary and secondary schools, (2) connecting schools' mathematics and science to the contexts found in the world-of-work (WoW). The connection with the world of work will hopefully make science more meaningful for young European students and motivate their interest in careers in science.

Within the *mascil* framework, the connection to WoW is done through designing IBL tasks involving the WoW aspects: context, role, activity and product, as shown in Figure 1.

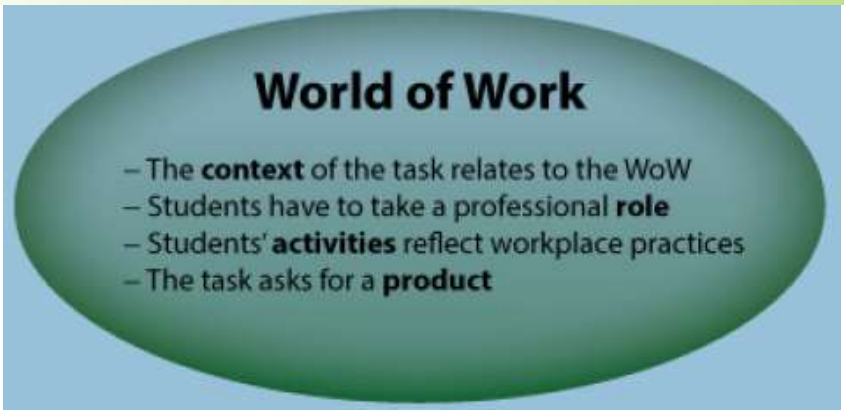

Figure 1. The World-of-Work dimension in the *mascil* framework (http://www.fisme.science.uu.nl/en/mascil/)

Within *mascil,* a professional development (PD) program was designed, following the "cascade model" [8] for a widespread implementation of IBL and WoW, and the "spiral model" [8] for improving teachers' pedagogical competence. Through the "cascade model" a set of multipliers in every country were trained, who in turn lead PD-courses (workshops) themselves. The "spiral model" was based on cycles of analysis-implementation-reflection. The multiplier education in *mascil* followed the Müller model [9] that consisted of three strands: learning off-job, by-job and on-job.
As part of *mascil*'s internal evaluation, all participating countries performed at least one case study. The guiding research question was: *In relation to the implementation of IBL and WoW, what impact has our overall PD concept on participants and what are the reasons for this?* This paper draws from parts of two Norwegian case studies. We present experiences from multipliers. In particular, we look closely at how the multipliers have developed themselves in terms of their beliefs, efficacy and motivation in implementing the *mascil's* ideas, and in spreading them through workshops with their colleagues

2. Materials and methods

We educated ordinary in-service science and math teachers as multipliers. We run PD-programs as followed: six half-day sessions for multipliers over 9 month period, including two lesson studies; followed by multipliers conducting workshops with own teacher colleagues for 10 months. The data collection was done following the case-study design (c.f. Yin, 1984 in Cohen, Manion [10]). Our case unit is composed of one PD-course with two multipliers and three teachers from the same school. Two case studies are conducted; one in school P and one in school S, see Table 1 for details.

Table 1. Overview of our two cases

Case	Multipliers	Teachers
School P P=primary (grade 1-7)	Andreas (16 years in primary, 1st to 4th grade, teaching math) Berit (16 years in primary, 1st to 7th grade, teaching math and science)	Anna Bodil Cate
School S S= primary and secondary (grade 1-10)	Arne (35 years in lower secondary school, passionate about math) Bjarne (6 years in lower secondary school, passionate about science)	Adrian Bernt Caroline

Multiple data sources were collected to insure in-depth analysis [10]: pre- and post interview with multipliers and with teachers, classroom and workshop observations. We describe results from multiplier pre-interviews and from observations of two workshop sessions, one from each school.

3. Results and discussion

3.1 Workshop observation

The workshop observation shows that all multipliers have acquired a good understanding of IBL and WoW, as described below:

In school P, the 22 participating teachers had yet to try the *mascil* ideas in a systematic way, so the multipliers stressed that the teachers should plan a lesson based on *mascil* tasks. The multipliers elaborated the WoW-aspect, and their explanation shows that they have understood the WoW-concept from the framework in Figure 1,

The pupils are to imagine themselves as workers; the context of the task should be related to the WoW, and that the task they are working on is an actual problem. (…) the task may require a product or someone requiring an answer.

Afterwards they discussed the role of the teacher, and participants were given the task "Bicycle insurance" (http://www.mascil-project.eu/classroom-material?adresse=toepassingen/28226).

In the subsequent discussion, the teachers commented on the open aspect of the task. They agreed that this method of working constitutes new aspects for students, that it might appeal to students that are usually non-active in mathematics lessons and that it involves role-shift of teachers, e.g. in formulating appropriate questions to supervise the inquiry.

We found similar results in School S, where Arne and Bjarne conducted their teacher workshop. They started by introducing the IBL-concept, explaining its characteristics and drawing its relevance to the science curriculum. They pointed to the benefit of this pedagogy for the learners: "(…) What we are doing in math and science has to be meaningful. Implicit in this, increasing pupils' understanding". The multipliers elaborated the WoW-aspect, in accordance to the framework (Figure 1). Next, the multipliers conducted exemplary lessons based on "Brine" (http://www.mascil-project.eu/classroom-material?adresse=toepassingen/28121). The context was the salt production. Bjarne took the role of a head engineer in a salt company. The 15 participating teachers were his assistants. They were instructed to make the best salt out of seawater samples, the criteria being purity, taste, smell, dryness and packaging. No procedural instruction was given. The task was very engaging. The teachers worked seriously, discussed in their groups how to proceed and make the best of the available equipment, then executed the experiments. The "engineer" Bjarne tested the products and rated the winning group. At the end of the session, the multipliers asked the teachers to discuss the characteristics of IBL and WoW in the task. The participants' answers showed that they had a good understanding, for instance: "The task itself is in overall inquiry-based", "We were free to choose our own method", "We could change (the procedure) on the way" and "You have of course the chemistry (engineer) job here. We are in a lab, doing experiments and working… and of course the food industry with salt. We need salt in food".

Throughout the sessions, the multipliers from both schools were highly engaged. They demonstrated that they themselves had grasped the *mascil* ideas. The approaches they used were exemplary. The features of IBL and WoW were made explicit in the plenary discussion. The observations indicate that all four multipliers have become highly enthusiastic and have been successful in spreading the pedagogy to their colleagues in their own school. The multipliers' professional growth is substantiated by the results of the pre-interviews, which took place after the multipliers had gone through the PD-sessions with us.

3.2 Pre-interview

Andreas had already considered IBL as a natural way to reach out to young students, especially 1st-4th graders. What he learnt from *mascil* boils down to a more deliberate use of IBL approach and more focus on the WoW-aspect, e.g.: "Kids are being creatively challenged on how we're going to find solutions (…) I think that I've been pretty good at this, but this PD-course has made me more deliberate". However, his implementation of WoW in early primary is scarce, even though he clearly sees the benefit for motivation. For instance, he refers to one episode of classroom implementation on the task "A housing project" by 7th-graders led by himself and Berit. The students became very eager.

Andreas described: “Yes, they were really engaged. (…) After two or three minutes, they were starting to talk and plan, even before I had given them the written task. So, I would say it was a success”.
Berit has become more comfortable now with implementing IBL, and more conscious of her role as a teacher, i.e. supervising more than giving the answer, focusing more on students’ work than on “blackboard teaching”. She believes that students should be more active, have to think more for themselves and develop their own ideas. Her choice of tasks, however, did not cater the WoW dimension as much as IBL. Her main professional growth consists thus on increased self-efficacy regarding IBL-implementation and a better understanding of teachers’ role in leading inquiry processes.
Arne interpreted IBL as doing open tasks, and WoW with trying to connect to real workplaces. He has now used inquiry approach rather often, meaning several times per month. “(…)it characterize my teaching (now)”. Moreover he thinks that WoW and IBL might improve students’ motivation. He finds challenges however, due to students’ limited experience and the exam pressure his 10th-graders faced. Despite challenges, Arne is enthusiastic working with *mascil*. Through the participation in the PD-course, he has become more reflected and inspired, eager to implement IBL.
Bjarne appreciates working with Arne as multiplier partner: “…having collaborated with Arne, (…) along with being a part of *mascil* (it becomes) a kind of turning point, or indeed, a boost in my progress as a teacher”. Through *mascil*, he understands better what it means to use inquiry approach and is convinced of its benefits. Today he runs rather long-lasting IBL-based teaching sequences in science, and shorter ones in math, due to greater passion for science. Moreover, he integrates WoW with his IBL-lessons: “This WoW factor, that’s what I have taken into my teaching to a highest degree”. He said further, “I feel that the WoW factor brings in another creative part in me as a teacher, compared to a pure IBL task (…). I feel it easier to make it more exploring when I can link it to a profession”. In short, Bjarne has experienced tremendous professional growth since he started working with *mascil*.
Lastly, all four multipliers found that their colleagues are motivating to work with. Their colleagues continue to practice integrating IBL and WoW in their day-to-day teaching. As Bjarne said: “…of those who have tried, 100% have continued. They did not just stop… They still come to Arne and me to talk about it. Then I feel that I have reached something (…)”. We follow closely three case teachers from each school (Table 1). Although the data collection is ongoing, we can already see that the multipliers’ work have resulted in fruitful development of teacher professional knowledge in their community of practice.

4. Acknowledgement

The project *mascil* has received funding from the European Union Seventh Framework Programme under grant agreement n° 320693.

References

[1] Maaß, K. and M. Artigue, Implementation of inquiry-based learning in day-to-day teaching: a synthesis. ZDM Mathematics Education, 2013. 45(6): p. 779-795.
[2] Hazelkorn, E., et al., Science education for responsible citizenship. 2015, Brussels: European Commission.
[3] Rocard, M., et al., Science education now: A renewed pedagogy for the future of Europe. 2007, Brussels: European Commission.
[4] Engeln, K., M. Euler, and K. Maass, Inquiry-based learning in mathematics and science: a comparative baseline study of teachers' beliefs and practices across 12 European countries. ZDM Mathematics Education, 2013. 45(6): p. 823-836.
[5] Kunnskapsdepartementet, Knowledge promotion, T.M.o.E.a.R.o. Norway, Editor. 2013.
[6] NOU, Fremtidens skole. Fornyelse av fag og kompetanser, Kunnskapsdepartementet, Editor. 2015: 8, Kunnskapsdepartementet: Oslo.
[7] Ødegaard, M. and N.E. Arnesen, Hva skjer i naturfagklasserommet? -resultater fra en videobasert klasseromsstudie; PISA+. NorDiNa, 2010. 6(1): p. 16-32.
[8] Maaß, K. and M. Doorman, A model for a widespread implementation of inquiry-based learning. ZDM Mathematics Education, 2013. 45(6): p. 887-899.
[9] Müller, U., Weiterbildung der Weiterbildner. 2003, Dr. Kovac: Hamburg.
[10] Cohen, L., L. Manion, and K. Morrison, Research Methods in Education. 7th ed. 2011, Abingdon, Oxon: Routledge, Taylor & Francis Group. 638.