Author(s): Havu-Nuutinen, Sari; Kervinen, Anttoni; Uitto, Anna; Laine, Aulikki; Koliseva, Anniina; Pyykkö, Lassi; Impiö, Pentti; Aittola, Tiina

Title: Pre-service and in-service teachers' experiences of inquiry-based primary science teaching : a collaborative team teaching model

Year: 2019

Version: Published version

Please cite the original version:

Havu-Nuutinen, S., Kervinen, A., Uitto, A., Laine, A., Koliseva, A., Pyykkö, L., Impiö, P., & Aittola, T. (2019). Pre-service and in-service teachers' experiences of inquiry-based primary science teaching : a collaborative team teaching model. Journal of Baltic Science Education, 18(4), 583-594. https://doi.org/10.33225/jbse/19.18.583

JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

PRE-SERVICE AND IN-SERVICE TEACHERS' EXPERIENCES OF INQUIRY-BASED PRIMARY SCIENCE TEACHING: A COLLABORATIVE TEAM TEACHING MODEL

Sari Havu-Nuutinen,
Anttoni Kervinen,
Anna Uitto,
Aulikki Laine,
Anniina Koliseva,
Lassi Pyykkö,
Pentti Impiö,
Tiina Aittola

Abstract. *This research clarifies how a collaborative team teaching model (CTTM) can support both pre-service and in-service teachers' professional development in using inquiry-based science teaching in primary schools. The data were collected via a questionnaire-based survey approach after inquiry projects implementation at public schools in four Finnish cities. In total, 98 pre-service teachers and 51 in-service class teachers were involved in the research. According to their experiences collaborative team teaching was seen as an adequate teaching approach in primary school science lessons. Both in-service and pre-service teachers experienced inquiry-based science teaching enthusiastically and received new ideas, knowledge and skills to carry out inquiries during the school projects. Also, they became more confident to use inquiry-based approach in their teaching. The findings indicate that the CTTM combines pre-service teachers' professional development and in-service teachers' expertise and the model successfully support the use of inquiry-based practices in primary school science education.*

Keywords: *collaborative team teaching model, inquiry-based science teaching, survey research, teachers' experiences.*

Sari Havu-Nuutinen
University of Eastern Finland, Finland
Anttoni Kervinen, Anna Uitto, Aulikki Laine
University of Helsinki, Finland
Anniina Koliseva, Lassi Pyykkö
University of Jyväskylä, Finland
Pentti Impiö, Tiina Aittola
Kokkola University Consortium Chydenius, Finland

Introduction

Inquiry-based teaching is widely discussed in science education research and several approaches have been presented to support its effectiveness. Inquiry-based teaching approach is an umbrella term that covers various constructivist approaches to teaching and learning, emphasizing students' active role in learning practices such as making observations and drawing on them to make conclusions (Crawford, 2014). Inquiry is reviewed as a successful teaching approach if extensive scaffolding is provided for student learning (Bennett, Lubben, & Hogharth, 2006; Hmelo-Silver, Duncan, & Chinn, 2007). However, there is still a need to develop supporting methods and models to strengthen the use of inquiry-based approaches in science teaching at school (Ireland, Watters, Brownlee, & Lupton, 2014).

School is a communal working organization, and for the teachers collaborative competency is one of the key components in their expertise. Also, collaboration is an important aspect in teacher education, helping students to learn about successful teaching, as well as acquiring team teaching abilities (Graham, 2006; Kervinen et al., 2016). However, collaboration is a widely defined concept, including varying groups and teams of teachers and schools working together, which makes it challenging to study in educational research. This research studied Finnish pre-service and in-service teachers' experiences of inquiry-based science teaching in primary education during a collaborative teaching project. Secondly, it was examined, how pre-service and in-service teachers experienced their collaboration, when working in teams. The research was part of a Finnish national development

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

project (www.luma.fi) that aimed to foster pre-service and in-service teachers' experiences and engagement in inquiry-based science teaching and introduced new collaborative approaches for teacher education. A specific collborative team teaching model (CTTM) to develop inquiry-based approaches in school science teaching was applied in this research (Kervinen et al., 2016). Applying the definitions of Vangrieken, Dochy, Raes, and Kyndt (2015), the teams of the development projects in this research can be defined as *communities of practice*, whose members comprise teacher educators, pre-service and in-service teachers working together interdependently, in development, discussion, decision-making, self-reflection and sharing built knowledge.

Inquiry Approach and Teachers' Experiences of Inquiry-Based Science Teaching

Inquiry-based teaching is highlighted in several curricula of science education (Abd-El-Khalick et al., 2004). In addition, several international science teaching reports and European Union-funded research papers (see e.g., Harlen, 2013; IAP, 2010; Rocard et al., 2007) have suggested to promoted inquiry-based teaching at all levels of education because of its motivational and cognitive gains in learning, such as improved science process skills (Yager & Akcay, 2010). In inquiry-based science teaching, the original idea is that a school curriculum should accurately represent the scientific endeavour as engaged in by practicing scientists, including active questioning and investigation. From this follows the idea of students posing questions, designing experiments, formulating hypotheses, collecting data, and presenting results and drawing conclusions (Wallace & Kang, 2004). Nevertheless, inquiry-based science teaching is challenging. Scientific research and science education have different goals, and the aim of a science classroom setting is not to imitate the processes that take place in a science laboratory (see Yager & Akcay, 2010). One of the most common challenges of inquiry-based science teaching is that its implementation is more time consuming than learning science through non-inquiry, teacher-led, so-called traditional methods (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013; McBride, Bhatti, Hannan, & Feinberg, 2004). This causes uncertainty to use inquiry-based teaching among teachers. In addition, some studies have indicated that teachers have insufficient knowledge and experiences of inquiry-based science teaching and that many challenges in inquiry approaches relate to teachers' competence and behaviour (Anderson, 2002).

Teachers often report that they use inquiry-based teaching but, the focus is more on hands-on activities (Ødegaard, Haug, Mork, & Sorvik, 2014) or step-by step problem solving experiments (Kang & Wallace, 2005). The conceptualization of the inquiry-based teaching among teachers is not clear and there are different kinds of conceptions of what inquiry-based teaching means in the practice of science education. In addition, among primary teachers there is large variation in using inquiry and the level of students' engagement and interest varies (Ireland et al., 2014; Wallace & Kang, 2004). One of the common challenges is maintaining students' interest and engaging them in the inquiry-based teaching activities as well as communicating with the students in the inquiry activities (Bencze, 2009; Oliveria, 2009).

There are several in-service trainings or research projects where teachers have been introduced to inquiry-based teaching, for example by aiming to support their beliefs, attitudes, experiences, satisfaction and self-efficacy. Short teacher training courses do not result major changes in behaviour, but may nevertheless have short-term effects (Silm, Tiitsaar, Pedaste, Zacharia, & Papaevripidou, 2017). Teachers generally feel positively towards inquiry and they report receiving sufficient support for implementing inquiry in science teaching. When teachers apply inquiry in a classroom, it changes their attitudes, reduces their anxiety and they seem to recognize that inquiry is motivating for the students (Ahokoski, Korventausta, Veermans, & Jaakkola, 2017; Silm, et al., 2017). Teachers are often engaged in the inquiry approach, but they still have difficulties applying the practices to local needs (De Vries, Schouwenaars, & Stokhof, 2017) – something which is in accordance with a recent research by Bjøness and Knain (2018) that the teachers' conceptions of inquiry were not consistent with those observed in practice.

Pre-service teachers struggle to implement inquiry approaches in science classes, although teacher training includes the inquiry-based teaching (Lehesvuori, Ratinen, Kulhomäki, Lappi, & Viiri, 2011). In addition, pre-service teachers often lack competence or general pedagogical approaches such as classroom management, teacher-student interaction and learning environments (Davis, Petish, & Smithey, 2006). Therefore, one of the common challenges revealed in several studies on primary school teachers and pre-service teachers is their lack of science content knowledge (Kallery & Psillos 2001; Ødegaard et al., 2014). Content knowledge is considered one of the core elements in implementing inquiry-based teaching. In addition, it affects the teachers' confidence and their

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

classroom management (Enugu & Hokayem, 2017). On the other hand, it has been reported that students fail to link and apply their science content knowledge with pedagogy used in the classroom (Kang, Bianchini, & Kelly, 2013). Despite the reported challenges, it has been noticed that pre-service teachers are often motivated to use inquiry-based approaches (Kang et al., 2013). McDonnough and Matkins (2010) have suggested that when pre-service teachers are offered a possibility to collaborate with in-service teachers in a classroom project, their understanding of the inquiry-based teaching can be effectively promoted. This viewpoint was addressed in this research.

A Collaborative Teaching Approach to Support Pre- and In-service Teachers' Inquiry-Based Science Teaching

According to the review by Vangriekenet et al. (2015), there are many studies on the benefits of collaboration, such as expert and novice teachers working together, capacity to initiate and improve professional development, confirmation of ideas about new teaching methods and assignments and teacher motivation. However, negative impacts are reported as well, such as emerging hierarchies and heightening of incompatibilities among different persons and differing pedagogical beliefs.

A few studies have emphasized the collaboration between pre-service and in-service teachers as an important element for supporting novice teachers in successful science teaching. Graham (2006) suggested organizing programmes in which collaboration is part of teacher training. Similarly, in-service teacher trainings have been considered to be effective when teachers have the opportunity to engage in authentic situations of inquiry-based teaching while being supported by other teachers in the implementation and reflection of their teaching (Capps & Crawford, 2012). The premises of this kind of collaborative approach are originated from co-teaching settings mainly implemented in special education (Hang & Rabren, 2009; Solis, Vaughn, Swanson, & McCulley, 2012), but recently studied actively in vocational or higher education (Zapf, Jerome, & Williams, 2011; Walters & Misra, 2013).

Team teaching is considered as an effective teaching model for several reasons. It provides a learning opportunity for the collaborating teachers, for example, to develop and reflect on their current teaching approaches (Stevenson, Duran, Barrett, & Colarulli, 2005). Pre-service teachers who have collaborated with expert teachers have perceived team teaching as an effective and helpful model of teaching in which every participant could share their strengths (Hwang, Hernandez, & Vrongistions, 2003). Studies on team teaching in science education have reported encouraging results as well (e.g., Roth, Tobin, Carambo, & Dallath, 2004). For the purpose of this research, it has been defined team teaching to include collaboration during the development and implementation of the teaching module as well as during the reflection and evaluation of the teaching.

Problem of Research

In science education, team teaching offers an opportunity for pre-service teachers to create a dialogue with expert teachers and learn about classroom management as well as use of resources such as practical pedagogical skills which could be not achieved without experiences of collaboration (Roth et al., 2004). Whereas the inquiry approaches in science teaching are perceived as challenging by teachers (e.g., Davis et al., 2006; DeVires et al., 2017), the collaborative teaching model seems to have potential in supporting teachers' professional development. This research was designed to examine pre-service and in-service teachers' experiences after participating in a collaborative team teaching project that aims to strengthen inquiry-based science teaching in classrooms. Two research questions were determined concerning pre- and in-service teachers' perceptions of their professional development and participation in team teaching during the development project:

1. How did the pre- and in-service teachers experience their professional development in inquiry-based science teaching during the collaborative project?

2. How did the pre- and in-service teachers experience their participation in team teaching during the collaborative project?

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Research Methodology

General Background

In this research the survey approach was applied to capture the pre-and in-service teachers' experiences of inquiry-based teaching and their experiences of collaborative team teaching model used in the school projects. The experiences were collected after school projects in which they participated voluntarily. The survey approach allowed the comparison between the teacher groups participated in the research and clarify their self-reflected experiences to develop inquiry-based teaching. The teachers' experiences have been reflected in the context of CTTM, which was developed for the research.

Collaborative Team Teaching Model and Implementation of the Inquiry Projects

In this research, the concept of team teaching was expanded to refer to the collaboration of several experts in different phases of the teaching process. A model of collaborative team teaching for the professional development of both pre-service and in-service teachers was designed and piloted (Kervinen et al., 2016). The model was designed to support pre-service teachers as well as in-service teachers to implement inquiry-based teaching at school as a part of teacher education. The model focuses on the strengths of both teacher groups and provides an arena to implement shared inquiry projects in an authentic context. In the model, the collaboration is manifested in several phases (Figure 1): The inquiry projects were initiated by university lectures and they invited the in-service teachers to participate in the process. In the planning phase pre-service, in-service teachers and university lecturers worked together to strengthen especially teachers' conceptual understanding, their understanding of science knowledge structures or support them to use specific equipment or methods for the inquiry. In the implementation phase, the inquiry projects were carried out together with pre-service and in-service teachers in the classrooms in which the in-service teachers regularly worked. In the reflection phase, again, university lecturers took part in the collaborative reflection and organised the reflection seminar at university. In the seminar, the teachers had an opportunity to describe and evaluate their projects and share their experiences.

The topics of the inquiry projects were introduced by the in-service teachers to ensure its suitability for the school schedule. The inquiry projects consisted of topics such as water, microbiology, health science and field work inquiries. The type of the inquiry varied, including mostly guided inquiries (Banchi & Bell, 2008), which meant that the teachers together provided systematic scaffolding to the students, when they needed it. The schedule and contents of the inquiry projects varied in different schools but all of them included fundamental features of inquiry-based teaching: students studied the phenomena through participating in scientific practices such as asking questions, doing experiments, making observations and analysing and communicating findings. Additionally, the role of reflection in the classrooms was significant, as the inquiry experiences were discussed with the students. The timing of the inquiry projects varied between the schools from a few weeks to a few months depending how often the lessons were conducted per week.

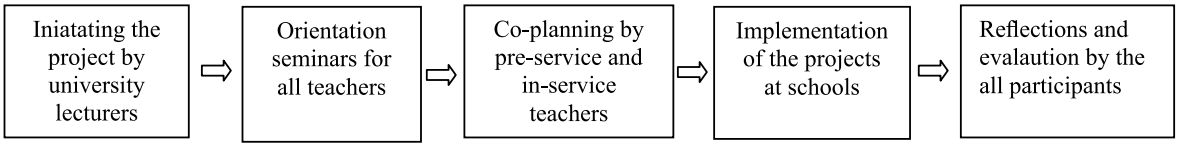

Figure 1. Implementation of the team teaching model (see Kervinen et al., 2016).

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Sample

The research data consisted of the pre-service and in-service primary school teachers who participated in the inquiry projects during the years 2015–2016. In total, 98 pre-service teachers and 51 in-service teachers were involved in the research. The inquiry projects were conducted in five cities, in a total of nine primary schools in southern, central and eastern Finland. In-service teachers participated in the research voluntarily and pre-service teachers enrolled in the projects as a part of their teacher education studies in three different universities. All students had completed their pedagogical studies as well as basic content studies in science education (approximately 5 ECTS). The inquiry projects were carried out as a part of their voluntary minor studies of science education. The participants formed teams of two to four pre-service teachers and two to three in-service teachers and the teams worked independently under the supervision of a university lecturer.

Procedures and Data Analysis

The teachers' experiences were clarified creating the questionnaire. The instrument was created by the authors to capture the pre-service and in-service teachers' experiences of the inquiry projects and how the teachers implemented the team teaching model. The instrument was created for the need of this particular case and comprised 16 Likert-type scale statements [answers ranging from strongly disagree (1) to strongly agree (4)] as well as seven open-ended questions. The questionnaire-based survey was designed to capture the teachers' experiences of inquiry-based teaching from the viewpoint of confidence to use inquiry and recognize the advantages and disadvantages of teacher collaboration when conducting inquiry-based teaching. The statements were created based on the challenges recognised from previous research papers (see e.g., Enugu & Hokayem, 2017; Kallery & Psillos, 2001).

All participants filled in the questionnaire in the final seminar or sent via mail and answered afterwards. The questionnaire was filled in voluntarily and the research purposes were explained for the teachers and their consent was asked in the seminar. Personal and psychometric data were omitted to confirm teachers' anonymity. The returned questionnaires were coded numerically for the data analysis and the coding numbers were used with the quotations.

Teachers' responses to close-ended statements (Likert-type scale) were analysed quantitatively. The collected data were descriptive, data did not follow normal distribution and the variables were measured using ordinal scale. Thus, a non-parametric data analysis method (Mann-Whitney's *U*-test) was used to examine item-based differences between variables and teacher groups (Nummenmaa, 2009).

Open-ended questions were analysed qualitatively using the phenomenographic approach (Niikko, 2003) aiming to capture the experiences. Firstly, the teachers' responses to open-ended questions were transcribed to a word document combining responses question by question and anonymising the respondents. Secondly, the files were uploaded to Atlas-ti 8.0 to conduct the analysis of each teacher's experience of two research areas –inquiry-based teaching and team teaching. The individual experiences were coded into these two different categories. In both categories, the initial codes were iteratively combined, and analysis proceeded from teacher's individual experience level to presenting the categories of teachers' common experiences (Perttula, 1995). In the other words, qualitative data analyses developed from each teacher experience to a combined description of teachers' experiences. The pre-service and in-service teachers' experiences were separated to indicate the differences between the teacher groups.

Research Results

Pre-service and In-service Teachers' Experiences of Inquiry-based Science Teaching

Nearly all pre-service teachers (98 %) reported that their interest towards teaching science with inquiry approaches increased during the project. Most of the pre-service teachers stated they have learned more about inquiry-based teaching, including content knowledge, pedagogical skills as well as skills to use different tools and materials.

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In addition, the pre-service teachers perceived in their statement responses that their knowledge about science teaching increased in general. They learned new knowledge about the science phenomena when teaching in the classroom. They also received new ideas about how to teach science content at a primary school.

The open responses of pre-service teachers indicated that their pedagogical skills with regard to science teaching increased and strengthened. They learned new ways to implement inquiry-based teaching in practice and became more confident to plan and use inquiry in their teaching. Pre-service teachers felt generally more competent and knowledgeable concerning how to teach science, and to use more specifically inquiry-based approaches, at school and on their own.

> *"I was able to practice working with primary school students and teaching them about science phenomena. My understanding of science concepts also increased (Pre-service teacher, 27)".*

> *"I received new ideas for inquiry-based teaching, and I learned to think about science teaching in a new way (Pre-service teacher, 36)".*

Table 1. Experiences of inquiry-based teaching project rated by pre-service teachers.

Teachers' Experiences of the Inquiry Project	1 (*f*)	2 (*f*)	3 (*f*)	4 (*f*)	DK (*f*)
I received more enthusiasm to teach science in the future, *n*= 98	0	1	50	46	1
I learned new issues about science phenomena, *n*= 97	4	18	44	31	0
I received new ideas for my teaching methods, *n*= 98	0	5	49	43	1
The project has changed my ways of teaching science, *n*= 93	1	9	34	26	23
Currently, I am more interested in teaching science, *n*= 97	1	10	58	26	2
I see that experiments are significant in science teaching, *n*=98	0	1	14	83	0
This project has fostered my development as a teacher, *n*= 96	0	8	47	38	3

Note: 1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree, DK = do not know

Pre-service teachers reported that they became convinced of how inquiry-based approach can promote students' interest and that the approach is effective in science teaching. In addition, they were convinced that experimental and investigative activities engage students in learning. In addition, pre-service teachers experienced that they needed to offer more space for students and reduce their own verbal instruction during the lessons. They were motivated to develop and use the learned activities in their own teaching.

The in-service teachers mostly rated their experiences similarly to the pre-service teachers (Table 2). Statistically significant differences (Mann-Whitney's *U*-test) between teacher groups were not indicated. For example teachers' experiences of enthusiasm to teach science ($U = 2183{,}5$ $p = .218$), receiving new ideas for teaching methods ($U = 2645$, $p = .372$) and learning new ideas of science ($U = 2034$, $p = .124$) did not reveal statistical difference between the teacher groups. In-service teachers did not perceive many changes in their teaching, but their experiences focused more on socio-emotional issues such as enjoyment of learning and student co-operation. Not every teachers' interest towards science teaching increased, but even these teachers reported to have achieved new ideas for everyday teaching.

Table 2. Experiences of inquiry-based teaching project rated by in-service teachers.

Statements Related to Experiences	1 (*f*)	2 (*f*)	3 (*f*)	4 (*f*)	DK (*f*)
I gained more enthusiasm to teach science in the future, *n*= 50	0	1	28	19	2
I learned new issues about science phenomena, *n*= 49	1	8	29	8	3
I received new ideas for my teaching methods, *n* = 50	0	0	24	25	1

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Statements Related to Experiences	1 (*f*)	2 (*f*)	3 (*f*)	4 (*f*)	DK (*f*)
The project has changed my ways of teaching, *n*=48	3	7	23	8	7
Currently, I am more interested in teaching science, *n*= 49	2	8	21	12	6
I see that experiments are significant in science, *n*= 50	0	0	6	44	0
This project has fostered my development as a teacher, *n*= 50	1	1	22	25	1

Note:1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree, DK = do not know

Like pre-service teachers, the in-service teachers' responses to the open questions indicated their focus on experiences dealing with students' learning and enthusiasm. The in-service teachers learned new ideas for implementing inquiry-based teaching, and most of them gained confidence to use inquiry approaches. They experienced that the project reminded them about the significance of inquiry approaches and especially the role of experiments and investigations in science teaching.

> "I again became enthusiastic to teach in a more holistic way (In-service teacher, 75)".

> "The students were motivated, and they learned a lot. I became more enthusiastic because of pre-service teachers' attitudes, and meanwhile I received new ideas (In-service teacher, 60)".

In-service teachers wrote that they have learned to use investigations in a better way and many of them highlighted learning about the subjects' integration in science teaching, as well as about students' active engagement. In addition, several in-service teachers developed their pedagogical understanding of the significance of student-centred approaches in terms of their science learning. The in-service teachers upgraded their methodological toolkit and gained new interest and confidence to apply new methods to their teaching. A few teachers reported that they may reduce the use of textbooks.

> *"I became very excited about the holistic projects* (In-service teacher, 78)".

> *"The students' engagement increased, and the teacher's role was to work as a supervisor* (In-service teacher, 76)".

Teachers' experiences revealed their enthusiasm towards inquiry-based teaching. The teachers who participated in the project reported how inquiry approaches activated and motivated students and that the students enjoyed practising science. Teachers reflected that this project inspired teachers and encouraged them to continue more systematically to use experiments, investigations and learning by doing activities in their classrooms.

In sum, pre-and in-service teachers had positive experiences of inquiry-based teaching and they reflected its importance in science teaching and learning. The projects encouraged them to continue to practice inquiry-based teaching. The projects helped pre-service teachers to apply their academic knowledge to the school practices and fostered their confidence to use inquiry in the future. For in-service teachers, the projects increased their courage to use inquiry approaches more systematically in their teaching.

Pre-service and In-service Teachers' Experiences of Collaborative Team Teaching

The collaborative team teaching model (CTTM) was perceived positively by both teacher groups (Table 3 and Table 4). Both pre-service and in-service teachers considered team teaching to be a valuable approach in science teaching and valued the shared expertise in collaboration. Teachers indicated that the collaboration was useful for their teaching experience and most of them found new collaborators during the project. In-service teachers rated collaboration as a significant approach in science education more generally than the pre-service teachers ($U = 2932$, $p = .009$). The pre-service teachers, on the other hand, expected to have more support from the class teachers than they received.

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

The pre-service teachers indicated team teaching was time consuming more often than the in-service teachers (U= 1759, p= .007). However, they experienced team teaching as important in all phases of teaching: planning, implementing and reflecting. Pre-service teachers planned their lessons with their peers very actively and perceived the peer-collaboration as significant. In-service teachers were not always actively involved in the planning phases, but they negotiated or provided feedback via email or phone with the pre-service teachers. The role of the in-service teachers was emphasized during the teaching sessions and in the reflection phase.

> *"I worked all the time with my peers, but I also communicated with the class teacher and university teacher. I also received support and feedback from the class teacher* (Pre-service teacher, 24)".

> *"The collaboration was active with peers, we had meetings in the beginning and at the end (seminars), we shared ideas via emails, and I received support and materials from the university lecturer* (Pre-service teacher, 54)".

Table 3. Experiences of collaborative team teaching rated by pre-service teachers.

Statements related to Collaborative team teaching	1 (*f*)	2 (*f*)	3 (*f*)	4 (*f*)	DK (*f*)
I had new collaborators throughout the project, *n*= 94	20	24	28	2	20
Planning and conducting lessons together with others takes time, *n*= 95	7	20	45	20	3
Team work is a resource in science teaching, *n*= 97	0	3	30	62	2
It is useful to work with experts from different areas, *n*= 97	0	5	43	45	4

Note: 1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree, DK = Do not know

In-service teachers received more new collaborators during the projects than pre-service teachers, but the difference was not statistically significant. They experienced team teaching as a way of collaborating with new colleagues. In addition, they enjoyed having teacher students in the classes as an extra resource. Pre-service teachers implemented teaching with their peers. In-service teachers found team teaching to be more of a resource for extra motivation, whereas the pre-service teachers considered team teaching more as a learning experience.

Table 4. Experiences of collaborative team teaching rated by in-service teachers.

Statements related to team teaching *n* =50	1 (*f*)	2 (*f*)	3 (*f*)	4 (*f*)	DK (*f*)
I had new collaborators throughout the project	6	7	16	18	3
Planning and conducting lessons together with others takes time	6	19	19	4	2
Team work is a resource in science teaching	0	0	8	42	0
It is useful to work with experts from different areas	0	2	35	77	1

Note: 1= Strongly disagree, 2= Disagree, 3= Agree, 4= Strongly agree, DK = Do not know

All in-service teachers rated team teaching as a resource in science teaching (Table 4). Many in-service teachers found the inquiry approach laborious and challenging, but experienced team teaching as supportive of their teaching. In addition, team teaching offered the opportunity to see their students' learning differently when two teachers were managing the classroom. Team teaching was perceived as a good opportunity to share pedagogical thoughts and to support each other.

Discussion

This research was designed to examine how a collaborative team teaching model (CTTM) can support both pre-service and in-service teachers' professional development in using inquiry-based science teaching in primary schools. The results of this research are based on the teachers' self-reported experiences of the inquiry-

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

based teaching projects using CTTM. The results show how the collaborative model can effectively support both in-service and pre-service teachers' understanding of inquiry approach and competence of implementing it in their science teaching.

The results are important because previous research papers and European-level guiding documents (IAP, 2010; Rochard et al., 2007) have highlighted the importance and effectiveness of inquiry-based teaching approaches. Yet, inquiry approaches are not implemented very systematically in school science (Havu-Nuutinen, Sporea, & Sporea, 2017; Uitto & Kärnä, 2014; Lehesvuori et al., 2011). Teachers have limited experiences of inquiry and many have found it challenging (Lederman, 1992). In addition, some primary school teachers lack understanding of science and they are not oriented to teach sciences through inquiry methods. On the other hand, collaboration and team teaching has been suggested to be important in supporting teachers' professional development and science teaching skills (Capps & Crawford, 2012; Roth et al., 2004).

Overall, the implementation of the team teaching model in this research enabled teachers to have positive experiences of inquiry-based teaching in science education. Pre-service teachers gained practical experiences to support their understanding and competence regarding the inquiry-based approaches, while they simultaneously became more analytical about the core features of the inquiry. Most teachers reported gaining new ideas and methodological tools for their own teaching. They highly valued the practical experience in teaching methods and the concrete examples of how inquiry-based science teaching projects were planned, instructed and assessed in the classroom. They had the opportunity to experience authentic classroom teaching, in which they had the opportunity to share their doubts and concerns with their peers or in-service.

Many pre-service teachers perceived that they became more competent to teach science in general. Most of the in-service teachers gained self-confidence to use inquiry. Many of them described that they had learned how to engage students in inquiry-based activities. They recognized how the use of inquiry approaches requires changing their own teaching techniques, to reduce their linguistic instructions and provide more opportunities for students to be active in planning, conducting and evaluating small-scale investigations. Roth et al. (2004) have shown how the creation of social and material resources by co-teaching provides opportunities for novice teachers to refine their own understanding of science content and how to teach it and thereby increases opportunities for actions that otherwise would not occur. Their findings supported this research.

Whereas the project was a learning experience for the pre-service teachers, in-service teachers' experiences related more to motivation and self-confidence. The project provided a chance to more profoundly plan and implement inquiry activities and reminded the teachers of the significance of inquiry-based teaching in primary science.

However, this research, again, indicated that inquiry as a concept is not standard and each teacher reflected their experiences based on their own understanding of it. Some teachers highlighted students' motivation, whereas some teachers emphasized students' engagement and knowledge building (see Ireland et al., 2014). Inquiry-based science teaching is understood very broadly and according to teachers is often considered as "learning by doing" or as an experimental project. For example, Ødegaard et al. (2014) noticed that teachers tend to focus on practical and hands-on activities instead of perceiving inquiry as diverse scientific practices. It seems that the concept of inquiry-based teaching is not clear for all teachers.

Especially, the in-service teachers were enthusiastic about the team teaching in their classroom because it provided extra professional resources to the classroom. Team teaching is a suitable additional resource to classroom activities and opens a perspective for in-service teachers to observe students' teaching practices. In addition, the collaborative team teaching model increases the opportunity to share teachers' understanding and talk about the science content with other teachers and university lecturers. One of the challenges is the teachers' lack of confidence concerning their science content knowledge (Yoon, Joung, & Kim, 2012). In this project, the teachers had the opportunity to discuss and talk with experts when they needed guidance.

In-service teachers found the collaboration useful. They regarded team teaching as a new opportunity to collaborate and share their thoughts with the pre-service teachers. They were perceived to have learned new ideas from pre-service teachers as well as from university lecturers. However, the collaborative team teaching model was not experienced as balanced; many pre-service teachers reported that not all the collaborative in-service teachers took equal responsibility for the teaching. It seems that experienced teachers seem to take a back seat and not play parallel with pre-service teachers. In addition, the results indicate that the in-service teachers perceive themselves as having more expertise than pre-service teachers and not as equal colleagues. A similar challenge related to unequal responsibilities between the co-teachers has also been noted in previous studies (Hang & Rabren, 2009; Vangrieken et al., 2015).

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Conclusions

The collaborative team teaching model, in which pre-service and in-service teachers together plan and implement teaching, support their professional development in inquiry-based science teaching, particularly increase their enthusiasm, and also foster and combine professional development of pre-service and in-service teachers. Moreover, the possibility to ask and negotiate with experts and colleagues in the classroom increases teachers' confidence to conduct teaching on their own. This research addressed a need to provide collegial support for teachers who are not confident with their skills to use inquiry in science teaching. It is necessary to use different kind of expertise in teacher training and challenge teachers with their different backgrounds to learn together. However, the research revealed the challenges of equal roles of teachers during the inquiry projects and this needs more focus in future research; how the collegial support could become balanced in terms of their roles in the classroom. Therefore, the collaborative team teaching model should be re-examined as a part of pre-service and in-service teachers' professional development and measure their self-efficacy systematically to strengthen the supportive interpretations from this data. On the other hand, the model should be included widely in teacher training programmes across the cultures to arrange new pre-service and in-service professional development arena for solving the challenges of inquiry-based science teaching and broadening the current discussion for different teacher education contexts.

Acknowledgements

This research was supported by the Ministry of Education and Culture through funding from the LUMA SUOMI network.

References

Abd-el-Khalick, F., BouJaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., Niaz, M., Treagust, D., & Tona, H-L. (2004). Inquiry in science education: International perspectives. *Science Education*, *88*(3), 398–419. doi: 10.1002/sce.10118.

Ahokoski, E., Korventausta, M. Veermans, K., & Jaakkola, T. (2017). Teachers' experiences of an inquiry learning training course in Finland. *Science Education International*, *28*(4), 305–314.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12.

Bencze, J. L. (2009). 'Polite directiveness' in science inquiry: A contradiction in terms? *Cultural Studies in Science Education, 4*(4), 855–864. doi10.1007/s11422-009-9194-5.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children,46*(2), 26–29.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research.

Bennett, J., Lubben, F., & Hogarth, S. (2006). Bringing science to life: A Synthesis of the research evidence on the effects of context–based and STS approaches to science teaching. *Science Education, 91*(3), 347–370.

Bjøness, B., & Knain, E. (2018). A science teacher's complex beliefs about the nature of scientific inquiry. *Nordic Studies in Science Education 14*(1), 54 – 67.

Capps, D. K., & Crawford, B. A. (2012). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education*, *24(*3), 497-526.

Crawford, B. A. (2014). From inquiry to scientific practices in the science classrooms. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 515–541). Abingdon: Routledge.

Davis, E., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research,76*(4), 607–651.

De Vries, B., Schouwenaars, I., & Stokhof, H. (2017). Turning teachers into designers: The case of the ark of inquiry. *Science Education International*, *28*(4), 246–257.

Enugu, R., & Hokayem, H. (2017). Challenges pre-service teachers face when implementing a 5E inquiry model of instruction. *European Journal of Science and Mathematics Education*, *5*(2), 178–209.

Graham, B. (2006). Conditions for successful field experiences: Perceptions of cooperating teachers. *Teaching and Teacher education*, *22*(8), 1118–1129.

Hang, Q., & Rabren, K., (2009). An examination of co-teaching. *Remedial and Special Education*, *30*(5), 259–268.

Harlen, W. (2013). Inquiry-based learning in science and mathematics. *Review of Science, Mathematics and ICT Education*, *7*(2), 9–33.

https://doi.org/10.33225/jbse/19.18.583

Havu-Nuutinen, S., Sporea, D., & Sporea, A. (2017). Inquiry and creativity approaches in early years science education. A comparative analysis of Finland and Romania. In Kimonen E. & Nevalainen, R. (Eds.) *Reforming Teaching and Teacher Education: Bright Prospects for Active Schools* (pp. 89–116). Rotterdam, the Netherlands: Sense Publishers.

Hmelo–Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem–based and inquiry learning: A Response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99–107.

Hwang, Y. S., Hernandez, J., & Vrongistions, K. (2003). Elementary teacher education students' perceptions of team teaching. *Education*, *123*(2), 246.

Ireland, J., Watters, J.J., Brownlee, L., & Lupton, M. (2014). Approaches to inquiry teaching: Elementary teacher's perspectives. *International Journal of Science Education*, *36*(10), 1733–1750.

IAP. (2010). *Taking inquiry-based science education into secondary education: Report of a global conference.* Retrieved from http://www.sazu.si/files/file-147.pdf.

Lederman, N. G. (1992). Research on students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*, 331–359.

Lehesvuori, S., Ratinen, I., Kulhomäki, O., Lappi, J., & Viiri, J. (2011). Enriching primary student teachers' conceptions about science teaching: towards dialogic inquiry-based teaching. *Nordic Studies in Science Education*, *7*(2), 140–159.

Kallery, M., & Psillos, D. (2001). Preschool teachers' content knowledge in science: Their understanding of elementary science concepts and of issues raised by children's questions. *International Journal of Early Years Education, 9*(3), 165–179.

Kang, N. H., & Wallace, C. S. (2005). Secondary science teachers' use of laboratory activities: Linking epistemological beliefs, goals, and practices. *Science Education, 89*(1), 140–165. doi: 10.1002/ sce.20013.

Kang, E. J. S., Bianchini, J. A., & Kelly, G. J. (2013). Crossing the border from science student to science teacher: Preservice teachers' views and experiences learning to teach inquiry. *Journal of Science Teacher Education 24*(3), 427–447. doi: 10.1007/s10972-012-9317-9.

Kervinen, A., Uitto, A., Kaasinen, A., Portaankorva-Koivisto, P., Juuti, K., & Kesler, M. (2016). Developing a collaborative model in teacher education – An overview of a teacher professional development project. *LUMAT International Journal on Math, Science and Technology Education, 4*(2*)*, 67-86.

McBride, J. W., Bhatti, M. I., Hannan, M. A., & Feinberg, M. (2004). Using an inquiry approach to teach science to secondary school science teachers. *Physics Education*, *39*(5), 1–6.

McDonnough, J. T., & Matkins, J. J. (2010). The role of filed experience in elementary preservice teachers' self-efficacy and ability to connect research to practice. *School Science and Mathematics*, *110*(1),13–123.

Niikko, A. (2003). *Fenomenografia kasvatustieteellisessä tutkimuksessa*. [Fenomenography in educational research]. Kasvatustieteiden tiedekunnan tutkimuksia, nro 85. Joensuu, Finland: Joensuu yliopisto.

Nummenmaa, L. (2009). *Käyttäytymistieteiden tilastolliset menetelmät (*1. rev.ed.*)*. [Statistics methods of behavioural sciences]. Helsinki:Tammi.

Ødegaard, M., B. Haug, B., Mork, S. M., & Sorvik, G. O. (2014). Challenges and support when teaching science through an integrated inquiry and literacy approach. *International Journal of Science Education, 36* (18), 2997–3020.

Oliveria, A. W. (2009). "Kindergarten, can I have your eyes and ears?" Politeness and teacher directive choices in inquiry-based science classrooms. *Cultural Studies of Science Education, 4*(4), 803–846.

Perttula, J. (1995). *Kokemus psykologisena tutkimuskohteena: johdatus fenomenologiseen psykologiaan* [An experience as a psychological research aim]. Tampere: Suomen fenomenologinen instituutti.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). *Science education now: A renewed pedagogy for the future of Europe*. Brussels, Belgium: European Commission.

Roth, W-M., Tobin, K. Carambo, C., & Dallath, C. (2004). Coteaching: Creating resources for learning and learning to teach chemistry in urban high schools. *Journal of Research in Science Teaching*, *41*(9), 882–904.

Silm, G., Tiitsaar, K., Pedaste, M., Zacharia, C. Z., & Papaevripidou, M. (2017). Teachers' readiness to use inquiry-based learning: An investigation of teachers' sense of efficacy and attitudes toward inquiry-based learning. *Science Education International*, *28*(4), 315–325.

Stevenson, C. B., Duran, R. L., Barrett, K. A., & Colarulli, G. C. (2005). Fostering faculty collaboration in learning communities. *Innovative Higher Education*, *30*(1), 23–36.

Solis, M., Vaughn, S., Swanson, E., & McCulley, L. (2012). Collaborative models of instruction: The empirical foundation of inclusion and co-teaching. *Psychology in the Schools*, *49*(5), 498– 510.

Uitto, A., & Kärnä, P. (2014). Teaching methods enhancing grade nine students' performance and attitudes towards biology. In C. P. Constantinou, N. Papadouris & A. Hadjigeorgiou (Eds.), *Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning*. Part 2. (315-321) Nicosia, Cyprus: ESERA.

Yager, R. E., & Ackay, H. (2010). The advantages of an inquiry approach for science instruction in middle grades. *School Science and Mathematics, 110*(1), 5–12.

Yoon, H. G., Joung, Y. J., & Kim, M. (2012). The challenges of science inquiry teaching for pre-service teachers in elementary classrooms: Difficulties on and under the scene. *Research in Science Education*, *42*(3), 589–608.

Zapf, M. K., Jerome, L., & Williams, M. (2011). Team teaching in social work: Sharing power with bachelor of social work students. *Journal Of Teaching in Social Work*, *31*(1),38–52. doi:10.1080/08841233.2011.539135.

https://doi.org/10.33225/jbse/19.18.583

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Vangrieken, K., Dochy, F., Raes, E., & Kyndt, E. (2015). Teacher collaboration: A systematic review. *Educational Research Review*, *15*, 17–40.

Wallace, C. S., & Kang, N-H. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 41* (9), 936–960.

Walters, K., & Misra, J. (2013). Bringing collaborative teaching into doctoral programs: Faculty and graduate student co-teaching as experiential training. *American Sociologist*, *44*(3), 292–301. doi:10.1007/s12108-013-9185-6.

Received: *May 10, 2019* Accepted: *August 02, 2019*

Sari Havu-Nuutinen *(Corresponding author)*	PhD, Professor, University of Eastern Finland, Yliopistokatu 7, 80100 Joensuu, Finland. E-mail: sari.havu-nuutinen@uef.fi Website: http://www.uef.fi ORCID ID https://orcid.org/0000-0001-5502-6361.
Anttoni Kervinen	MSc, Doctoral Student, University of Helsinki, P.O. Box 9 FIN-00014, University of Helsinki, Finland. E-mail: anttoni.kervinen@helsinki.fi Website: https://www.helsinki.fi/ ORCID ID: https://orcid.org/0000-0003-1689-6457.
Anna Uitto	Phd, Professor, University of Helsinki, P.O. Box 9 FIN-00014 University of Helsinki, Finland. E-mail: anna.uitto@helsinki.fi Website: https://www.helsinki.fi/ ORCID ID: https://orcid.org/0000-0002-1568-7808.
Aulikki Laine	Msc, Project Officer, Environmental School of Finland, Malmin kauppatie 8 B, 4. krs., 00700 Helsinki, Finland. E-mail: aulikki.laine@sykli.fi Website: https://sykli.fi/sykli-creating-environmental-experts/
Anniina Kervinen	MSc, University Teacher, University of Jyväskylä, P.O. Box 35, 40014 University of Jyväskylä, Finland. E-mail: anniina.koliseva@jyu.fi Website: https://www.jyu.fi/science/fi/luma
Lassi Pyykkö	MSc, University Teacher, University of Jyväskylä, P.O. Box 35, 40014 University of Jyväskylä, Finland. E-mail: lassi.s.pyykko@jyu.fi Website: https://www.jyu.fi/science/fi/luma
Pentti Impiö	MSc, Senior Planning Officer, Kokkola University Consortium Chydenius PL 567, 67701 Kokkola, Finland. E-mail: pentti.impio@chydenius.fi Website: http://www.chydenius.fi
Tiina Aittola	MSc, Project Researcher, Kokkola University Consortium Chydenius, PL 567, 67701 Kokkola, Finland. E-mail: tiina.aittola@chydenius.fi Website: http://www.chydenius.fi

https://doi.org/10.33225/jbse/19.18.583