

Pre-Service Teachers' Challenges and Affordances in Implementing Inquiry-Based Science Teaching at Lower Primary

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Abstract

Our study is a designed-based research with our pre-service teachers as participants. We aimed at mapping pre-service science teachers' challenges and affordances when they faced the task of planning and implementing inquiry-based science teaching (IBST) at lower primary, followed by reflection on their experiences. Using thematic analysis framework, we looked for emerging patterns of challenges and affordances across our data set comprising of lesson plans, classroom observations, pre-service teacher focus group interviews, mentor teacher interviews and pre-service teachers' self-reporting. Our preliminary analysis suggests that given the carefully designed support, the pre-service teachers have managed to implement inquiry-based science teaching even with young students at first and second grade in primary school. A great range of scientific practices was implemented, including formulating hypothesis, making observation, constructing explanation and building argumentation. Some of the challenges dealt with insufficient age appropriate classroom management skills and in developing age appropriate scaffolding for leading inquiry work. However, despite the challenges, the affordances comprising of the usefulness of the 5E-model and the Nysgjerrigper method as teacher guide introduced by the teacher educators, and the children's natural curiosity have supported the pre-service teachers in the implementation of IBST.

Keywords: *Inquiry, science, implementation, lower primary, pre-service teachers training;*

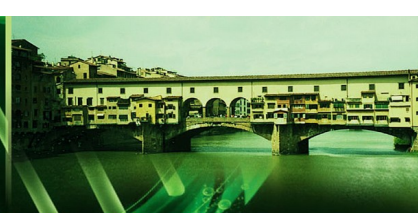
1. Introduction

Literature shows the intention from both the science educators' milieu and the policy makers to widespread the implementation of inquiry-based science teaching (IBST) and learning [1, 2]. IBST generally refers to student-centered ways of teaching in which students raise questions, explore situations, and develop their own paths toward solutions [3]. Since there is still no universally agreed upon definition of the term *inquiry*, we use the definition of IBST that we developed in the mascil project [4], which among others characterize inquiry tasks as meaningful, open and with multiple solution strategies. The teacher role is a guide that values and builds upon student's reasoning and reflections, and connects to student's experience [4].

IBST is considered a way to raise motivation, increase student performance and to provide students with the attitudes and skills in science necessary in society [5]. However, the inquiry approach is not implemented as widely as expected [3]. Thus, there is a discrepancy between the intention and the implementation of inquiry at the classroom level. The lack of inquiry enactment is also the case in Norway, despite the good systemic support. Some of the obstacles to teach science through inquiry comprise lack of teachers' knowledge and skills, lack of confidence and lack of ability to manage classroom and time [6]. As teachers are key stakeholders for whatever is happening in schools, one possible way to overcome these obstacles is by equipping pre-service teachers (PST) with appropriate pedagogical content knowledge (PCK) and pedagogical knowledge (PK) for inquiry in their training program.

What constitutes effective teacher professional development (PD) have been described in the literature [7], also when it comes to PD for implementation of IBST [8]. There is also a strong field of literature around the practicum in pre-service teacher education. However, there has been a limited focus on how PST themselves perceive their development during this learning period and little is known about how initial teacher education (ITE) enable them to implement IBST.

From literature, we know that being a novice teacher, challenges are connected to eg. classroom management, meeting special needs, classroom resources, long-range planning, time for preparation, and mentorship [9]. Teacher training should strive to meet and prepare PST for these challenges. The role of teaching experience and reflection in science teacher education is a way of better



understanding the complex entities that constitute a knowledge base for teaching [10]. We know that practice is essential for PST to generate their own practical schemes of action. Reflection in and about practice allows PST to analyze their classroom behavior and contrast it with their previous conceptions, and with that of their companions [11]. Since PST learning includes personal, social, and professional development [12], support from university instructor, mentor teacher and fellow students is also fundamental for their educative process [11]. PST practicum intend to bridge the gap between theory and practice [13], but the relevance of coursework in preparation for practicum has shown to be low during the first two years of ITE [14]. In our study, we provided PSTs with methodologies for IBST during their second year of ITE, eg. the 5E-model [15] and the Nysgjerrigper method [16]. Our research question was: *What are the challenges and affordances PST face in implementing IBST at lower primary school during their practicum?*

2. Method

We followed the design-based research principle involving cycles of design, enactment, analysis and redesign [17]. We have done three cycles within three consecutive school years, one cycle per year. This paper gives an overview of the results of the data accumulated during these years.

2.1 Participants and Setting

The main participants of this study were primary school PST at the second year of their ITE. We worked with a new batch of PST each year. First, the PST worked in the university where we (researchers) introduced them to IBST and to teacher guide on planning inquiry lessons, e.g. the 5E-model [15] and the Nysgjerrigper method [16]. Then, we assigned them the task of planning and implementing IBST in the topic of their choice, at 1st or 2nd grade of primary school where they had their practicum [13]. During the practicum, the PST worked in groups, and each group was supervised by a mentor teacher (MT) from the placement school. After the practicum ended, the PST came back to the university and we asked them to reflect on what went well or not and why, and about the challenges and affordances in the IBST implementation [10,11].

In total, we have worked with 60-70 PST in 18 groups, having two-three week practicum in 12 different primary schools, and taught more than 250 6-8 year old students. The chosen topics consisted of: “senses”, like sight, hearing, taste, smell and touch (6 groups), “digestive system” (3 groups), “floating and sinking” (3 groups), “autumn” (2 groups), and the topics “sound”, “day and night”, “windmill” and “oil in water” with 1 group each.

2.2 Data Collection and Analysis

We collected the lesson plans and the reflections from all 18 groups after the PST came back to university from the practicum. The reflections were audio-recorded. In addition, we distributed open-ended questionnaires to PST and MT and conducted semi-structured interviews. The PST interviews were done in-group, and the MT interviews were individual. Only those who were available and gave consent were interviewed. Eight questionnaires or group interviews of PST and nine questionnaires or MT interviews were collected. All interviews were audio-recorded.

We also conducted at least two classroom observations per cycle to see directly the implementation of the planned lessons. Together with the MT interviews, the classroom observation served as validation of the data from the PST, enhancing reliability beyond self-reporting.

The collected data were analyzed qualitatively using thematic analysis [18]. We looked across our data set for emerging patterns of challenges and affordances for IBST implementation.

3. Results and Discussion

Our preliminary analysis suggests that given the carefully designed support, the PST successfully implemented IBST even with young students at first and second grade in primary school. A great range of scientific practices was applied, including formulating hypothesis, making observation, constructing explanation and building argumentation [19]. These were confirmed by classroom observations.

Moreover, we saw that the PST acquired a good understanding of IBST. From the interviews, when asked about what inquiry means, most of them came up with the characteristics of inquiry approaches as presented in [3,4]. They also viewed IBST approaches as engaging and motivating. Some also thought that students would learn better, when they were taught using IBST approach.

Despite a good understanding of IBST and the fact that the PST managed to implement a great range of scientific practices, they met challenges, see Fig.1.

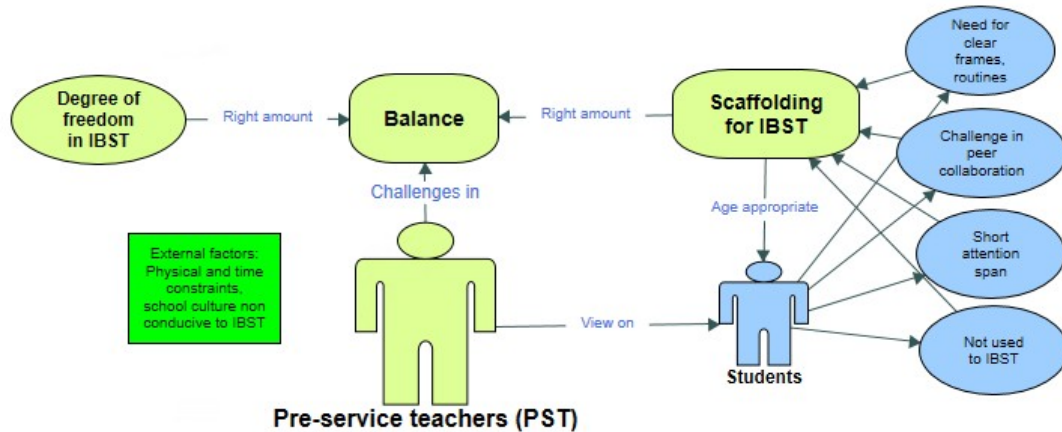


Fig. 1. Challenges in IBST implementation at 1st and 2nd grade primary school

The PST understood that IBST is a student-centred pedagogy, as opposite to traditional approach. They also knew that young children need guidance and clear boundaries for instance on accepted behaviour. The most challenging factor for the IBST implementation was to get the right balance between giving the children enough space for doing the investigation, and providing enough scaffolding of the activities, like step-to-step, detailed enough instructions for the children to understand. They were worried that giving the children too much space would lead to chaos and a loss of control over children's behaviour. Giving them too much scaffolding would lead to no or almost no degree of freedom, and the activities that initially were planned to be open or inquiry-based [3,4], ended up being "closed", or teacher-centred like in traditional approach. Many of our PST successfully stroke the balance by giving the children the appropriate type of scaffolding in an appropriate amount, but some did not. Even those who succeeded still acknowledged scaffolding young children for inquiry work in a balanced way as challenging.

Recurrence themes emerging from the MT interviews were "relationship with students" and "knowledge of students" which both came under "classroom management". The fact that the PST were still novices influenced how successfully they familiarized themselves with the students and understood their needs [9]. For instance, the students had a relatively short attention span; hence, the lesson sequences should be of appropriate length. Some had limited writing and reading skills, hence alternatives like drawing should be offered. Moreover, terms had to be explained, like what "*collaborating*" means in a group work. Some of the PST managed well, while some others struggled. The mentor teachers considered the lack of classroom management skills of some PST as a challenge.

However, despite the challenges the affordances comprising the usefulness of the 5E-model and the Nysgjerrigper method as teacher guide introduced by the teacher educators, and the children's natural curiosity supported the pre-service teachers in the implementation of IBST, see Fig. 2.

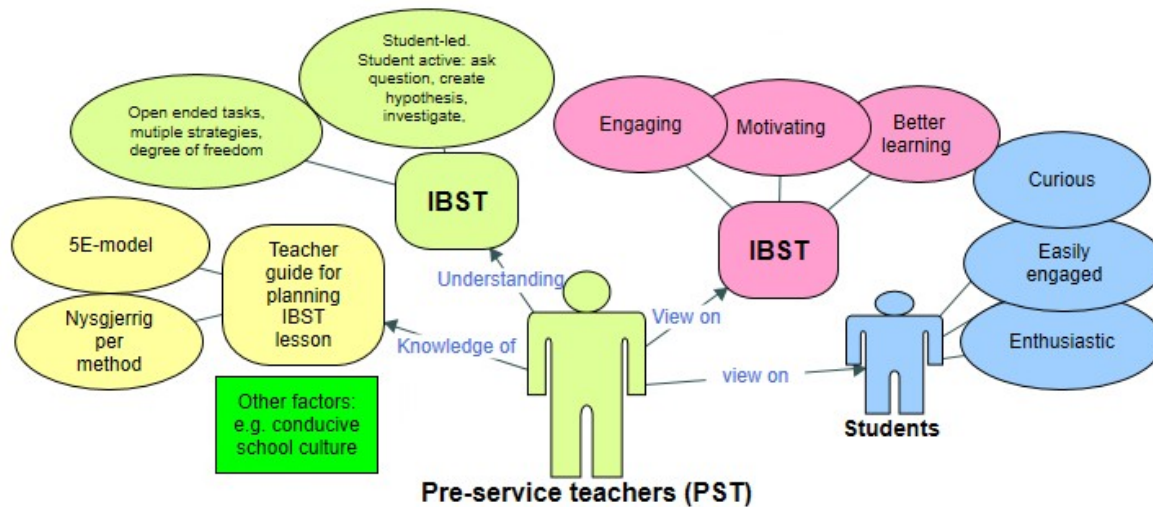


Fig. 2. Affordances in IBST implementation at 1st and 2nd grade primary school

Children's curiosity and engagement were indeed the recurring themes emerging as main affordance. This result was validated by MT's perspective. Although sometimes the children could be overly excited and resulted in rushing the inquiry steps (e.g. jump over the hypothesis), it was encouraging for the PST to see the students easily engaged, enthusiastic and highly motivated: *"It doesn't required much to engage the students, really!"* (PST, interview). The students were also very curious and asked questions, such as *"Why do we have one eye on each side of the nose?"*, *"Why is the poop brown?"*, etc.

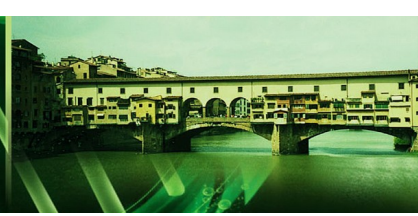
Besides, the PST considered the 5E-model and the Nysgjerrigper method as being useful teacher guide in planning the lesson, although in the implementation they often had to make adjustments based on the students and the external factors such as time and physical constraints, like room availability, limitation of resources, etc. We considered the PST's good understanding of IBST and their view of IBST as affordances for implementation of IBST, because without a good understanding of IBST and a belief that IBST would enhance motivation and engagement, the implementation would be impeded. From the MT's perspective, the PST's ability to know well the students' needs and limitation and to provide adequate support within a clear frame were considered as affordances.

4. Conclusion

In conclusion, the pre-service teachers managed to implement IBST at lower primary. However, due to the young age of the students, it is important that the PST acquired age-appropriate classroom management skills combined with skills for developing age-appropriate scaffolding (in type and amount) that enable them to lead inquiry work of the students. Although more PST training is commendable, our intention to equip the PST with appropriate PCK and PK in their training program was achieved at least for some PST.

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