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TEACHERS' BELIEFS AND GOALS CONCERNING INQUIRY-BASED SCIENCE

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For several decades now, inquiry-based learning has been an important element of science education. However, research findings show that inquiry-based learning is applied only rarely in science classes. To increase the implementation of inquiry-based learning, professional development programmes that address science teachers' beliefs and attitudes need to be offered. In the course of a teaching initiative, we created a respective programme and investigated the participating teachers' beliefs and goals concerning inquiry-based science. The programme lasted about six months and was attended by teachers from five schools. For the purpose of data collection, we conducted two group discussions with the participating teachers, one at the beginning and one at the end of the programme. The data were analysed in two steps: In the first step, the transcripts of both group discussions were analysed via qualitative content analysis, facing differences in beliefs and dispositions between the first and the second group discussion. During this analysis, it became apparent, that the formulated goals and beliefs were fostering and hindering factors for teachers when making decisions about the teaching methods. For further analysis, we applied the Documentary Method according to Bohnsack. This approach shed light on teachers' tacit knowledge. The reconstructed orientational frameworks show that the participating teachers see "inquiry" as contradictory to "learning" at school. This might constitute one obstacle to the implementation of inquiry-based learning that has not been considered yet.

Keywords: inquiry-based learning, professional development, qualitative methods

INTRODUCTION AND CONTEXT OF THE STUDY

Inquiry-based learning (IBL) has been considered an important part of science education for decades now (Dewey, 1910; Schwab, 1960). As engaging in science practices is indispensable for students to acquire scientific literacy (Barron & Darling-Hammond, 2010; Roberts & Bybee, 2014) instructional approaches such as IBL have been incorporated in several science curricula and standard documents (e.g., BIFIE, 2011; NGSS Lead States, 2013; NRC, 1996). Nevertheless, international studies indicate that IBL is still not or only rarely implemented in most of science classes (Capps et al., 2016; Forbes et al., 2020; Hofer et al., 2016). To foster the implementation of IBL, it is unrewarding to develop an abundance of "ready-to-use" material. Instead, teachers need to be supported in professional development programmes that address their beliefs and dispositions towards IBL and meet their individual needs (Capps et al., 2012; Darling-Hammond et al., 2017).

The Austrian initiative IMST (Innovations Make Schools Top!) aims at promoting the pedagogical development of schools by supporting teachers in implementing innovative pedagogical approaches in their own classes. The initiative started in 1998 and is financed by the University of Klagenfurt and the Austrian Federal Ministry for Education, Science and Research. Despite providing a manifold support system for in-service teachers (regional

networks, provided instructional material, project supervision, financial contribution to material costs etc.), IMST offers professional development programmes that bridge the gap between science education research and teachers' classroom practice. IMST encourages teachers to conduct own action research projects (Laudonia et al., 2018) to evaluate developed material, instructional strategies or their own classroom practice (Krainer et al., 2019).

As science education researchers working for the initiative IMST, we developed a professional development programme called 'Inquiry Steps'. In the course of the pilot phase of this programme, we collected data for two purposes: programme evaluation and science education research. In the following, we give an overview of the professional development programme and provide an insight into initial results of our research.

DESIGN AND METHOD

Inquiry Steps is a professional development programme that aims at promoting schools' pedagogical development by implementing IBL in schools' science programmes. For this purpose, science teachers are supported in planning and applying IBL units for their own science classes. In the 2019/2020 school year, *Inquiry Steps* was offered the first time. In this pilot phase, teachers from five schools (all levels from primary to upper secondary school) participated in the professional development programme. The participating schools were required to delegate teams of teachers (at least two teachers per school) collaborating in a project in order to establish a structural basis for IBL at the school, thus increasing the impact of the professional development programme regarding the schools' pedagogical development.

Overall, the pilot phase of the professional development programme lasted about six months and was organised in two strands: the professional development strand and the research strand (see Figure 1). Arranging the programme in two strands allowed us to fulfil the professional development goals while pursuing our research interests at the same time.

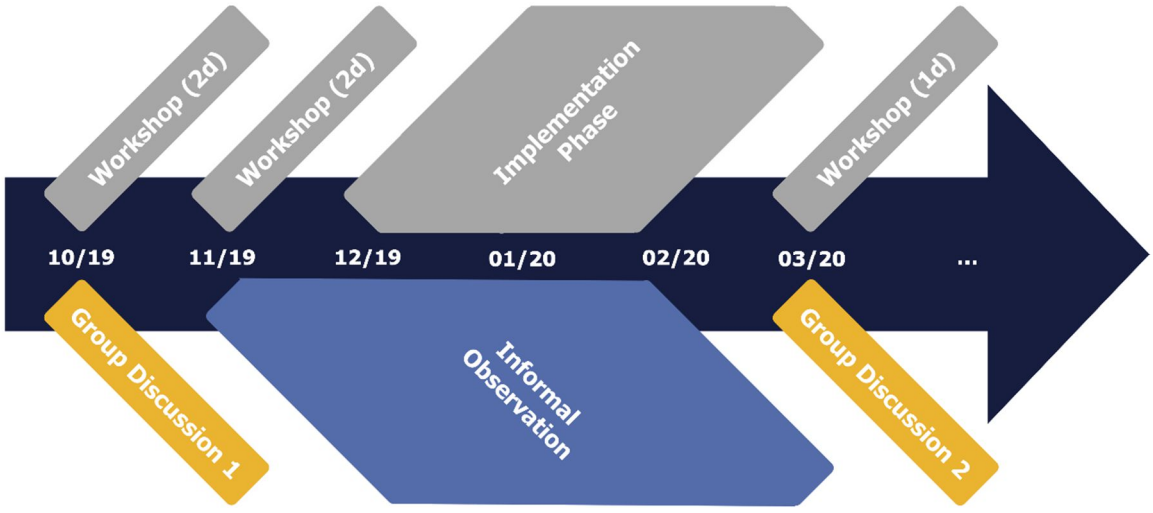

Figure 27. Schedule of the programme *Inquiry Steps* in the pilot phase. The upper part of the figure (in grey) shows the professional development strand, the lower part addresses the research strand (Hofer et al., 2020).

The professional development strand

As shown in Figure 1, the professional development strand of *Inquiry Steps* consisted of two different elements: three workshop parts (five days in total) at the University College of Teacher Education Lower Austria and one implementation phase at the teachers' own schools. In the first workshop part, the participating teachers formulated their individual expectations and needs and presented ideas for IBL-projects at their own schools. Beyond that, science education researchers provided a theoretical framework for IBL to the teachers. In short presentations, teachers learned about the instructional goals for IBL (Abrams et al., 2008), the levels of openness of IBL (Blanchard et al., 2010) as well as of scaffolding (Hammond & Gibbons, 2005) as an indispensable instructional strategy when implementing IBL in science classes. Beyond that, teachers got to know the principles of the Universal Design for Learning (Baumann et al., 2018) in order to consider their students' diversity. Based on this theoretical framework, the teachers were asked to revise and – if necessary – to re-design their initial project ideas.

The second workshop part focused on teachers' views of scientific inquiry. For this purpose, the teachers visited a research institute where they had the opportunity to keep in touch with "real" researchers in an authentic setting. During this visit, the teachers got an insight into a couple of research projects and had the possibility to talk to the researchers and ask them questions about their projects and activities. After this visit, the teachers discussed and reflected their views on scientific inquiry with the science education researchers followed by a brief input about Nature of Science (Lederman et al., 2013). Thereafter, the work on the IBL-projects was continued: the teachers specified and refined their project goals, worked on the planned instructional strategies, outlined the experimental setting and the required equipment, and started to create the teaching materials (e.g., information or instructional sheets) for the planned IBL units. After this workshop part, the teachers had to continue the work on their projects individually. In this phase, they were supported by the science education researchers. Beyond that, each team had the possibility to get financial contribution to material costs by the initiative IMST. After the teachers had finished the instructional design and the required equipment was available, the planned IBL units were proved with students (implementation phase).

In the third workshop part, the teachers presented their final IBL-projects to the other participants of the professional development programme, talked about their impressions and shared the experiences they made in the course of the implementation. Moreover, they were asked to reflect on successful and improvable aspects of their units and had to formulate plans for the sustainable implementation of the projects in their schools' science programme.

The research strand

In parallel to the professional development aspects of *Inquiry Steps*, we collected data in order to evaluate the professional development programme and pursue our research interests in the field of teacher professional development regarding IBL (see Figure 1). The focus of our research interest was reflected by the following research questions: What are the teachers' beliefs about and dispositions towards IBL prior to and after their participation in the professional development programme *Inquiry Steps*? Are there any differences?

To answer these questions, we conducted two guided group discussions (Cohen et al., 2018), one at the beginning and one at the end of the programme. Beyond that, we made informal observations in the time in between (see Figure 1). Both group discussions lasted about 60 minutes, were audiotaped and fully transcribed. To analyse the data, we applied the method of qualitative content analysis combining a deductive and inductive approach (Kuckartz, 2014). The categories used in the deductive step of the analysis were taken from Abrams et al. (2008) and Hofer et al. (2018), respectively. After having analysed the data deductively according to the main categories (learning environment, objectives, scaffolding), we inductively completed the coding manual by developing or revising subcategories.

In order to gain deeper insights into teachers' beliefs and dispositions, we decided to analyse the data one more time by applying the Documentary Method (Bohnsack, 2010). As suggested by Bohnsack (2010), the Documentary Method is especially useful to explore the tacit knowledge of participants in group discussions. When analysing data with the Documentary Method, the analytic stance has to switch from immanent to documentary meaning, from the question "What?" to the question "How?" (Bohnsack, 2010). To achieve this, we answered the "What?" in a first step by writing a formulating interpretation of the group discussions. In the next step, we selected those sequences of the transcript where many teachers were involved in the discussion and analysed these sequences more in-depth in the form of a reflecting interpretation (Bohnsack, 2010). As a result, we were able to reconstruct teachers' implicit orientations towards IBL that will be presented further down.

RESULTS

The results of the first step of analysis (qualitative content analysis) showed that the teachers extended and deepened their knowledge about IBL in several aspects, however, some of the gap identified in the first group discussion persisted even after the teachers' participation in the programme *Inquiry Steps*. For example, some of the teachers denied the necessity of a research question as starting point for IBL. The goal "learning about inquiry" (Abrams et al., 2008) was not mentioned by the teachers at all. Moreover, the teachers claimed that IBL would not match the curriculum and that younger students would be able to carry out research intuitively while older students could not carry out research anymore. The results of the qualitative content analysis are presented in detail in Hofer et al. (2021).

In the course of the qualitative content analysis, some parts of the group discussion arouse our attention. It seemed that the participating teachers would hold a common orientation towards learning that contradicts IBL in school science. This view of 'learning' is reflected in sequences such as the following (translated from German):

> *B146: […] That means I am learning a lot of things alongside, although I have the feeling that I am actually not learning anything, yes.*
>
> *B147: Mmm.*
>
> *B148: Well, I don't have to sit down and learn something, I learn alongside.*

Following this "discovery", we looked for parts of the discussion where teachers spoke about 'learning' and used the documentary method to reconstruct teachers' views on *learning* and on

inquiry. For this step of data analysis, the following question was central: "Which shared orientational frameworks for *inquiry* and for *learning* can be reconstructed from the group discussions?" In the following, we present the reconstructed orientational frameworks on *inquiry* and *learning* in a first step and contrast them in a second step.

Applying the Documentary Method showed that teachers see *inquiry* as something positive and joyful. It is like playing, where students take active parts in and no predefined goals are needed. *Inquiry* allows for trial and error; it is open for alternative ways. Students are intrinsically motivated for *inquiry*. If they are motivated and interested in the problem, students will do some kind of *inquiry* automatically.

Reconstructing teachers' views on *learning*, we were able to identify different types of *learning* in teachers' mind. *Learning* is viewed differently depending on the area of application and the students' age. One type of learning we were able to reconstruct describes learning from the perspective of learning in early childhood. This type of learning is considered to be natural, consisting of trial and error and guided by the question "What happens if…". Contrary to this type of learning (*early childhood-learning*), learning as it takes place at school (*school learning*) is considered to be guided and artificial. There is no room for alternative ways or trial and error in *school learning*. Regarding students' age, teachers differentiate between younger students who rely on material – they learn intuitively by trying things out (haptically) – and older students who need concrete instructions and guidelines for learning.

In Table 1, the reconstructed orientational frameworks of *inquiry* and *school learning* are outlined by a few contrasting aspects. Comparing the two columns of Table 1, it becomes apparent that teachers' views on *inquiry* and teachers' views on *school learning* are not compatible – they are even contradictory. While *inquiry* is seen as joyful and playful, *school learning* is described as exhausting and joyless. *Inquiry* is seen as intrinsically motivated connected with students' active role, whereas they have a passive role in *school learning*, which is seen as rather passive. *Inquiry* is seen as open, something for that trial & error represents an appropriate method. *School learning* – on the opposite – has to be restricted and straightforward.

Table 1. The contradictory orientational frameworks for *Inquiry* and *School Learning* reconstructed from the two group discussions.

Inquiry	***School Learning***
joyful, playful	joyless, exhausting
intrinsically motivated	extrinsically motivated
active, students as producers	passive, students as consumers
open, trial & error	restricted, straightforward

In summary, *inquiry* as it is seen by the teachers is rather compatible with *early childhood learning* than with *school learning*. The older students become; the more *learning* diverges from *inquiry*. At the higher secondary level, *inquiry* is seen as effectively incompatible with *school learning*.

DISCUSSION AND CONCLUSION

The reconstructed opposing orientational frameworks for *inquiry* and *school learning* are worth discussing in terms of the implications for IBL. Teachers seem to associate IBL with their orientational framework for inquiry rather than with learning at school. This leads to contradicting goals for IBL and for traditional science classes. Teachers find themselves in a conflicting situation when trying to implement IBL what could explain findings from previous studies, where a focus on content learning was identified as an antipole to a focus on procedural skills and joy in conducting experiments (Hofer et al., 2018; Koliander, 2017). This conflicting orientational frameworks might be an obstacle for implementing IBL that has not been considered yet. As the conflicting orientational frameworks may impede the implementation of IBL, they need to be explicitly addressed in teacher education and teacher professional development, e.g., by giving pre- and in-service teachers the opportunity to reflect on their own views on *Learning* and *Inquiry*.

To find more evidence for this hypothesis, we will continue our research by analysing data from other projects (interviews, teachers' reports on action research projects) addressing teacher professional development in the field of IBL. Applying Documentary Method to these data as well, we aim at developing types of teachers' views on *learning* and *inquiry*.

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