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CONGRUENCE AND DISCREPANCY BETWEEN OBSERVATION AND TEACHERS' SELF-REPORT OF INQUIRY-BASED INSTRUCTION

Abstract: Opportunities for self-reflection and collaborative reflection support inquiry-based teaching. The presented study focuses on retrospective self-reports of 14 science teachers about teaching inquiry lessons in their regular science classes. Their self-reports were compared with observation reports of researchers. Data from semi-structured interviews were added. The results indicate that teachers overestimated their performance in the class in all observed areas of inquiry instruction. The most misinterpreted and overestimated area by teachers seems to be formulating research questions, analysing data and drawing conclusions, which are the most effective processes in student learning. Based on the results of the study, several implications are suggested in order to focus on the self-reflective skills of teachers.

Keywords: self-report, teacher reflection skills, inquiry-based instruction

Introduction

Reflection is considered to be an important element in the professional development and learning of teachers, especially when new approaches are being implemented [1, 2]. It helps to connect theory and practice [3], as well as the teachers' beliefs and practice [4]. This is considered to be an essential way to master one's teaching practice [5] and improve current analysed teaching practice [6]. Enderle et al. [7] and many other researchers [8] point out that teachers can change their beliefs via reflection about classroom practice. Lin et al. [9] state that teachers involved in observing other teachers and discussing their practice focused more on asking inquiry-oriented questions.

In their study, Monet and Etkina [10] state that teachers had difficulties reflecting on their learning during the continual professional program (CPD) and have mistaken assumptions about what they are doing in the classroom. Their self-report about their teaching practice is often not accurate and sometimes even wrong [11]. The relationship between one's declared competence and actual practice is insufficient [12]. Naturally,

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teachers can understand and interpret practice in the science class only according to their conceptions [13], knowledge, skills, understanding [14] or expertise in the material being taught [15]. Their preparation is therefore essential [16]. Teachers with a greater and deeper understanding and knowledge of their subject matter seem to be more flexible and responsive to student ideas and the actual situation in the classroom than teachers with less such knowledge [17]. Feldman and Ozalp [18] question the self-reports of teachers since there might be the possibility that they do not have the knowledge, understanding, or skills to accurately assess what they have accomplished. They are often unaware of their deficits and over-estimate their skills [15].

The mentioned discrepancy between the science teachers' self-report, their pedagogical preferences and their practice in the classroom has been analysed [19]. The authors state that the teachers' action in the class is goal-driven and their practice reflects the urge to reach the active goal set for that particular class. The teachers' beliefs and knowledge as mediating representations suggest possible routes for how to reach that goal. The author's reason that teachers hold traditional (transmissive) or constructivist (inquiry-based) mediating representations. If the goal does not reflect constructivist pedagogy, then mediating representations active during planning and teaching are those that help to reach the currently active goal. While answering questions in their self-report protocol, the teachers operate with a different goal, and different mediating representations are active. Hutner and Markman [19] suppose that the mediating representations reflective of constructivist teaching might be viable to answer self-report questions but might not be seen as viable to reach active and prioritised goals during planning and teaching which can be connected with improving good scores in testing, parental wishes, administrative requirements, etc. or everyday coping as stated by Maseko and Khoza [20].

The teachers prefer the constructivist approach [21], but, as mentioned earlier, classroom observation did not confirm this [11, 22]. Prevailing transmissive beliefs especially hinder professional vision [23, 24]. Savasci and Berlin [22], using the Constructivist Learning Environmental Survey tool (CLES), found that the most preferred component of the science classroom by teachers, based on their self-reports, was the personal relevance of school science to out-of-school life and student negotiation, which meant verbal interaction with other students to build their scientific knowledge. However, the component most noted by researchers was the critical voice which represented the students' ability to comment on the quality of the learning activities. Shared control was the component that was least preferred, as perceived by the teachers and also observed by the experts. This component represents shared control of the learning environment, including learning activities, assessment criteria and negotiations. The teachers expressed the need to follow goals connected with the subject matter as stated in the science curriculum and to prepare their students for standardised tests. This finding reflects the active goal that teachers are urged to reach during their practice in the class as described earlier by Hutner and Markman [19]. Savasci and Berlin [22] also point to another study when shared control was identified as a peripheral belief since teachers were not able to implement it in their teaching, expressing the need to follow the local curricula [25].

It seems that the teachers' beliefs make them sensitive and responsive to only some phenomena occurring in the science classroom [26, 27]. Also, Meschede et al. [23] point out that mere declarative knowledge is not sufficient for noticing and interpreting the classroom situation in a professional way and that practical experience might also play an important role in the process. The authors also point to the model of competence proposed by Blömeke et al. [28], who describes it as a transformation of disposition represented by the teachers' knowledge and beliefs about professional vision and consequently about their performance in the class.

Despite the subjectivity of self-reports, their lack of validity and accuracy, in combination with other reflective methods, this might be a powerful instrument for professional development as a part of CPD programs [11, 15] to discover what part of the implemented approach is misunderstood and misinterpreted.

Research questions and methodology

The purpose of the study was to identify how science teachers look back critically on their classroom practice and identify relevant events in inquiry-based instruction. We focused on their retrospective self-reports of what was happening during the science class. We wanted to find out how accurate and reliable the self-reports of teachers are after the CPD program, which was focused on the implementation of inquiry-based teaching and learning. Self-assessment reports were compared with observation reports of two researchers who observed the classes as well. We wanted to learn if science teachers have any commonly misunderstood issues or misinterpretations in the process of leading their students through inquiry. We formulated the following research questions:

1. What domains and parts of inquiry-instruction in teachers' self-report correspond with observed actions in the science class?
2. What domains and parts of inquiry-instruction are misinterpreted in self-report by teachers?

The research took place at the end of the CPD training program, which was focused on inquiry-based instruction in science education. The goal of the CPD program was to provide teachers with a guided experience with inquiry-based teaching and we expected them to be flexible about leading students through their own investigation. The teachers received teaching and supporting materials on various science topics. They familiarised themselves with the materials during face-to-face workshops and used it in their regular science classes.

To discover the teachers' perceptions of their activities in an inquiry-based science lesson, we asked them to analyse two whole lessons via a self-report [29]. The same class was observed by two researchers. Semi-structured interviews with the teacher followed. Generally, the interview took 15-60 minutes, and open questions were linked to the unclear situations in the structured observation. Data collected from researchers and teachers were compared and analysed [29].

The Tool for Enhancing Inquiry in Science Education (TEISE) [29] was designed to support the effective implementation of an inquiry-based approach to science teaching. The tool is adaptable for observation purposes as well as for self-reports for teachers. This tool was adapted for our purposes by categorising domains of inquiry practice into eight areas. It contains 38 items (Table 1). After the lesson, an evaluation is recorded as 'yes', 'no' or 'not applicable', and additional comments are recorded as well. 'Yes' (1) implies that the practise occurred, it did not occur accidentally (teacher's intention was evident or explained in following interview) and that it was relevant in the context of the observation, 'No' (0) implies that the practice did not occur at all or occurred accidentally (which was clarified in an interview after the lesson), but that it was relevant in the context of the observation, 'Na' implies that the practice is not relevant in the context of the session observed.

Table 1

Areas examined by the self-report and the observation tool

The tool for enhancing inquiry in science education (TEISE) - areas	Example of items	Domain of inquiry
Uncovering P's previous knowledge (3 items - 1a, 1b, 1c)	T asks questions requiring P to give their existing ideas. T helps P to formulate their ideas clearly	Conceptual
Formulating research question (3 items - 2a, 2b, 4a)	T encourages P to ask questions T helps P to formulate productive (investigable) questions	Procedural
Formulating predictions (2 items - 2c, 4b)	T encourages P to make predictions P make(s) predictions based on their ideas	
Supporting P's own investigations (6 items - 2d, 2e, 4c, 4d, 4e, 4f)	T involves P in planning investigations T encourages P to include fair testing in their planning	
Data collection (2 items - 2f, 2g)	T encourages P to check their results T helps P to keep notes and record results systematically	
Written records (7 items - 6, 7a, 7b, 7c, 7d, 7e, 7f)	Records clearly state the problem or question being investigated Records indicate what data were collected and how	
Analysing data and drawing conclusions (10 items - 3a, 3b, 3c, 3d, 3e, 3f, 3g, 4g, 4h, 4i)	T asks P to state their conclusions T asks P to compare their conclusions with their predictions	Epistemic
Working with others (5 items - 5a, 5b, 5c, 5d, 5e)	P engage in discussions of their investigations and explanations P respond to each other during reporting	Social

T - teachers, P - pupil(s)

The tool overlaps with the abilities to do inquiries and the essential features of inquiry as summarised by Capps et al., [30] and the Practices of Science Observation Protocol (P-SOP) [31], which measures the essential features of inquiry [32] in the science classroom.

Participants

14 teachers took part in the study. There were 3 men and 11 women with teaching experience varying from 2 to 22 years. They teach biology, physics, chemistry and geography in grades five to nine. The selection criteria included their willingness to participate in all workshops during the CPD program, to cooperate with experts on one to one basis (individual sessions), to use supporting material in their science classes and discuss it with CPD lecturers, to let researchers be present during their teaching, analyse the lessons with them, ask for help or express any concerns. The teachers participated in the CPD program voluntarily and with the full support of their school leadership which was an important criterion for their selection, too. They all had taken university teaching courses and university science courses in the field they were teaching. The teachers claimed to have very limited previous training in inquiry-based instruction. However, they tried to implement various inductive methods (project teaching, discovery teaching, problem-based

learning, etc.) and hands-on activities in their science lesson. They were very motivated to learn about and implement inquiry-based approaches in their science classes. The education and teaching experience was likely representative of teachers at lower secondary level in the country. The participating teachers obtained systematic methodological and personal support, as well as help with organisation and the supporting materials (worksheets, methodological guidance, other supplemental material).

Data collection and analysis

Two independent science lessons were analysed for each participating teacher at the end of the CPD training (self-evaluation by the teacher and observation of the researchers using the same tool). Various biology, chemistry, physics and geography lessons were observed. The researchers took additional notes to explain the observed phenomena in the classroom. Additional information was collected through semi-structured interviews to clarify some data after each observed science lesson. The interview questions were driven by the TEISE tool [28] if some clarification of classroom activity was needed. Researchers agreed on questions for semi-structured interview based on possible discrepancies in their notes or disagreement in their observations. Standardise questions were chosen from TEISE tool and both observing researchers were present during teacher interview.

Observations were conducted and additional information was collected by researchers who discussed the observed activities and collected data before they were approved for analysis. In the end, inter-rater reliability concern was reached by agreement of 96 % between two experienced researchers about observed phenomena (their assurance or their absence) in the classroom [33].

Table 2

Nature of additional data from structured observation and their evaluation

Nature of data	Item from TEISE	Example	Evaluation
Teacher's quotes	(4b) Ps make predictions based on their ideas	"Have you ever seen anything like that? If so, where was it?"	Yes
	(4a) Ps pursue questions which they have identified as their own, even if introduced by the T	"We are going to find out what kind of soil does not let water pass through." Research question was introduced by the teacher. There was no prior discussion leading to it.	No
	(1a) T asks questions requiring Ps to give their existing ideas	"What do you think the shape of the Earth is?" Too simple question for grade 5 to start discussion about various models. Pupils reacted instantly with correct answer.	I
Teacher's reaction	(2g) T helps Ps to keep notes and record results systematically	Teacher talks to groups while they are observing. Her questions stimulate students to take notes simultaneously with their observation.	Yes
	(1c) T provides Ps with positive feedback on how to review or take their ideas further	Teacher does not react to pupils' "incorrect" responds.	No
	(2e) T encourages Ps to include fair testing in their planning	Teacher does not react to all suggested procedures how to test hypothesis.	I

Nature of data	Item from TEISE	Example	Evaluation
Pupil's quotes	(4b) Ps make predictions based on their ideas	"I think if there are no plants soil will be just washed away. There is nothing to hold it in place. It happened behind our house last summer when there was a heavy rain. Almost all got washed away."	Yes
	(4c) Ps take part in planning an investigation	"And why do we need to blow five times?" Pupils do not understand the procedure for testing hypothesis. They just read how to proceed in the worksheet.	No
	(1c) T provides Ps with positive feedback on how to review or take their ideas further	From discussion among groups: "Our body burns only bad things. The ones which our body does not need." "No, we burn what we need." "Our body does not burn proteins." The teacher calmed down the group and talk to them quietly (researchers did not hear).	I
Pupil's reaction	(2g) T helps Ps to keep notes and record results systematically	Pupils ask how to fill out the table with data. The teacher helps them to adjust the table and suggests to add additional data.	Yes
	(4a) Ps pursue questions which they have identified as their own, even if introduced by the T	Pupils kept asking for instructions or approval when they were supposed to work (take data). The teacher was helping them.	No
	(4d) Ps include "fair testing" in their plan if appropriate	Pupils suggest observation. Variables control is not necessary.	Na
Description of the context	(1a) T asks questions requiring Ps to give their existing ideas	Time given for group discussion about stimulating situation.	Yes
	(1b) T helps pupils to formulate their ideas clearly	It is unclear if students understand what it means that shape of animal's body depends on environment. There was no example. Later during investigation the teacher had to explain it.	No
	(2b) T helps Ps to formulate productive (investigable) questions	Pupils asked a lot of various questions about oxygen dissolved in water and water animals in connection with photosynthesis. Teacher wrote questions on the blackboard.	I
	(1a) T asks questions requiring Ps to give their existing ideas	Teacher did not ask about pupils' previous experience with studied phenomena. They discussed about it a formulated hypothesis on the previous science lesson.	Na
Description of a team work and cooperation as a class	(5d) Ps listen to each other during reporting	The teacher asks students to listen to each other when they present groups' findings.	Yes
	(5b) Ps engage in discussions of their investigations and explanations	The teacher did not initiate final discussion. Pupils just took turns answering questions at the end of the activity.	No
	(5a) Ps collaborate when working in groups	Problem with distribution of tasks in the group.	I
	(5) Working with others	Lesson ended before groups could share their findings. The teacher asked them to get ready to present the next lesson.	Na

Ps - pupils, T - teacher, Yes - observed practice occurred, No - observed practice did not occur, Na - not applicable here, I - situation discussed in interview

We analysed the obtained data from structured observation (teacher) and self-reflection tool (researchers) after data were approved for analysis by using the non-parametric

Wilcoxon signed-rank test to examine any possible significant differences between the teachers' self-report about their practice in a particular science class and the observation of the same lessons viewed by two observing researchers. Both tools for collecting data focused on the same features (the same questions). In using self-reflection tool, the teachers used also their methodological preparation. In using structured interview, researchers used their notes form observation. There were always two researchers observing each lesson. Researcher observation reports and the semi-structured interview after each lesson helped to understand, explain and interpret the results found from the analysis. Examples are presented in Tables 2 and 3.

Table 3

Clarification of observation by semi-structured interview

Item from TEISE / areas	**Examples of unclear situations from structured observation**	**Clarified by teachers in semi-structured interview**	**Evaluation**
Uncovering P's previous knowledge	(1c) From discussion among groups: "Our body burns only bad things. The ones which our body does not need." "No, we burn what we need." "Our body does not burn proteins." The teacher calmed down the group and talk to them quietly.	"Oh, I just asked them to concentrate on what they were supposed to do, to calculate their daily intake." (Teacher 2)	No
	(1a) "What do you think the shape of the Earth is?" Too simple question for grade 5 to start discussion about various models. Pupils reacted instantly with correct answer.	After asking what the teacher expected to hear and what she wanted to find out: "I do not really know. I did not think about it much before." (Teacher 1)	No
Formulating research question	(2b) Pupils asked a lot of various questions about oxygen dissolved in water and water animals in connection with photosynthesis. Teacher wrote those questions on the blackboard.	"I took a picture of the blackboard at the end of the lesson. We will get back to these questions during our project week. Every team will specify a different research problem and investigate it." (Teacher 2)	Yes
Formulating predictions	(4b) "Could these organisms (algae *Volvox globator*) consists of microorganisms?" Pupils gave various answers.	Could grade 5 pupils answer / speculate about such question? "We studied photosynthesising single-celled photosynthesising organisms before." (Teacher 2)	Yes
Supporting P's own investigations	(2e) Teacher does not react to all discussed and suggested procedures how to test hypothesis.	"Well, it is not easy if there is only one teacher in the class with 25 kids. I listened to their discussions while they were talking in groups and then I called on the ones which could stir further discussion. I know, all of them should have their turn but it is simply not possible because of time." (Teacher 10)	Yes
Data collection	(2g) Are notes and results recorded systematically?	"I collect their notes at the end of every quarter and give them a feedback on them. I have started even to give them grades. So, they know how to keep their records. Also, they can use them when we discuss what we investigated in the past. It teaches them to do it properly. They even started adding their own personal notes. That is great." (Teacher 13)	Yes

Item from TEISE / areas	**Examples of unclear situations from structured observation**	**Clarified by teachers in semi-structured interview**	**Evaluation**
		"We follow what is in the worksheet. When they are supposed to write answer or some numbers, or, you know, what data they take, they put it down." (Teacher 6)	No
Written records	(6) Pupils controlled (and copied) results from each other in the group.	"There is an agreement in the class that group comes up with one set of data. They do not copy from each other but other member of the group might had worked on a different task and did not manage to put down the data. Pupils work in the same group for half of the year. They evaluate their team work once a month." (Teacher 4)	Yes
Analysing data and drawing conclusions	(3b) It is not clear if conclusions proposed by one group fit with all other groups results.	"You never asked other groups what their conclusions were. Are you sure they would be the same?" "Well, they should be. That was a correct conclusion and that is what they need to remember." (Teacher 11)	No
Working with others	(5a) Problem with distribution of tasks in the group.	"They do not work in groups very often. I never know what would work. They are teenagers. That is the problem." (Teacher 10)	No

Yes - observed practice occurred, No - observed practice did not occur

Results

A Wilcoxon signed-ranks test indicated that the teachers evaluated their performance during the science lessons statistically significantly higher than the evaluation of their performance by researchers (z = 2.521, $p < .01$) (Fig. 1).

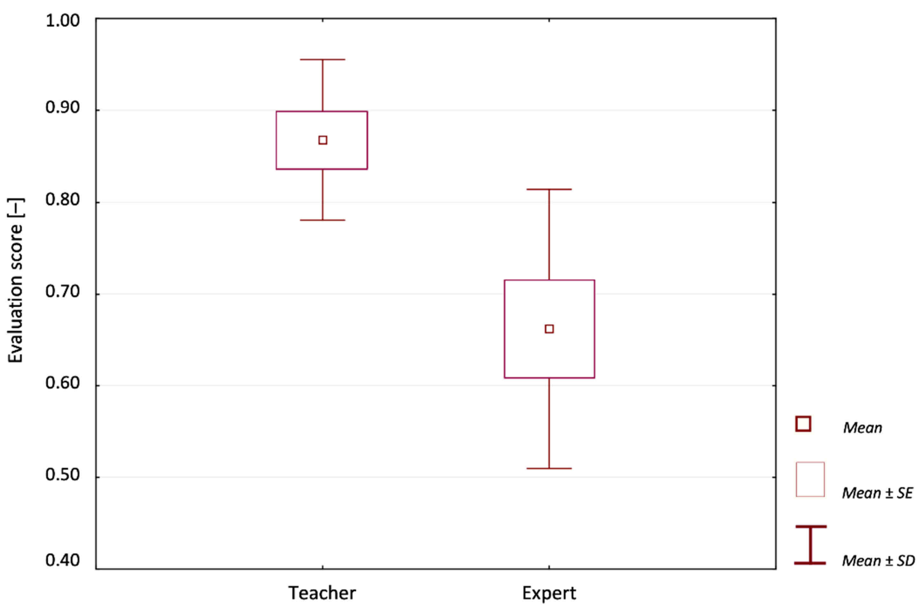

Fig. 1. Comparison of teacher's self-evaluation and researchers' observation

When we look more closely at particular areas, except for the formulating prediction, we see that all of the differences between the teachers' self-report and the researchers' reports were rather high and statistically significant ($p < .01$) (Table 4). The results indicate that the teachers overestimated their performance and the situation in the class in all observed areas of inquiry instruction. The most misinterpreted and overestimated area by the teachers seems to be formulating research questions, analysing data and drawing conclusions.

Table 4

Wilcoxon test statistics z scores expressing the differences between the teachers' self-report and the researchers' report in all observed areas

Area	**z score**	***p***
Uncovering students' previous knowledge	2.641	0.008^{**}
Formulating research question	3.680	0.000^{***}
Formulating predictions	1.348	0.178
Supporting students' own investigations	2.868	0.004^{**}
Data collection	3.180	0.001^{**}
Written records	2.311	0.021^{*}
Analysing data and drawing conclusions	4.238	0.000^{***}
Working with others	3.080	0.002^{**}
All areas	**2.521**	**0.012^{*}**

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Discussion

The reason for this study was to approach the teachers' comprehension to conduct inquiry-based instruction by making them reflect on their own teaching and compare their self-analysis with that of the researchers. The differences in these two views are significant as Wilcoxon test results present. The teachers misinterpret and overestimate their performance and the performance of their pupils in various ways described in Result section (also in [18, 22]). Furtak's overview of research which took place during years when inquiry was the main focus of science education reform shows the positive effect of inquiry-based teaching on student achievement and stresses the importance of the role of a teacher in actively guiding activities [34]. However, placing the stress on the epistemic domain of the inquiry which focuses on data analysis and reflection, their verification, drawing conclusions, generating and revising theories, pointing out the nature of science produces the highest effect size when compared to focusing on other inquiry dimensions or their combinations [34, 35]. Our findings indicate that the epistemic dimension of inquiry in the science class is one of the biggest misinterpreted areas by teachers (also in [35]).

The teachers use suggested prepared material. However, constructing the explanation and the meaningful reflection of the class on the obtained data is the matter of adaptation to the particular situation in the science class and cannot always be explicitly expressed in methodological material. The teachers assume that they involve their students in inquiry when they only follow a prepared plan "with highly structured step-by-step instructions" as stated also by McLaughlin and MacFadden [36]. Described misinterpretations repeatedly point to the lack of knowledge about how science works and about learning itself. Uncertainty about how to work with the students' preconceptions or misconceptions or how to handle the students' curiosity is solved by avoiding situations when they could be expressed and/or by simply "sticking with the plan". Responding in this way might, of course, be understandable, especially when a teacher starts using the inquiry approach in science classes. However, the concern is about the misinterpretation of such steps in the teacher's self-reflection, which points to the teacher's professional vision.

An identified misreading of the teachers' own practice in the science class indicates a misunderstanding of the purpose of certain "steps", e.g. formulating a hypothesis or collecting data itself. Consequently, these steps do not result in what they are supposed to - namely, with the pupils drawing conclusions or confronting them with the formulated hypothesis. Also, a prepared and presented research question or plan for how to investigate it is assumed by these teachers to ensure the students' active involvement in formulating research questions and suggesting an appropriate procedure to test them. Teachers stressing and concentrating merely on the hands-on part of inquiry activities are not really concerned about the data collected by pupils which sometimes remained incomplete, unsystematic or inaccurate. Such activity loses its meaning and purpose (also [35, 36]). Monet and Etkina [10] found out that teachers who could describe how they learnt from evidence had the highest learning gain as identified in their self-reflection protocols. By contrast, the teachers who never or seldom reasoned showed the smallest learning gain. The teachers who were not able to conceptualise how they learnt or who stated that they learnt by observing or doing experiments (seldom stating that it was by reasoning from evidence) might be missing the understanding and sensitivity to the process of how their students learn, and this results in presenting knowledge to them instead of constructing it. This explanation is also emphasised by a study conducted by Feldman and Ozalp [18] who point out the lack of experience of teachers with learning itself.

The teacher-centred approach dominates in-class discussion when most of the reports and comments are directed to the teacher, and he/she accepts, answers or corrects them; this practice does not contribute to the understanding of the scientific community of which we are part of and to which we are supposed to contribute; it fails to appreciate the joint effort in science, technology and other aspects of society. We assume that failing to stress or simply neglecting certain steps in science class inquiry contributes to a misunderstanding of the nature of science and does not actually help to develop the pupils' scientific literacy, despite the fact that they engage in hands-on activities, formulate hypotheses or collect data.

Interviews with teachers suggest that misinterpretation might be also connected with the alternative active goals that teachers formulate during their planning and teaching [19]. They reflect on existing science curricula and expect to come to the exact same conclusions stated in the document; this eliminates or lowers the possibility of shared control over the learning process as observed also by Savasci and Berlin [22]. This is highlighted by the frequent asking for tests which could help them to evaluate what their students have learned and if they have learned what they were supposed to. For instance, the teachers want to make sure that the data the pupils record are correct or that they all reach the same correct conclusion. They ignore or at least underestimate the process of analysing and comparing them and eventually deciding which data could be used for further analysis and which seem to be inaccurate. Consequently, the model of students pursuing their own research questions is not really an option.

Conclusion and implications

The research adds to the rather limited number of studies which have analysed the teachers‘ perception of their own performance and compared it with observation of the lessons by researchers. We analysed the ability of science teachers to reflect on inquiry-based science lessons. Our results show that their self-evaluation was significantly overestimated compared to the researchers' observation. The teachers focused on objectives stated in curricula stressing final concepts. They omitted the process of working with evidence in constructing knowledge in a community of learners, which is proved to have the highest effect on the students' learning.

The findings presented here have important implications for the preparation of potential science teachers and for future work with in-service teachers. Learning to reflect should be an essential part of pre-service as well as in-service CPD programs. Monet and Etkina [10] point out that it is not sufficient to merely ask teachers to reflect. The reflection has to foster a higher level of thinking. It seems to be important to participate in peer classroom observations and reflect on what is observed in order to get feedback and compare one's own performance with others as suggested also by Feldman and Ozalp [18] or Savasci and Berlin [22]. Curriculum material or adjusted material with inquiry design are important means for teachers to design inquiry teaching situations in their science classes. However, teachers seem to rely entirely on them, without adjusting to the current situation in the class and by merely following proposed steps which are emphasised by other research [31, 32]. Designing and adjusting material for science class should proceed after stating the objectives and goals for particular sessions, pointing out all aspects of scientific literacy as stated in the curricula.

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