EXAMINING THE ROLE OF FACILITATORS IN THE CONTEXT OF PLANNING AN INQUIRY-BASED MATHEMATICS LESSON

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This paper presents categories and codes of an analytical framework that combines both Knowledge Quartet and Mentoring Strategies to understand the role of facilitators in collaborative learning community through lesson study. The data is from a Norwegian lesson study involved three facilitators and six elementary teachers working together on an inquiry-based lesson. The new categories reported in this paper contributes to build a robust analytical tool to explore and discuss the role of facilitators in a future large-scale international study including several countries and all three phases of lesson study.

INTRODUCTION

The role of facilitators in collaborative work with teachers has been identified as central to the professional development of mathematics teachers (e.g. Borko & Potari, 2021). A difficult task is how to conceptualize the contribution of facilitators in such collaborative settings. For instance, Shulman's pedagogical content knowledge (PCK) (Shulman, 1986) could be used to understand the difference of knowing something for oneself and being able to help others to know it. Yet, it is difficult to use PCK to interpret the differences we (Skott & Ding, 2022) found in how facilitators talked with teachers and what content-related aspects they talked about in mathematics lesson study (LS) in Denmark and China. This is not only because of the fact that LS is new in Denmark, but also because of cultural, social and power-related aspects of the different roles of facilitators in the two cultural settings.

Based on this previous study, we will in the present study further develop categories and codes to describe, understand and interpret the tacit and abstract nature of how facilitators interacted with teachers and what content-related aspects they talked about in a mathematics LS in Norway that targeted inquiry-based learning (IBL) in elementary school. Our goal is to build a robust analytical tool to explore and discuss the role of facilitators in a large-scale international study including several countries and all three phases of LS (i.e. planning a research lesson, conducting the research lesson and observing student activities, reflecting on the lesson based on observations). Our research question in this paper is: how do facilitators interact with a group of elementary school teachers to learn to plan an inquiry-based mathematics lesson?

THE ROLE OF FACILITATORS IN TEACHERS PROFESSIONAL DEVELOPMENT

There has been a growing recognition of the significant role of facilitators in supporting teachers' professional development through collaborative work related to classroom

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practices in general and in LS in particular. Nevertheless, the research into the nature of the facilitators' interactions with teachers in LS is scare (Skott, 2022). Thus, there is a need to develop a new analytical tool to describe, understand and interpret the complicated role of facilitators in teachers' professional development. Gu and Gu (2016) developed an analytical tool based on empirical data to conceptualize how teaching research specialists (facilitators) mentor teachers during post-lesson LS-debriefs based on more than 100 hours of videos of 50 facilitators in China. They developed a two-dimensional framework for analysing the mentoring activity: the first dimension is of the mentoring strategies, which encompass the dynamic between the facilitators and the teachers; the second dimension is the knowledge that mentors pay attention to (i.e. mathematical, pedagogical and practical knowledge). Regarding the mentoring strategies, Gu and Gu found that "the conversations between [the facilitators] and teachers were … monologues rather than dialogic in nature", with the facilitators paying most attention to "what they know and what they anticipated, rather than … what teachers were concerned about in their teaching" (p. 451). Regarding the knowledge, the facilitators focused on practical knowledge, helping teachers to analyse concrete cases that embraced mathematical and pedagogical ideas. Ding and Jones (2018) propose that there is a *dual nature* of Chinese facilitators' expertise in Chinese LS. The first nature is scaffolding the teachers to learn concurrently the act of the multiple theoretical ideas (i.e. teaching with variation) through the LS. The second nature is scaffolding the teachers to learn to reflect on their own beliefs about the subject, pedagogical thinking and action, and to develop their identity as mathematics teachers.

Recent studies have showed that the different qualities of facilitators' mentoring may promote alternative aspects of teachers professional development in special contexts. In a previous comparative study (Skott & Ding, 2022), we found big differences in the ways that the facilitators in Denmark and China interacted with the teachers. While the facilitators in the Danish LS rarely talked more than 2 minutes and interacted in a dialogic-relational mode with teachers during LS meetings (about 60 min), the Chinese facilitator dominated the conversation in a seemingly authoritative way in LS meetings (45 min). An important result of this study is that "cultural, social, and power related issues at the interactional level as well as at a broader level have high influences on their [the facilitators] engagement" (p. 8). An analytical tool should to some extent be able to take into account such issues. Comparing two mentoring strategies in a two-year large-scale study in Germany, Richter et al. (2013) conclude that constructivist-oriented mentoring (i.e.; when mentors initiate inquiry stances towards teaching) supports new mathematics teachers more appropriately than transmissive-oriented mentoring (i.e.; when mentors convey their own teaching ideas and often focus on technical skills). The authors further suggest that the quality of mentoring rather than its frequency and close guidance explains successful career paths. Their conclusions are based on teachers' self-reported experiences of (among other things) self-efficacy and teaching enthusiasm. Skott (2022) investigates what happens in lesson study beyond its initial adaptation in countries outside East Asia with no use of external

support (facilitators). Based on a comprehensive Danish case, the study suggests that external support (or other external knowledge sources) are crucial at the mature stages of adaptation too. Skott (2022) highlights that compared with LS in Japan and China, two activities are new for the external support in the Danish context: 1) prevent teachers' use of artefacts and actions from transforming into rote procedures. 2) identify problems to be analysed during reflection and challenge teachers' views.

THEORETICAL APPROACH

Given the research question of this paper, two analytical tools are referred to in the initial data analysis: the Knowledge Quartet (KQ) (Rowland, 2013) and the Mentoring Strategies (MS) (Gu & Gu, 2016). The KQ is an empirically based conceptual framework developed particularly for the analysis of the relation of mathematics content with teaching in classrooms. We refer to the KQ rather than other frameworks, because it enables us to largely focus on the classification of situations of the collaborative learning and working between facilitators and teachers in which the subject matter is related to teaching. The KQ includes four components: (1) *Foundation*, about knowledge 'possessed', meaning the teacher's theoretical background and beliefs in terms of what they learned at school and teacher education etc. The other three components are about knowledge-in-action, as they refer to ways and contexts in which knowledge is brought to bear on the preparation and conduct of teaching" (p. 200). (2) *Transformation*, about the capacity to transform the content knowledge one possesses into forms that are pedagogically powerful. (3) *Connection*, about the coherence and mathematical connections in mathematics pedagogy. (4) *Contingency*, about responses to classroom events that were not anticipated.

Here, we wish to make clear two points of the KQ that enable us to develop further reflection on the categories for accounting for the ways facilitators interact with teachers in our study. First, the strength of the KQ is to enable researchers to focus on the relations between content-aspects and teaching situations. Second, we are aware of the differences between *transformation* and the capacity of a facilitator to enable other teachers not only to learn about, but also to agree on how to make *transformation* in their classes. We are thus open to the data to enrich the description of this category in our analysis. Nevertheless, the social and affective aspects are not less important in teachers' learning and working in collaboration (Skott & Ding, 2022). This is what the second analytical tool of mentoring strategies enables us to examine, namely the complex relations between more cognitive aspects and affective and social aspects of the ways facilitators contribute to the social interactions in our study.

Gu and Gu (2016) identify four types of mentoring strategies in their study of Chinese facilitators: (1) *General comments*, what teachers should know and do in classroom teaching in general; (2) *Comments on anticipated problems*, that teachers may encounter and advice on how to deal with them; (3) *Responses to teachers' questions*, raised and related to the issues in the class taught; (4) *Dialogues with teachers*, discussing problems that occurred in class.

Based on the Danish data, Skott and Ding (2022) showed that Gu and Gu's four types proved to be insufficient to capture all the strategies used by the facilitators, thus adding three new types: (1) *Encouraging comments*, such as emotional recognition of teachers' ideas and suggestions; (2) *Challenging comments*, such as disagreeing with teachers' proposals and understandings; (3) *Building on or reformulating teachers' ideas* that are expressed in the conversation. The three new codes are also examined in our analysis of the Norwegian lesson study.

THE INQUIRY-BASED MATHEMATICS LESSON STUDY IN NORWAY

The context of the Norwegian lesson study

The project involved two schools in the outskirts of a city in central Norway. The goal was to enhance the use of inquiry-based pedagogies in mathematics and science teaching by engaging teachers in lesson study. Explicitly, the goals were being defined in the project as focusing on inquiring activities (i.e. open tasks with multiple solutions or solution strategies) to develop such as students' engagement, critical thinking, asking questions; cooperation and communication, etc.

In the IBL LS meeting discussed in this paper, three teacher educators and researchers (called facilitators in the rest of the paper) participated. One of the facilitators DS (all anonymous) was a mathematics teacher educator while DR and DJ were natural science teacher educators. Six teachers participated: 1) TM2 (the school principal), 2) TR (1st grade classroom teacher), 3) TI (1st grade classroom teacher), 4) TM1 (special education teacher with specialization in mathematics and Norwegian), 5) TT (2nd grade classroom teacher), 6) TS (2nd grade classroom teacher). TM2 and TM1 do not do classroom teaching. The school had previously participated, with the facilitators, in two projects focused on IBL, but of the teachers only TM2 had been actively involved in those previous projects.

Given the research question of this paper, we concentrate on the planning meeting of the first lesson. The teachers had talked briefly about the meeting in advance, and agreed that the first lesson is on mathematics, and partly spurred by TS, that the mathematical goal should be related to functions (one task of her mooc education was on the learning of functions). In the initial analysis, we focus on the first meeting (2 hours). Using Microsoft Word, the words in the transcript (in Norwegian) were counted as follows: teachers uttered 14843 words and facilitators uttered 3843 words.

Data analysis strategy and procedure

In this section, we describe how we have developed our strategies for the data analysis and interpretation according to the two analytical tools presented above: KQ (Rowland, 2013) and MS (Gu & Gu, 2016; Skott & Ding, 2022). All three authors analyzed the transcriptions individually (see Table 1 for an example of coding data in the analysis). We then validated our interpretations and use of the codes in digital meetings. In the same way we analyzed and discussed our use of MS codes (see Table 2).

Table 1: The use of KQ categories and codes in the data analysis

Categories	Codes of KQ (Rowland, 2013)	Example of data
Foundation (F)	F1. awareness of purpose; F3. overt subject knowledge; F4. theoretical underpinning of pedagogy; F5. use of terminology.	DS: mathematics is about recognising patterns and do generalisations and such, and you can say that with functions it is also about finding expressions or formulas for it

Table 2: The use of MS categories and codes in the data analysis

Categories	Codes of MS (Gu & Gu, 2016)	Example of data
Dialogues with teachers	Gu 4. Facilitators and teachers dynamically and dialogically discuss and share their own opinions	TR: Maybe the task could be to find different ways to continue the pattern. DR: Or if you first start the way you were thinking, how do you think the next one will look like, and then you can say that there are at least three ways to do it, can you find them. TM2: More advanced, more creative. TR: I think that was very smart.

In this paper, we examine the facilitators' interactions with teachers to gain new insight into the differences between the components of the KQ and the capacity of a facilitator in collaborative working with teachers in the LS. That is, it is necessary to address analytical vs. holistic ways of thinking (Ding & Jones, 2021) to develop a relational understanding of the key codes. For instance, two questions were largely discussed in the planning meeting regarding the IBL LS: (1) Is the mathematics goal clear? (2) Does the plan offer students' enough space to inquire, explore, discuss and cooperate? In the next section, we describe our identification of one new strategy of MS and two new codes of one new category of KQ.

FINDINGS

The first episode (see Table 3) illustrates the identification of the new strategy and one new code of the new category of KQ. The analysis of DS' utterances, in the first twenty minutes, showed how DS played an important role in facilitating LS, namely seeking and actively listening to feedback from teachers towards promoting a collaborative learning and working culture of being open, honest and constructive (new category of MS). In so doing, the facilitators played a significant role towards developing a shared mathematical knowledge foundation for planning and teaching the IBL lesson.

Table 3. Data analysis in the first episode.

Facilitating LS, and seeking and actively listening to feedback from teachers towards promoting a learning process of open, honest, constructive.	DS: … and we can see the importance of planning, but reflection after the first lesson is also very important, so we don't have a perfect lesson planned even if we are several people now spending hours at planning. […] It is also important to know what we are looking at in the first lesson so the discussion afterwards becomes productive …
Probing and understanding what knowledge and thoughts teachers actually have about functions (F1, F3, F6).	DS: Maybe you could say more about that task and what kind of literature that is relevant.
After having sought and actively listened to feedback from teachers, DS responded to teachers' expression of lack in F3 and F4. And he also tried to extend teachers' mathematical knowledge about functions in general to establish a shared mathematical knowledge foundation for planning and teaching at grade 1.	DS: It is about discerning patterns and relations. E.g. that a triangle has three edges and that the number of edges and vertices are related, and how it is in a quadrilateral: a quadrilateral has four edges and four vertices. And this are words and concepts and figures that are also relevant at grade 1. TS: Absolutely. DS: And I am thinking, at grade 1 we are looking for simple connections, and it is important to discuss connections already at grade 1, since it lays the foundation for further development, as mathematics is about finding patterns and make generalisations.

In the second episode, the analysis of DS' utterances in the main part of the meeting (16:39-1:00:33) could be largely coded as *Building on or reformulating teachers' ideas* towards establishing shared goals of the LS (e.g., generalization). Here, DS tried to support teachers' knowledge-in-action (i.e. C20 (contingency of KQ) in Table 4) and enhancing their awareness of the relationship between teachers' role in teaching and students' role in learning mathematics (students' situation, individual differences) (see Table 4).

Trying to focus on the theme-the learning goal, not time (at this moment). (Facilitating LS) Focus on learning goal (F1, F3). Gu4, pointing to generalisation (F1, F3). Teachers openly expressed their feelings to the facilitator's shared mathematical knowledge for	16:39 - 28:38 DS: I believe it is important that we don't spend much time discussing how long things take but rather discuss the theme for the lesson. TI: What we are supposed to do. DS: Yes, and what the learning goal is. What are the students supposed to learn from the lesson. DS: Yes, then you have a simple start and several possible paths ahead. How do you think figure number 20 will look like? Then you are approaching generalization, … TS: Yes, so that is interesting, what will number 20 be. And then

establishing the shared learning goal.	building on that … TR: That would be fun. TI: Yes, really fun.
After having sought and actively listened to feedback from teachers, the facilitator, for instance, responded to teacher insight (C20), to highlight the role of teacher and teaching for helping pupils to move on in learning mathematics. (*Building on or reformulating teachers' ideas*).	40:04 - 1:00:33 TT: But do you understand the difference. … if you think as a teacher, the process is important, that they sit there reflecting, right, that they are reflecting together and are able to launch lots of ideas. That is the important part. Whether I get to know all those reflections is maybe not so important. … DS: The first thing we have to do is to discuss how do you think the next figure will look like, and if they think it is only one more, it is clear what number 13 will be, but if they take one, two, one, two, there needs to be some kind of reasoning, so there can be different solutions.

Table 4. Data analysis in the second episode.

DISCUSSION

In this paper, we have identified a new category of mentoring strategy (MS) and two new codes of a new category of KQ of the communication and collaboration in the lesson study community, to contribute to the existing study of the role of facilitators (i.e. Skott & Ding, 2022; Gu & Gu, 2016; Richter et al., 2013). The new category of mentoring strategy is: Seek and actively listen to feedback from teachers towards promoting a collaborative learning and working culture of being open, honest and constructive. The new category of KQ is an effort to address the relational understanding of the components of KQ (Rowland, 2013) in our collaborative learning and working LS community in the context of real-world work. The first code of this new category is: Trying to establish a shared mathematical knowledge foundation for planning and teaching the IBL lesson (tackling the conflict between the facilitators' mathematical knowledge foundation and the teachers' lack of mathematical knowledge). The second code is: Towards establishing shared goals of teaching mathematics (e.g., generalization) (a need to construct together about a foundation of knowledge-in-action of both the facilitators and teachers).

As the analysis shows, the number of teachers' words (14843) in the planning meeting was almost four times than of the three facilitators (3843). Also, the strategy *Building on or reformulating teachers' ideas* was common in both the Norwegian LS as well as in the Danish LS. Apparently, teachers are provided much space in communications with facilitators in the context of Norwegian and Danish LS. In Chinese LS (i.e. Gu & Gu, 2016; Ding & Jones, 2018; Skott & Ding, 2022), the facilitator appeared to give more respect and space to openly talk in the post-lesson debrief meetings. Further study

is needed to understand in depth of the different role played by facilitators regarding building up an open, honest and constructive learning and working community at real-world work. Given the different respects and space given to LS participants to talk in the different cultural settings of LS (e.g., China, Denmark, Norway in our study), it is necessary to reconstruct the oversimplified dichotomy between a constructivist-oriented vs. a transmission-oriented learning (Richter et al., 2013) in the context of teachers' professional collaborative learning and working. Noticeably, Richter et al. (2013) highlighted the importance to reduce attrition that particularly happened to beginning teachers in the context of Germany school teacher professional field by support them to adjust to their new work environment, reduce stress levels and enhance job satisfaction. In China (and likely in other east Asian countries), attrition is not largely reported as a major problem for teacher professional development. Thus, as pointed in Skott and Ding (2022), future study needs to take into account the cultural social and power related issues particularly regarding the value-oriented pedagogy in teacher professional development, in order to make high influences on the participants [i.e. facilitators and teachers] engagement in collaborative learning and working. Our future research also needs to deal with further extending the tool by using it in the other phases of LS that have not yet been investigated in our study, and by using it with more LS cases. We also aim to test it against data from possibly new countries.

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