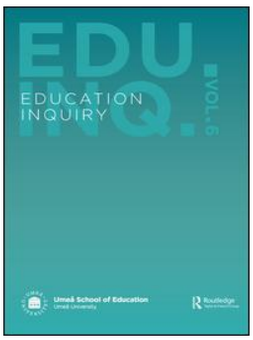

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Exploring teaching academic literacy in mathematics in teacher education

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ABSTRACT

Living in complex knowledge societies requires citizens who master multiple literacies involving both cognitive and social skills. Thus, all individuals should be offered relevant educational opportunities and teachers capable of integrating subject expertise with relational aspects. This paper demonstrates a teaching design for mathematics that student teachers have indicated integrates both these dimensions. Drawing on theoretical perspectives that conceptualize academic literacy as a socially situated discourse practice, we investigate one teacher educator's teaching design for mathematics. The evidence indicates that the teaching approaches in this design are highly student centered and process oriented. Student teachers report that the approach supports both individual and collective learning of the discipline of mathematics while also modeling how to teach mathematics as a school subject. The teaching design comprises varied and exploratory approaches to teaching mathematics and represents an alternative to more traditional mathematics pedagogy. In this way, the study contributes to an empirically informed understanding of how the goal of learning to master academic literacy may be facilitated by a varied repertoire of writing, reading, and oral activities. The study indicates challenges for traditional teaching and teacher education more broadly.

KEYWORDS

teaching design; mathematics; academic literacy; writing pedagogy

Introduction

To successfully negotiate the growing complexity of global societal structures in an increasingly knowledge-rich and networked society requires the mastering of multiple literacies (Darling-Hammond 2010; Macken-Horarik et al. 2006; Street & Stang 2008). Thus, both children and adolescents should be offered learning environments that integrate cognitive, social and emotional skills to support them in their development of academic literacy and provide them with the tools for success in the modern world (OECD 2015). To meet such requirements, researchers have called for teachers who are able to integrate subject expertise with relational expertise across different knowledge domains at all educational levels, teachers who are prepared to teach in new and varied ways comprising all aspects required by academic literacy and not just historically institutionalized core practices (Edwards 2010; Edwards, Gilroy & Hartley 2002;

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Hargreaves 2003). Teaching academic literacy implies an integration of knowledge in which the close relationships among writing, reading, and oral activities are foregrounded (Barton, Hamilton & Ivanič 2000; Myhill 2009; Lea & Street 1998; Kress 2000). Such expectations put demands on teacher educators because, as Macken-Horarik et al. (2006) argue, only those student teachers who learn to control academic literacy can become teachers who will be able to scaffold young learners in their learning of academic literacy.

In this paper we focus on teaching academic literacy in mathematics in teacher education. We find the investigation of the teaching of mathematics to be particularly interesting and opportune as both teaching and learning mathematics imply several timely challenges. Classified as a challenging pure-knowledge discipline, the teaching of mathematics is often linked to stable and standardized knowledge provided by teachers; learning outcomes are quantitatively measured through testing systems and exams; and teachers tend to embrace traditional methods such as non-interactive ways of teaching—methods in which the student is more a receiver of the teacher's knowledge delivery and less an active participant (Neumann, Parry & Becher 2002). Both researchers and politicians call for ways to improve teachers' competencies in mathematics to make them capable of teaching in new ways to scaffold pupils' learning (Mullis et al. 2012). Currently, this endeavor is seen as a challenge because many student teachers tend to fail or struggle with learning mathematics. In many countries, a range of initiatives have been undertaken to improve the level of mathematic competencies among teachers as well as among student teachers. As an example from the Norwegian context, new requisites were introduced in 2016 that affect teacher education. Pre-courses in mathematics were arranged by universities to help students improve their grades to an acceptable level (Tønnessen & Lie 2016). It is too early to judge whether such initiatives will improve the quality of future mathematics teaching.

While the level of competencies when entering teacher education is of course important, research indicates that teaching approaches matter even more and varied teaching approaches seem to be of particular significance to student learning outcomes (Ivanič 2004; Hattie 2015; Solbrekke & Helstad 2016). As Lillis (2003) argues we must continuously seek educators who develop teaching designs that challenge the traditional monological approaches in all subjects where pedagogical practices are oriented to the reproduction of knowledge. However, innovative methods in the teaching of mathematics in higher education are relatively infrequent (Abdulwahed, Jaworski & Crawford 2012). As previous research indicates, teacher-led innovations tend to be small-scale and sometimes short-lived, depending on time, resources, and teachers' personal priorities. Yet, research on higher education teachers' practices and chosen didactics[1] in teaching academic literacy is still relatively scarce (Tuck 2012).

Academic literacy research has usually investigated the perspectives of students. However, in this paper, we focus on teacher's reflections and classroom practices. Applying an ethnographically informed approach we investigate one teacher educator's teaching design for academic literacy that students experience as significant to their learning. Core research questions are:

- What are the underlying reflections of the teaching design as presented by the teacher educator?
- What characterizes this teacher educator's classroom practice?

Learning from such a teaching design, we indicate challenges and possible implications for new approaches of teaching academic literacy in teacher education more broadly.

The paper builds on data collected in a Scandinavian project in which we investigated students' struggles with learning academic writing in different disciplines in five teacher education programs. One crucial finding from the interviews with students in the Norwegian context was that one of the mathematics teachers integrated multiple aspects encouraging both social and cognitive dimensions of academic literacy (Wittek, Solbrekke & Helstad 2017). The following excerpts from student interviews demonstrate a common opinion:

> "So, we learned more directly from the teacher educator in mathematics. She used didactics with us that we can use in the same way with our pupils when we become teachers. …We listened to her and got an idea about how it should be done…The responses were so concrete, and she helped us take a big step forward with just a small comment."

Repeatedly encountering similar accounts made us curious about how this teacher educator in particular, who we have given the fictive name Hege, reflected upon her mathematics teaching and how she functioned in classroom practice with her student teachers. As Blikstad-Balas and Søvik (2014) argue, empirical literacy studies benefit greatly from looking into classroom practices, i.e.: how students are encouraged to read and write; how they talk about literacy; and what they *do* when working with texts. Thus, methodological questions concern not only how we make sense of what is said about teaching and learning but also of what goes on in classroom settings where literacy is studied. In this paper, we capture both what people *say* and *do* by combining interviews with the teacher educator and her students with observations of her classroom practice. The content of the discipline is not a core issue in this study; rather, it centers on how the teaching design unfolds with regard to teaching academic literacy, which is exemplified by a teacher educator teaching mathematics in a teacher education program.

The paper is structured as follows: First, we present the theoretical perspectives that we draw on in order to develop an analytical framework. This is followed by a section on our methodological approach and the context of the study. Then, we provide a thorough analysis of the classroom observation and interviews we carried out before turning to a discussion of some possible implications of the study. Being mindful that the research design has clear limitations due to its narrow scope, we nevertheless suggest that the results provide valuable insight into a rich repertoire for the teaching of academic literacy in mathematics. Finally, we indicate challenges and implications for new teaching approaches to teaching academic literacy in teacher education more broadly.

Theoretical and analytical perspectives

The theories that we have found useful in developing analytical lenses for this study are all situated under the umbrella term *sociocultural* (Ivanič 2004). Such perspectives suggest widening the focus of the frame of research from individuals constructing their own knowledge to also encompass collective and sociocultural issues

(Abdulwahed, Jaworski & Crawford 2012). Previous research (e.g., Lillis & Scott 2007; Macken-Horarik et al. 2006; Street & Stang 2008; Tuck 2012) has recognized the central role of literacy practices in the success—or failure—of student learning in higher education. Likewise, researchers have shown that writing as a core academic activity may increase reflection (Ryan 2011) and transform students' self-image related how they learn and who they want to become as professionals (Lea & Street 1998). Research has also demonstrated that students need more than just superficial help to familiarize themselves with academic literacy in their struggle to learn (Fernsten & Reda 2011; Rai & Lillis 2013). From these perspectives, facilitating learning in mathematics implies teaching designs that emphasize academic literacy to help students see the value of writing, reading, and classroom dialogues while learning the subject (Ulleberg & Solem 2014).

Our theoretical framework is inspired by three strands of perspectives. First, we draw on theories of *teaching academic literacy* that emphasize the close relationships among writing, reading, and oral activities (Myhill 2009; Lea & Street 1998). According to Blikstad-Balas (2016, p. 37), literacy rests on two traditions: literacy as cognitive skills, i.e., reading and writing skills, the strategies we use, and what we think about our own understanding (metacognition); and literacy as social skills, i.e., to be able to use knowledge in various social and cultural practices. This involves a transition from using literacy as a static concept, i.e., a set of skills people have obtained or will attain, to using literacy to refer to something people *do*. From such a perspective, the purpose of teaching is to encourage learning academic literacy in a broad sense, a direction that is in line with the definition provided by UNESCO (2004, p. 13):

> "Literacy is the ability to identify, understand, interpret, create, communicate, and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society."

This perspective highlights that reading and writing can never be detached from the social settings within which they are embedded, and facilitating learning environments in which these dimensions are integrated requires teachers who are able to orchestrate multiple texts embedded in complex knowledge societies. Moreover, as Macken-Horarik et al. (2006, p. 245) argue all student teachers must learn to operate within and across different discourse domains. In teaching academic literacy we find the concepts of academic literacy and everyday literacy useful as an analytical lens in order to investigate the teaching design as practiced by the teacher educator. As Vygotsky (1986) argues; moving between everyday and academic concepts is crucial to learning new scientific concepts. Translating between academic and everyday concepts contributes to connecting academic literacy and the students' future professional roles as teachers as well as more "privileged ways of knowing in a given domain," as Macken-Horarik et al. express it (2006, p. 255).

Second, we find the concept of *teaching design* fruitful because it emphasizes how teaching is a process mediated through the use of a range of cultural and pedagogical tools situated in a specific institutional frame that influences students' learning design (Darling-Hammond & Hammerness 2005; Vestøl 2016). This perspective helped us

identify significant tools when listening to the teacher educator talking about her teaching and when observing her teaching in practice; it is also reflected in how the students respond to the teaching design in forms of activities related to writing, reading, talking, collaboration, and feedback patterns. Likewise, Lillis' (2003) three strategies of teaching design help us capture essential approaches to teaching academic literacy. Inspired by Bakhtin (1986), she emphasizes a dialogical approach to talk-back on student texts, seeing feedback-giving as a complex social practice which allows the highlighting of feedback as an interactive process of dialogue between teacher and students as well as among peers. This view contrasts talk-back with the traditional monological textual feedback in academia—a product-oriented approach with closed comments, including evaluative language such as "right" and "wrong" or "good" and "bad." Instead, Lillis proposes talk-back on texts in progress, focusing on the range of potential meanings. This is a process of dialogue that may be characterized as "feed forward" to encourage the learner to develop a varied approach to meaning-making. Taken together, Lillis underlines the need to use both oral and written activities to encourage a rich repertoire of understandings and also open up disciplinary content to external interests and influences. In the context of this study, this may include revealing the disciplinary content of mathematics to students' perceptions while also advising them on how to go about this as future teachers of mathematics. Finally, Lillis suggests opening up academic writing conventions to new ways to teach that encompass challenging different disciplinary genres and reconsidering the privileged ways of teaching in academia. These concepts and strategies remind us of the importance of investigating how learning from a teaching design may encourage new and varied approaches to teaching.

Thirdly, in accordance with the ideas of Lillis (2003) we find the theories on *process-oriented writing pedagogy* fruitful in order to elaborate a dialogical and polyphonic classroom (Bakhtin 1986) emphasizing how meaning-making is a collective endeavor (Dysthe 1995). Ideologically, these perspectives are rooted in pedagogy of learning that includes a strong focus on literacy competencies that go beyond skills and where the teacher is the facilitator and supervisor and students are resource persons for one another (Hertzberg & Roe 2015). Such perspectives have played an influential role in teaching literacy. In the Norwegian educational context, these perspectives have not only been dominant in mother-tongue teaching since the latter half of the 1980s but also in other subjects. Emerging as a grassroots movement, it has drawn significant inspiration from the National Writing Project in California in the United States since the early 70s (Applebee & Langer 2006; Hertzberg & Dysthe 2012). Taken together, process-oriented writing pedagogy focuses on phases of brainstorming, mind mapping, prewriting, drafting, response, and editing. Following Gillespie, Graham, Kiuhara, and Hebert (2014, p. 1044) we may summarize the ideas and promotion of process-writing as related to five beliefs: (1) writing promotes explicitness, (2) writing leads learners to make connections between ideas, (3) writing supports reflection, (4) writing fosters personal involvement, and (5) the process of putting ideas into words helps learners think about what the ideas mean. In this perspective writing is seen as an important part of the student's identity development and as a means for reflection in which learning is emphasized (Ivanič 2004). In the Norwegian context, there has been increased political ambition to integrate elements of process-oriented approaches into

teacher education with the purpose of qualify students to teach writing in all subjects in order to qualify teachers for the challenges embedded in the Knowledge Promotion Reform program introduced in 2006 (KP 2006). This curriculum requires the integration of the teaching of writing, reading, oracy, numeracy, and digital competences at all levels to be undertaken by teachers across all subjects (Hertzberg & Roe 2015). Today, some teacher education institutions use core elements of this pedagogy, such as portfolios, which involve the use of process-oriented methods (Wittek, Solbrekke & Helstad 2017). However, despite the influence of process-writing pedagogy in school teaching, it is still used quite sporadically in the teaching of higher education disciplines more generally (Hattie 2015).

Methods

As introduced above, the study reported in this paper is part of a larger Swedish–Norwegian project, "Struggle with the Text," funded by the Swedish Research Council over the 2012–2015 period. The project explores student experiences and struggles with learning academic writing in different teacher education programs and institutions. The Norwegian part of the project is ethically approved by the Norwegian Centre for Research Data (NSD). As the core focus of the study reported on in this paper is teaching approaches used by the featured teacher educator in mathematics, Hege, and how her approaches to teaching are experienced by her students, we applied a longitudinal, ethnographically inspired research design that includes interviews with students and teacher educators as well as observations of classroom practices (Alvesson & Sköldberg 2000). All interviews were audio-recorded and lasted between 45 and 120 minutes, and the three-hour-long observation was recorded and captured through rich field notes. The interviews were transcribed verbatim, anonymized, and analyzed by all three researchers involved in the study (who are the authors of this paper) (see Wittek, Solbrekke, and Helstad (2017) for further description of method and sampling). Together, we applied an abductive mode of analysis inspired by what Alvesson and Sköldberg (2000, p. 247) described as "reflexive interpretation." This implies an interactive moving between theory and empirical data and is characterized by its iterative and critical readings of data interpretations. As an example of such an iterative process, perspectives on process-oriented pedagogy emerged as significant when we observed and reflected on how Hege deliberately included such approaches in her teaching design.

Data collection

The data of the Norwegian part of the study reported here was collected in three steps.

First, we carried out focus group interviews with 18 student teachers (two to eight students per group) on two occasions: in the fall of 2012 and in the spring of 2013. The topic of the interviews concentrated on learning academic literacy in different disciplines. In the same period we employed individual interviews with four teacher educators, asking them how they taught academic literacy in their disciplines. Through interviews with the students, we learned that the teaching design of two teacher educators, one in pedagogy and one in mathematics, stood out as significant

to students' learning. Thus, we interviewed these two teachers individually in the spring of 2013.

Second, one group interview with the two "significant" teacher educators and one group interview with two students who, in an explicit way, had demonstrated experiences recognizable among most students were carried out in the spring of 2014. In these interviews we used student assignments as artifacts to help our interviewees reflect on teaching and learning academic literacy (Helstad & Lund 2012). When showing the teacher educators the texts, we asked them to consider whether they represented "typical" assignments and requirements of different disciplines. The students were shown some of their own written assignments and were asked to tell us about their experiences working with these texts. Listening to both the teacher educators' and the students' reflections helped us gain more insight into the processes of writing and various other aspects of academic literacy, such as how they worked with texts both orally and by reading and writing in different subjects. In turn, this helped us become more aware of how the students reacted to different teaching designs concerning academic literacy.

Third, as literacy is primarily social and should be studied in context (Blikstad-Balas & Søvik 2014), we decided to dig deeper into the teaching design developed by the teacher educator in mathematics, Hege, who was initially mentioned by the students as significant to their learning. Thus, we approached Hege and asked for permission to observe her teaching for one day in January 2017 and to carry out contextual interviews —interviews that took place immediately after the observation—with a selected group of students who wanted to share their experiences with this particular teaching design. In addition, we asked for and received permission to interview Hege and four of her students immediately after the observation of the teaching session. In this paper, we primarily make use of observation data and these contextual interviews. Data from previous interviews with Hege collected in the first two steps complements these empirical data.

Situating the study

The teaching design we investigate is situated within a four-year teacher education program at a public university college in Norway that offers preparation for accreditation to teach in secondary schools. Years 1 to 3 in the program include pedagogy (on-campus teaching and internships, 60 credits), the Norwegian language or mathematics (60 credits), and two other selected subjects (30 credits each). Students in Year 4 can choose between specializing in an additional subject (60 credits) and using it as the first year of a master's program (See Wittek, Solbrekke, and Helstad (2017) for more detailed description). The particular class we observed in this university college consisted of 26 students, 13 female and 13 male, who were in their twenties and in their first year of the teacher education program. After finishing their education, all of the students planned to become teachers in mathematics and science in secondary schools.

The particular semester we collected our data, students had lessons in mathematics from 8:30 a.m. to 11:30 a.m. three or four days a week in which the teacher educator, Hege, taught the class for most of the lessons. The observations and the interviews took place two weeks before the students would start their first internship period. The

teaching sequence we observed was followed by contextual interviews with a group of two male and two female students who voluntary accepted the invitation to participate in a group interview, and thereafter, with Hege. Below, we present our findings, starting with Hege's description of herself as a teacher educator and her reflections on her teaching design and followed by a presentation and analysis of the teaching design enacted in practice.

The teacher educator

Hege has been a teacher educator for 12 years. Her previous experience as a teacher is extensive. She worked as a teacher in both primary and secondary schools in Norway for 25 years. Through her work as teacher, she learned that many pupils did not cope well with or were not interested in mathematics: "They thought it was the most boring subject in school." Moreover, Hege noticed that in general, it was hard for teachers to change their teaching approaches in mathematics. Most teachers worked very traditionally, rehearsing the pupils rather than questioning and investigating the subject and exploring different solutions to problems. Hege found a calling in this challenge: "My mission was to change pupils' attitudes to mathematics by introducing new ways of teaching." The inspiration to do so was strongly connected to significant experiences she had when, after 10 years as a teacher, she participated in a continuing education course in mathematics—inspired by the process-oriented courses referred to above. Hege remembers this as a collective learning arena in which the participants learned from one another and were all extremely inspired by the course teacher, who Hege described as "an enthusiastic and knowledgeable teacher who worked innovatively with mathematics." Evidently, this teacher acted as a significant role model to Hege, modeling new ways of teaching mathematics that challenged traditional approaches, as her following account indicates: "He showed us what to do with the subject and how to make mathematics relevant and meaningful to pupils. He articulated and explicitly demonstrated what I already did as a teacher: point to the theory, test it out in practice, and reflect on it afterwards. My own beliefs about teaching were confirmed, and ever since, I have worked this way." Hege herself was encouraged to follow the call to explore new teaching approaches to promote pupils' conceptual understanding of mathematics (cf. Abdulwahed, Jaworski & Crawford 2012).

As a teacher educator, Hege encountered the same challenges as with the younger pupils she had taught. She says: "Quite often, I meet students who express attitudes like 'I will never learn mathematics.' So, I have really fought throughout my entire career to find the proper methods." Hege has followed up on her mission to work in an explorative way and to contribute to the formation of future teachers: "I want my students to adopt varied methods that they might use when they become teachers." Together with a colleague in the teacher education program who shared her beliefs about teaching mathematics, Hege has developed new and varied teaching methods and also a range of resources (e.g., textbooks and digital resources) which are available for student teachers. Hege strongly acknowledges the collaboration with colleagues in mathematics as well as in other subjects, such as pedagogy, as crucial for her in developing her own teaching design. Nevertheless, through the different interviews we had with her, she more than once indicated that it could be exhausting to work like this

and that she would have preferred a more supportive milieu and more engagement from program leaders. She explicitly called for broader institutional support, saying: "I miss signals from the leadership." She continued: "Working as a teacher in schools or in teacher education should not be a private endeavor. I think leaders should be braver in stimulating collaborative work among teachers across disciplines to enhance the subject-specific teaching and, in turn, student learning".

Hege's reflections on her teaching design

Hege's task is to help students understand the discipline as well as learn the didactics of the school subject. She is particularly concerned with how her teaching design may support students' emerging understanding of mathematics and how it helps them learn how to reason. Hege emphasizes that it is important to stimulate students' capability to understand the principles in mathematics and articulate in written and oral texts how they can go about learning the discipline while also modeling how they might teach the subject as future teachers. Evidently, Hege is concerned with bridging theory to practice as it will help them think critically: "That's what I believe in, to get students to think for themselves. So, we need to start with the practical and see how it works." Additionally, she aims at helping students benefit from what they have learned in other disciplines. For example, she helps her students to see how they may use what they learned in pedagogy to critically reflect on the application of theory to practice—and vice versa. From this perspective, she aims at integrating how to teach the school subject with mathematics as a disciplinary domain. She says: "I try to find a balance between the discipline of mathematics and the school subject, and I work a lot to make the subject more professionally oriented." Simultaneously, she urges her students to explain how they can explore new ways of teaching involving exploration and problem-solving.

To obtain information about the students' academic level and what they have actually learned, Hege relates that she often arranges small assignments. The results inform her design for her next teaching sequence. She has two crucial guiding principles: 1) always search for new and varied ways to create situations in which students are well scaffolded in their learning of the discipline; and 2) look for ways to encourage them to transform what they learn across disciplines and from internship periods to apply to future teaching. As she reflects: "Students repeatedly meet different subject and disciplinary cultures, but how do they translate all of this into their future jobs as teachers? How do they cope with transforming theory into practice in their own classrooms?" To enable students to give and receive feedback in constructive ways, Hege gives her students small tasks that help her to see the students' capabilities and how she might follow their individual development. She says: "I quickly get to know who they are, both academically and personally, through the tasks they do every week. They work with tasks at campus, then I walk around supervising […] We have that dialogue all the time, so I get to know them." Hege invests a lot of time in building strong relations with her students: "I learn their names immediately. I take a picture of them, then I simply go home and memorize […] and I have small conversations with everyone early in the semester." By this, Hege demonstrates both the mission and the struggle to make the subject relevant and meaningful to her students in order to transform the subject knowledge into future teaching. In her reflections Hege reveals

a concern with designing her teaching in ways that support students' learning (Vestøl 2016).

So far we have listened to Hege's own account of her motivations and intentions regarding her teaching. Now we turn to how these correspond with observations of Hege and her students acting together in the classroom. Below we move from Hege's reflections to what she actually demonstrates in her teaching.

Encouraging a dialogical and polyphonic classroom

It's a Tuesday morning in January, and Hege introduces the teaching session we observe, which consists of three hours and includes three breaks. The students are sitting in pairs, and almost all the students have a computer and some books on their desk. From what we see, most of the students are actively involved in the teaching as designed by Hege. The atmosphere in the class seems to support a dynamic and polyphonic dialogue (Bakhtin 1986; Dysthe 1995) in which all students participate and freely speak out loud when Hege invites them to. It seems like all kinds of responses are welcomed; new questions from students arise, and peer students comment. Evidently, the climate in the class seems to be a result of Hege's teaching design as attested to by one student: "It is largely because of Hege that we can have this kind of community where everyone is participating […] I think it is because of the way we have been taught."

Hege is concerned with integrating cognitive and social skills by combining lecturing on theoretical concepts with interactive student activities, as is demonstrated when she briefly introduces theoretical and core concepts in mini-lectures before facilitating short conversation sequences in pairs or groups and then turning to plenary reasoning. A teaching design such as this seems to encourage students to engage in the conversations. Quite often during the session, Hege says: "Talk to your neighbor." When Hege instructs students in this direct way, they immediately get started. Some students make drawings and explain things to each other; others make notes while questions and hypotheses are swirling in the air. After a few minutes, Hege asks: "What did you talk about?" In these sequences, she walks around the classroom. She asks students to reformulate what they were talking about so that the whole class might take part in the conversation. She encourages the students to have the courage to think aloud and to develop the confidence to suggest answers even though they may be unsure. She says: "Anne and Sara, it's not a big deal if you haven't gotten the answer yet, but let's hear how you think about this topic…." Such an approach may also contribute to opening up opportunities for new meaning-making. After listening to what the students say, Hege responds by acknowledging their answers and connecting their accounts to theory. In doing so, she demonstrates the value of what students have contributed. This way of reasoning is in line with Dysthe (1995), who demonstrates how a polyphonic classroom may work as a robust learning tool. In the interview with the students immediately after the teaching session, one of them confirms that talking about topics in small groups during lessons is experienced as supporting individual learning: "It helps me afterwards when I do the work myself, these 'talk with your neighbor' exercises are really good […]." Hege urges students to explore first and then to find some rules in collaboration with peers before summing up. In plenary reasoning, Hege

catches up on some of the suggestions from the conversations, sometimes by returning with new problem-solving questions for group discussion. She asks: "Does anyone have an idea about this?" After observing how the students have worked collaboratively on problems, she encourages the students by saying: "You really have good suggestions […] when I walk around and listen to what you're talking about I am pleased […] You pose questions and alternatives, you give examples, yes, it is wise to refer to an example before moving to the formula […]." After responding to students' contributions, Hege returns to the board, where she writes a formula to explain and show examples from the students' work. In this way, Hege makes the contribution of the students transparent by acknowledging each and every one, and she makes their efforts public and visible to the whole class of students. When students suggest something, she confirms their statements by saying, "You managed both to explain and justify your argument. That's good!" or by asking individual students to comment on the problems, e.g., "What about you, Anders? What do you think?"

From the observations above, we see how the teacher educator draws on several tools that support the development of learning in the classroom. She is concerned with creating an atmosphere in which students may strengthen their self-confidence by underlining the importance of sharing ideas, always reinforcing the fact that there are no "stupid" answers. She lets them reflect individually, in groups, and thereafter in plenary discussions. This encourages them to interact and feel free to speak out and articulate their reasoning. We see how Hege facilitates a dialogical and polyphonic classroom while letting the students take an active part in her teaching and also stimulates meaning-making as a collective endeavor. The way Hege arranges in her classroom, using whole-class discussion in mathematics where the teacher's orchestration of the discussion in order to unpack the mathematical content for the students is crucial, reflects what Kleve and Heiberg Solem (2014) point to as the significance of a dialogical classroom. In doing so, Hege draws on various feedback patterns and different types of classroom conversations.

We now move on to examples of how the teacher educator explicitly uses writing in a course teaching mathematics and, in turn, how she makes use of everyday and academic language.

Facilitating writing processes

Hege highlighted the use of writing as a significant tool for learning mathematics: "I have realized that I, as a math teacher, must teach students writing techniques, not only the syllabus and the content of the discipline. I myself need to know how to structure texts so that I am able to supervise my students in how to do it." She uses core elements from process-writing pedagogy, such as brainstorming and organizing thoughts through short writing activities, and she facilitates feedback not only via peer responses but also by providing direct feedback on the assignments (Hertzberg & Dysthe 2012). Her expert comments and questions are an important element of the teaching design, as she points out: "I give my students feedback in the form of 'feed forward.'" On written student assignments, she usually gives feedback twice: "Students often say they have done the best they can, but I try to give constructive feedback to guide them in how to make progress and indicate what to work more on." Hege makes it clear that she

expects the students to work hard to learn to master mathematics. This is confirmed by her students: "We really have to work hard; Hege is a demanding teacher." Even if Hege responds in a way that means more work for students, she always gives them credit: "But even if I comment on what to revise, I always give a positive comment to everyone." In her approaches, Hege shifts between different writing activities. She interacts synchronically with the students' own writing when writing formulas and key words on the electronic board while students write their own notes on paper and on their laptops. Hege emphasizes the importance of using writing to increase academic reflection by meta-communicating the importance of writing. For example after introducing a core scientific concept in a mini-lecture, she urges the students to use writing "all the way": "It is a good idea to write down what you're wondering about; it supports your understanding. This is my advice—use writing all the way!" In this way, Hege encourages students to adopt writing as an important strategy for learning and critical reflection (Ryan 2011). Simultaneously she helps the students to familiarize themselves with academic literacy in their learning: "Write while you are thinking […] use writing as a main strategy in problem solving—it always works well!" Later in the session, she repeats the call for writing to learn. This time, she uses concepts from process-oriented writing pedagogy, talking about writing as a "thinking tool" (Hertzberg & Roe 2015). In the interview with students, we ask specifically about the use of writing as a tool for learning. The following sequence indicates that students have a conscious awareness of some of the specific elements of process-writing pedagogy:

Interviewer: Hege talked a lot about writing to learn and writing as a thinking tool. What does this mean to you?
Girl 2: You get a topic, and then you write for two minutes. You just write down everything you know.
Interviewer: Why is this relevant strategy?
Girl 2: You start the process, you start thinking about the topic, and you pick up old information that you might not have thought about for a while.
Boy 2: It helps me afterwards when we use the writing notes when we do the "talk with your neighbors" or "group talk" exercise
Girl 1: Yes, the writing goes along with the talk and the mind maps.
Boy 2: We do mind mapping on the board together, all of us. Then it is evident what we all understand the topic and it helps a lot more than just reading or thinking individually.

Both the observation and the student accounts confirm that the way Hege uses writing in teaching mathematics provides opportunities for learning multiple literacies (Macken-Horarik et al 2006). Hege repeatedly emphasized writing pedagogy, with its stress on drafting, planning, and revising texts. This didactic approach involves writing in non-traditional ways—especially in difficult pure-knowledge disciplines such as mathematics. In line with Lillis (2003) suggestions Hege offers a range of possibilities in the pedagogy of writing to open up the syllabus content for the students where her feedback pattern contributes to scaffolding the students' processes of learning. She points to what the students struggle with, and she helps them to reason and articulate what they think about the problems that she introduces both orally and in written texts. To borrow from Gillespie et al. (2014), we may argue that Hege uses writing: 1) to

promote explicitness, 2) to make connections between ideas through mind mapping and talking in pairs, 3) to support thinking in knowledge production, 4) to engage students in personal involvement, and 5) to combine with oral activities to put ideas into words and thus to help learners think about what the ideas mean. Moreover, she actively and supportively invites students to take an active part in her teaching, models how to "feed forward," and, as we see below, opens up the discipline in different ways. Hege uses writing to scaffold the students' struggle with their conceptual understanding of mathematics in which the writing pedagogy she offers shows rich potential to enhance the students' learning. When using feedback as "feed-forward," Hege is highly involved, responding to her students' texts in both written and oral form. Relations between students are activated through these different aspects of feedback and collaboration, and the teaching design strongly emphasizes collective exploration of the tools involved. However, it is up to the students as individuals to use and make sense of the collaboration and to transform these tools into their own learning (Wittek, Solbrekke & Helstad 2017).

Moving between academic and everyday literacy

When Hege introduces new scientific concepts, she moves between academic literacy and everyday literacy to communicate the meaning of terms to the students (Macken-Horarik et al. 2006, p. 245). She even uses meta-language to explain what she does when she says: "So far, we have used the concepts both in an everyday and mathematical way. […] now I introduce a new term, *permutation* […] Let's have a round of exemplifications of the term […]." After a mini-lecture where Hege has explained the terminology she has introduced using examples, she comments on what she has done and why in this way: "Now I have introduced a term that is important for you to understand. I have tried to translate what it means into everyday language." Hege demonstrates how this translation might be done: introduce an academic term, translate it into everyday language, and return to the academic term. Further, the students negotiate the meaning of the concept by using it themselves for concrete reasons. Hege asks: "What is the meaning of this concept? Talk to your neighbor!" By doing this, Hege shows the students how to make use of linguistic tools in learning mathematics. By saying: "You may have noticed how I did it; this is one way to do it when you become teachers," she is modeling how they may work in the same manner in their future careers. In the interview with the students immediately after the session, our impression of this modeling was confirmed when student said: "I think it's important with the conversations about the use of scientific concepts we have in class […] then we get used to it, and then we will take it with us and use it because we have experienced the positive effect of these kinds of conversations about language […]." In particular, writing and talking about core concepts are seen as constructive strategies to help students learn. Shifting between academic and everyday concepts also contributes to opening up the disciplinary content (Lillis, 2003) and connects literacies and the students' future professional roles. As one of the students explained, Hege uses authentic and practical problems rather than the fictive examples that many of the students recall from previous teaching of mathematics: "I remember from school, quite typically, the teacher just came in, put some semi-realistic examples on the blackboard like, for

example, *Peter bought forty watermelons* […] who buys forty watermelons?" The student continued: "I do not want to become such a teacher. I would rather demonstrate how mathematics is useful in real life, like Hege does!" Hege combines lecturing with dialogue; she introduces core scientific concepts through mini-lectures lasting five to seven minutes, and then, through a variety of oral and written activities, she includes students' voices in a common endeavor to solve problems. Drawing on the examples provided above, we get an impression of a teacher educator who knows the content and didactics of mathematics as well as the core concepts of different discourses.

Role modeling in practice

The teacher educator we observed introduced mathematical theory and integrated reading, writing, and oral activities by introducing core concepts before facilitating short conversation sequences in groups. Then, she arranged for plenary reasoning, encouraging students to engage in the conversations. In these sequences, the teacher walked around in the classroom and actively challenged students to reformulate what they were talking about so that the whole class could take part in the conversation (Dysthe 1995). Hege's approaches responded to students' reasoning by acknowledging their answers, elaborating on their accounts, and connecting them to theory. In doing so, she was modeling how to do act as a teacher in practice while at the same time developing a more dialogical and polyphonic classroom (Bakhtin 1986). For instance, she encouraged her students to look for connections—not only between theory and practice but also between the disciplines. As Hege argues, "It is often useful to use elements from pedagogy in order to learn the discipline of mathematics." Hege is aware of the influence she may have on student teachers, and she deliberately draws on her own experience as a school teacher when modeling and demonstrating in practice what she believes in. As such Hege applies a rich repertoire of didactics that is not only strongly content-oriented but also provides opportunities for several ways of reasoning: "This is *one* way to do it—not the only way; there are several routes to the solution." In interviews with the students, they confirm the importance of how Hege facilitates her teaching approaches: "She shows us how it can be done," a student says. Another elaborates: "She tells us how to organize the teaching. But more important is the fact that she shows us how we can do the same by using the methods she talks about from her own teaching." In this way Hege is modeling her teaching practice while also widening the scope of her own discipline and reflecting on what counts as appropriate knowledge for her student teachers as they travel on their journey to becoming teachers. Hege repeatedly asked exploratory questions with regard to mathematical knowledge while, at the same time, bridging the subject concepts with authentic problems. In this way, she helped students see the relevance of academic literacy in mathematics by interconnecting the different concepts in ways that make sense to the students. Through offering a rich repertoire of approaches, Hege gives her students a variety of tools to cope with teaching mathematics when they start their professional work. By modeling how to teach, Hege illustrates the methods involved and the relevance of the subject: "I cannot just tell my students how to do it—I must show it to them as well."

Hege demonstrates what we may define as an integrative and relational approach laying the groundwork for learning multiple aspects of academic literacy (OECD 2015).

We see that Hege's teaching design challenges traditional norms and conventions in teaching mathematics (Lillis 2003). To use Hege's own words: "One must move beyond merely training mathematic skills and instead encourage the students' capabilities to reason and articulate […] I do think students learn more when I ask questions and explore the problems together with them before offering the answers". Hege highlighted the importance of helping students transform their knowledge into how to act in the future as teachers. In her teaching approaches, she assumed that students wrote and talked as future professional teachers. While such expectations may be challenging for students, our findings suggest that students find inspiration and motivation in teachers' articulated expectations; they gradually unpack these expectations and learn from explorative activities as long as there is strong support from teachers and peers. In her design for teaching, Hege invests in building trust and a foundation for dialogue by meeting her students where they are and listen to them with respect. The students are stimulated to design their own learning by making use of multiple tools such as discussion, problem-solving and writing.

To summarize we found that this teacher educator scripted a teaching design in which she is modeling how to explore the discipline of mathematics, how to provide and get feedback, yet also opening up the discipline to external interests by demonstrating how to teach mathematics in schools (Lillis 2003). Hege opens up writing conventions by continuously combining writing, reading, and oral activities in her teaching, which is highly appreciated by her students. Although the students find this teaching design both demanding and challenging, they point to how it encourages them to learn the discipline of mathematics and to teach the school subject. Evidently, we have witnessed a teaching design that may be characterized as aimed at learning academic literacy and one that the students experience as significant to their learning (Vestøl 2016). Being mindful of the narrow scope and even though we might have missed information that could have painted other aspects of the picture, from our observation of Hege in her classroom and from the impressions gained in interviews with the students, we may conclude that Hege teaches what she preaches.

In the final section we summarize some core characteristics of the teaching design, yet also indicate some challenges and implications for such approaches to teaching academic literacy more broadly.

Challenges and implications for varied approaches of teaching academic literacy

What has been evident throughout the investigation of Hege's teaching design is how she, as a teacher educator, not only provides her students with strong tools to help them learn mathematics but also help them see how these tools may be used in their future teaching. By applying a rich variety of approaches Hege is facilitating the development of multiple literacies when learning the discipline. Always starting teaching from a practical task, Hege arranges for problem solving while elaborating how practical issues may be understood theoretically. She supports student learning by modeling possible ways to go about transforming academic language into everyday discourse and vice versa while also meta-reflecting on what she actually does by modeling how to teach and develop different strategies to learn the students how to control academic literacy.

In doing so she demonstrates a teaching design comprising several of the premises that researchers have proven to be crucial to learning academic literacy (e.g., Lea & Street 1998; Lillis 2003; Macken-Horarik et al. 2006; Tuck 2012). Hege helps the students move from their individual preconceptions toward a more elaborated understanding by using classroom dialogue to negotiate students' understandings. By this she demonstrates the argument stated by Macken-Horarik et al. (2006): "We cannot bring expert knowledge to bear on issues of practice unless we have been able to understand the key concepts we are applying to practice." (p. 255).

The teaching design is highly relational, student centered and process oriented – features needed for creating a polyphonic and dialogical learning community (Bakhtin 1986; Dysthe 1995). This is evident in various ways: in the way the teacher educator builds relations by using students' names and by acknowledging their voices when responding to their accounts in a respectful yet challenging manner; in the way she connects students' reflections and accounts by rephrasing what they say; in how she helps the students to unpack what the academic concepts may mean by moving between academic and everyday literacy; in how she asks them to articulate their own understandings; in how she helps them create images of their future professional practice; in how she arranges for discussions; and in the way she makes her high expectations known. Collectively, these approaches applied support both cognitive and social skills that are essential dimensions for learning academic literacy (Blikstad-Balas 2015).

The teaching design we have explored in this study draws on the teacher educator's rich experience as a previous school teacher, and what she has gained through collaboration with colleagues. However, from what Hege told us in interviews, we remain with an image of a teacher educator who to a large extent work individually and with long working hours. Hege revealed that she had experienced periods of burnout and that she often felt the need to develop more "efficient" strategies of teaching. She argues that she feels a lack of support from the institutional leadership and also a lack of collective will to develop teaching designs beyond the individual level. As research indicates, teacher-led innovations tend to be small-scale and sometimes short-lived (Tuck 2012). Accordingly, working innovatively is a complex effort that should not be left to the teachers alone. We may ask how sustainable a teaching design contingent on a high degree of investment from individual teachers may be in the long run. There are signals that the teaching design may run the risk of remaining just a local enterprise. On the basis of these indications we will argue that in order to make teaching designs like the one demonstrated in this study more sustainable, there is a need to identify and support those teachers who are able to integrate subject expertise with relational expertise in and across knowledge domains, and to stimulate teachers who are prepared to integrate varied and rich approaches to teaching academic literacy in their teaching. One way to support teacher educators in their designing of teaching is to encourage teachers to see that academic literacy lies at the core of learning in every discipline. This implies collaboration in which teachers, students and institutional leaders engage collectively in a mutual practice. While acknowledging that there is no easy recipe to follow, we argue that this study is an example to learn from if the goal is to develop more holistic and integrated education – in which academic literacy comprises the multiple dimensions of

cognitive and social skills. If student teachers experience a rich variety of approaches to teaching academic literacy, they may themselves become teachers that know how to encourage young students' learning of multiple literacies and to provide them with the tools for success in their personal and professional lives.

Note

1. In this paper we apply the concept of "didactics" (stemming from a Central and North European tradition) to refer to what frames our interpretations and understanding of teaching and learning, including the distinctiveness of the didactics of different school subjects (Mølstad & Karseth 2016). The concept of didactics includes planning, enacting, and thinking about teaching, all significant issues in teaching designs (Vestøl 2016).

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