How a SPOC might facilitate in-service teachers' interactions in professional development

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Abstract

Online professional development programs for teachers are much discussed. Teachers are obliged to continuously renew their skills in teaching methodology to keep pace with changing demands in society. Providing flexibility in time and space and opportunities for interaction, online courses are expected to facilitate teachers' professional development in general. Informed by a single-case study design,we explore in-service teachers' perceptions of a professional development program organized as a small private online course (SPOC), the Massive Open Online Course (MOOC) in Mathematics Education. We compared teachers who joined the course individually from their schools with teachers collectively participating from their own schools. We conclude that the teachers who participated as a group from distinct schools appear to be more actively involved in offline activities that enhance professional development than their individually participating counterparts. Finally, we provide some implications for further research.

Introduction

Teacher professional development and continuing education is high on the policy (e.g., Schleicher, 2016) and scholarly agenda (Avalos, 2011; Ji & Cao, 2016; Musset, 2010). As educators of the next generation of students, teachers at all educational levels need to keep pace with changing requirements in society, and thus need to continuously renew their knowledge and skills in teaching practices.

Over the last decade many countries have implemented extensive education reforms, including a reform of continuing education of in-service teachers (e.g., Musset, 2010).In Norway in 2011, the government established the strategy *Competencies for Quality* to enhance professional development of teachers and head teachers (Norwegian Ministry of Education, 2011).

Limited research exists on in-service teachers' continuing education and professional development by means of Massive Open Online Courses (MOOCs) at the micro-level (e.g., Kalman, 2014). To our knowledge, only a few studies have explored how MOOCs might

facilitate social interactions among teachers as participants of MOOCs to improve professional learning. Taking a social network perspective, Kellogg, Booth, and Oliver (2014) explore the characteristics, mechanisms and outcomes of peer networks of teachers in compulsory educational settings. Given limitations in scope and methodology (case study) the authors conclude that MOOCs might be improved to foster professional networks and improve peer-supported learning. Another study, a pilot study from Australia, investigates a MOOC for primary school teachers in computer science, addressing teachers' needs by providing more flexibility, spontaneous interactions, support, and sharing of online resources. Findings indicate that participating teachers generally appreciate the opportunity to interact with other participating colleagues (Vivian, Falkner, & Falkner, 2014).

A systematic review of the empirical MOOC literature published between 2014 and 2016 concludes that only a small number of studies apply qualitative methods, such as focus groups and MOOC session observations (Zhu, Sari, & Lee, 2018).

To address this knowledge gap, the purpose of this article is to explore how a MOOC course in Mathematics Education addressing Norwegian teachers at primary school level might facilitate social interactions among two groups of in-service teachers, and thus might enhance teacher professional development. The online course under study, the MOOC in Mathematics Education, may be characterized as what researchers define as small private online course (SPOC) (e.g., Hayes, 2015). This course addresses professional education of mathematics teachers in Norway and is limited in number to 300 teachers. When referring to this course, we therefore use the term SPOC, or the original label *MOOC in Mathematics Education*, while we use the more overarching term MOOC more generally.

MOOCs as professional development program

MOOCs are a relatively new phenomenon in higher education in terms of professional development programs for teachers (see for reviews: Liyanagunawardena, Adams, & Williams, 2013; Veletsianos & Shepherdson, 2016) (Langset, Jacobsen, & Haugsbakken, 2018). In general, they differ from traditional higher education courses as they are massive, openly accessible and online. Several scholars have highlighted difficulties in providing a clear definition (Bates, Phalen, & Moran, 2016). According to Jansen and Schuwer (2015) a MOOC can be defined as an online course targeting a large number of participants; it can be reached by anyone, anywhere, as long as they are connected to the internet. MOOCs are open to everyone without any entry qualification and offer a complete course experience in an online mode at no cost.Compared with traditional higher education courses, however, MOOCs have some clear challenges for participants. These are, for example, low completion and high dropout rates, and reduced incentives for interaction between participants and for self-determined learning (e.g., Jacobsen, 2019; Dalsgaard & Gislev, 2019; Kreijns, Kirschner, & Jochems, 2003; Macià & García, 2016).

MOOCs include various technologies and ways of organization. Research has demonstrated that countries around the world adjust and interpret MOOCs to fit their educational systems, technological infrastructure, and their cultural and economic system (Tømte, Fevolden, & Aanstad, 2017).

Moreover, there are various pedagogical concepts of MOOCs, and research has identified some of these to be small private online courses (SPOCs) (e.g., Hayes, 2015) or blended learning MOOCs (bMOOCs) (Langset et al., 2018). To a greater degree than that of MOOCs, this concept emphasizes individual characteristics of participants (e.g. teachers) with the aim of combining the advantages of face-to-face learning with the advantages of e-learning by addressing a restricted group of participants (e.g., Langset et al., 2018).

There is support for the idea that collective participation in professional development appears to increase efficacy in teaching, and thus might improve student achievement (e.g., Cordingley et al., 2015; Schleicher, 2016). Boyle, Lamprianou, and Boyle (2005) found that teachers participating in different professional development activities, among them study groups over a longer period, reported changes in their teaching practice. While there is a great need to improve professional development by programs facilitating school-based professional development, schools in many countries suffer from a shortage of qualified teachers, which might prevent school leaders from releasing teachers for professional development (Fuller, Pendola, & Young, 2018).

To strengthen teacher professional competence through professional development programs without the expense of release, and to facilitate teacher learning over time, MOOCs provide promising potential. They are openly accessible, online, and provide flexibility in time and space, in contrast to traditional campus-based professional development courses. Drawing on research-based principles and addressing teachers in primary and secondary education, the *MOOC for Educators*, an approach to professional development, has incorporated four major design principles for educators' professional learning, i.e., self-directed learning, peer-support learning, work-related learning and multiple voices (Kleiman, Wolf, & Frye, 2014). For teacher training in general, Zhou, Guo, and Zhou (2015) stress the advantages of MOOCs to advance collaborative learning, social interaction among teacher colleagues, and feedback. However, research on the importance of MOOCs to improve teacher training in general, and teacher professional development programs more specifically, is rather limited.

Teachers as participants in MOOC and online learning

Some studies have looked at the potential of MOOCs for teacher education in general (Levy & Schrire, 2015; Vivian et al., 2014; Zhou et al., 2015) and teachers in professional development programs in particular (e.g., Langset et al., Tømte, 2019). It was found that university teachers make up a relatively large group among participants in MOOCs, compared with other professional groups. At the same time, teachers, more than other professionals, seem to be actively engaged in discussion groups (Saadatdoost, Sim, Jafarkarimi, & Mei Hee, 2015; Seaton, Coleman, Daries, & Chuang, 2015). To improve MOOCs, Seaton et al. (2015) provide a couple of recommendations to give opportunities for interaction, strengthen teachers' networks, and use teachers' professional experience. At the same time, research on teachers as participants in MOOCs and SPOCs is mainly descriptive and based on quantitative research methods with a lack of in-depth studies of social interactions between participating teachers (e.g., Zhu et al., 2018). The strong focus on teacher professional development in Norway (e.g., Postholm & Wæge, 2016) might have inspired the development of MOOC-like courses that address teachers. In their study, Langset et al. (2018) followed a group of pre- and in-service teacher educators at the Norwegian University of Science and Technology (NTNU) in a vocational teacher-training program over a period of two years (2014–2016). The teacher educators had created a blended learning MOOC (bMOOC) on digital learning and offered it to different teacher-training faculties as a resource for enhancing their digital professional competencies.

The literature on online learning highlights the importance of social interactions between online study group members to facilitate learning (Bates et al., 2016; Trust, Carpenter, & Krutka, 2017). Consequently, interactions between members of an online *professional learning network* (Trust et al., 2017), such as teachers participating in a MOOC, might facilitate learning and knowledge creation for these teachers to improve their professional development.

However, research on group learning has found that *asynchronous distributed learning groups* (Kreijns, Kirschner, & Jochems, 2003, p. 335) within computer-supported learning environments often lack frequent interactions, which are needed to establish dialogs enabling deep learning and knowledge creation. In their literature review, Kreijns et al. (2003) identified two major traps for social interaction: first, taking it for granted that social interactions automatically occur just because it was made technologically possible, and second, a tendency to limit these to educational interventions targeting cognitive processes, while social (psychological) interventions addressing socio-emotional processes are neglected. Even though the authors argue that these traps are not exclusively related to online collaborative learning contexts, the nature of online contexts make these more likely compared with face-to-face (offline) situations. Contexts such as MOOCs might exclude non-formal social interactions. They might be mainly used for task execution, as group members often lack a collegial history, being unacquainted with each other – aspects that are less common in face-to-face contexts. At the same time, this literature review might no longer be up to date in terms of technologies it refers to, which we should keep in mind when interpreting the results.

Face-to-face interactions have been shown to be an important supplement to online interactions. Reviewing the literature on informal online communities and networks, Macià and García (2016, p. 303) show that many teachers tend to take 'a passive role, taking benefit from the conversations held by others […] rarely expressing their own opinion'. They conclude that face-to-face interactions seem to reinforce participation in online groups; thus, interactions in online environments seem to be weaker than those in face-to-face or blended environments. Also,McConnell, Parker, Eberhardt, Koehler, and Lundeberg (2013) found that teachers seem to prefer face-to-face professional learning communities, even though they could show effective combinations between online and face-to-face activities or interactions.

With respect to school-based learning, other scholars show examples of online communities related to teachers from the same school, who form a group of learners with regular group meetings and face-to-face situations (Kling & Courtright, 2003). Furthermore, it has been shown that discussions in online groups, where group members share common interests, in turn might facilitate face-to-face contacts offline (Zhao, 2006). For social interactions among teachers in general, (Duncan-Howell, 2010) found that teachers easily make contact with their peers in contexts other than their own school.

Research questions

Our study is framed by a socio-cultural theoretical perspective of learning (Vygotsky, 1980) with an understanding of learning as a human activity in a social context, in interaction with the environment (e.g., Säljö, 2001), including peer-learners, i.e., an understanding of teacher learning as a collective phenomenon (e.g., Postholm & Wæge, 2016). From that perspective, learning can be understood as a participation in communities of practice (e.g., Lave & Wenger, 1991). Here, the concept of communities of practices emphasizes, among other things, having the opportunity for teachers to develop their professional knowledge through cooperation with other peer-learners (e.g., Postholm & Rokkones, 2012). This can be teachers from the same school, who might collectively participate in a professional development program, or teachers from different schools, who might individually participate. Vangrieken et al. (2015) show several positive outcomes related to cooperation between teachers with regards to professional development at different levels, for example individual teachers and the school as an organization. The significance of the school as a workplace for sharing and building knowledge was previously stressed by Dewey (1970),

who maintained that 'the success of excellence teachers tends to be born and die with professional communities' (cited in Rismark & Sølvberg 2011, p. 151).

Drawing on this perspective, we ask the following research questions:

1. How might a SPOC facilitate interactions for individually participating teachers?
2. How might a SPOC facilitate interactions for collectively participating teachers, i.e., teachers from the same school?

Methodological approach

This article draws on data from a formative evaluation study of the professional development program, the MOOC in Mathematics Education, addressing teachers in Norwegian primary schools (mainly grade 5–7) for the duration of one year, from September 2015 to August 2016. Formative evaluation means that researchers are in a constant dialog during the evaluation period with the commissioner of the study (e.g., Baklien, 2000). Here, the researcher's role can be characterized as being a kind of intermediate between a neutral observer of what is happening, and that of a change agent who actively takes part in the intervention. (Olsen, Mikkelsen & Lindøe, 2002). In this study, researchers were affiliated to a research institute and commissioned by a governmental body to evaluate the program.

The MOOC in Mathematics Education led to 30 credit points, which corresponds to one semester of further education studies at BA level.I t covered six different units and different topics with limited duration. Each unit consisted of three to four modules. The course was provided completely online, without any organized in-person meetings.

Video meetings were organized in a digital colloquy room for each group by means of an online platform. They were scheduled on a weekly basis, being a mandatory part of the learning modules. Tasks to be discussed were announced beforehand; for each session, one of the students was appointed to lead the discussion. Once a month, some of the SPOC lecturers participated, acting at the same time as a group facilitator. To facilitate interaction and discussions during the meetings, participating teachers were asked to discuss specific tasks from the learning modules. Contrary to non-mandatory discussion contexts, video meetings invited teachers to discuss in real time. As interactions imply sound and are visual, they might contribute to mutual trust and to the establishment of a professional learning community over time. Video meetings addressed pre-defined groups of SPOC students, with approximately eight to ten participants.

The overall formative evaluation study addressed two different levels – the user level (mainly teachers and school leaders), and the governance level (mainly funding models and the cooperation of the two higher education institutions involved with project leader Tømte (2019)). Data sources included qualitative and quantitative data at both levels. The study was approved by the Norwegian Social Science Data Service (NSD).

In this article we focus on the user perspective, which means the perspective of participating in-service teachers or SPOC students. The analyses draw on teacher interview data, observational data of participating teachers, and data from a teacher survey.

To address the research questions, a single case study, combining qualitative and quantitative data, informs the empirical work in this article. In general, the case study method is defined as an empirical inquiry that investigates a contemporary phenomenon in depth by combining different sources, usually qualitative and quantitative data, collected within its real context, in particular when the boundaries between phenomenon and context are not clear (e.g., Yin, 2009).

For recruitment, informants were strategically sampled according to the following criteria: schools where SPOC students were located; SPOC study group; participating either individually or collectively.

Table 1 Data sources

	Data sources	N	Addressing …
Qualitative	1) Telephone interview with individual teachers	9	perceived participation
	2) Face-to-face-interview at 2 schools, with a subsample of teachers earlier interviewed	5	perceived participation over time; perceived interactions
	3) Data collected by participatory observation of video study group meetings	3	observed activities and interactions; participant engagement
Quantitative	Survey of teacher participants; (N=265 invited; 65 % completion rate)	171	participation together with colleagues or not; online/offline collaboration; perceived importance of collective participation etc.

Qualitative data included three different sources: 1) Telephone interview data with nine participating teachers; among these teachers, seven participated with colleagues from the same school while the remaining two were single participants from their school; 2) Data collected through face-to-face interviews with a subsample of five teachers (who had been interviewed at an earlier stage by telephone). The five teachers were interviewed at two points in time to enhance continuity and a broader perspective over time and to strengthen the methodological approach, informed by a case study design. Face-to-face interview data were collected at two primary schools in the Eastern part of Norway: School 1 in a municipality near Oslo, and School 2 in a more rural municipality. During the interviews, conducted by two researchers, one of the researchers took extensive notes, which were later reviewed and verified by the second researcher. Each interview lasted between 30 and 45 minutes; 3) Data collected during participatory observation of three study group video meetings with an approximate duration of one hour. For this data collection we used a coding scheme covering dimensions such as time sequences, activities, and students' engagement as participants. The number of participants in the three groups was between six and eleven. The group with six participants included a group of teachers from the same school, while the other two groups consisted of teachers from different schools.

The quantitative data consist of survey data from teachers participating in the course. All 265 registered participants (SPOC students) were invited to answer the electronic questionnaire via e-mail, which 171 teachers (65%) completed. The survey consisted of closed and open response questions. SPOC students were asked, for example, if they participated together with colleagues from the same school and whether they collaborate online or offline, together with colleagues from the same school or from other schools. They were asked about a wide range of themes, including the perceived importance of collective participation. Response categories consisted of either a four-point or a five-point Likert scale.

Analysis: Data from semi-structured interviews and open responses from the survey were analyzed by an approach drawing on qualitative content analysis (Krippendorf, 2004). Interview notes were gathered in one document and read several times by the first author, applying different reading techniques, such as wide and narrow reading. During the wide reading process, and with respect to the aim of this paper, the respondents' answers were openly coded, according to the overarching topics, professional learning communities, collaboration and interaction. During the close reading process, subcategories were derived,

describing different types of collaboration and interaction, such as formal interactions and non-formal interactions, and online and face-to-face interactions. The results of this process were validated by the second author. The results from the analyses of interview data and participatory observation protocols were combined with descriptive statistics of the teacher survey data. Descriptive data include frequencies and mean values of single items. Findings from the literature review were applied in the validation process to reduce positive bias, which might be a problem related to some of the survey questions.

Findings

In the findings section, according to the research questions, we distinguish between individually participating teachers and collectively participating teachers, i.e., two different groups of SPOC students. To reduce repetition in terminology, we use the terms SPOC student and teacher interchangeably when we present and discuss the results of our study.

Individually participating teachers

Among all teachers participating in the survey (N=171), 98 teachers (58%) reported individual participation in the SPOC. However, among those, 54 teachers reported collaborating with participating peers in settings other than in the mandatory video meetings when asked, *Beyond the mandatory video meetings, do you interact with other participating teachers?* Among these 54 teachers, the majority of 44 reported collaborating online, while only six teachers reported face-to-face (offline) collaboration; the remaining four teachers reported cooperating online and face-to-face with participating teachers from a school other than their own affiliation. Thus, this finding indicates that more than half of the individually participating teachers (54 teachers) interact with peer teachers in contexts other than mandatory video meetings.

Face-to-face (offline) interactions between peers are perceived as highly important for professional development.
Furthermore, teachers were asked whether the course has laid foundations for collaboration among SPOC students. A lower share of individually participating teachers (highly) agreed to this statement compared to their collectively participating counterparts (37% vs. 47%). Answer categories were provided by a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

In our survey data and interviews, we find similar findings thatface-to-face (offline) interactions between teacher colleagues are perceived as highly important for professional development. The following quotation from an individually participating teacher illustrates the perceived importance of non-formal, regular, face-to-face interactions with a befriended teacher and SPOC student from a different school for her own professional development: 'We chat and write SMSs and work together. I and the other one work together nearly every weekend. And we met at my apartment last time when participating in the video meeting. (…) We use each other as discussion partners' (Teacher 3 C).

This teacher refers to regular face-to-face meetings and online interactions for learning purposes related to the course. Being asked how the SPOC works for her, given no face-to-face meetings, this teacher appreciated flexible provision in terms of time and space, but at the same time stressed the importance of existing discussion partners from her own teacher colleague network. The importance of face-to-face interactions with peers from a pre-existing professional learning community is underlined by the literature on blended learning

(e.g., Gynther, 2016). Face-to-face interactions have been shown to be an important supplement to online interactions (e.g., Macià & García, 2016, p. 303). McConnell et al. (2013) show that as students, teachers seem to prefer face-to-face professional learning communities, even though effective combinations between online and face-to-face activities exist. The following quote illustrates the importance of a longer pre-existing professional learning community for this SPOC student and her own professional development: 'We have worked together for some years and know each other well, so we keep in touch.' (Teacher 3). The same teacher refers to a co-existing school-based professional learning community, related to the school's strategy for mathematics. She states that participation in the SPOC makes her discuss and reflect on its content at her school, and that this attracts attention from her non-participating colleagues. For this teacher, the opportunity to participate in the course is of specific value as the overall school's strategy has a focus on mathematics.

Individually participating teachers appear to have a modestly larger gain from the non-formal part of the SPOC study group meeting

In general, individually participating teachers might have few opportunities for interactions with participating peers in settings other than the SPOC study group. We can therefore expect that these teachers might gain more benefit from interactions related to the SPOC study group compared with their collectively participating counterparts.

Analyses of the survey data indicate that individually participating teachers have a modestly larger gain from the non-formal part of the SPOC study group meeting than their collectively participating counterparts. Among individually participating teachers, 72 percent (strongly) agree with the statement *I get most out of the informal communication at the end of the study group meeting*, compared with their collectively participating counterparts, where 60 percent (strongly) agree. With respect to formal interactions during the study group meetings, a higher share of individual participants (strongly) agree with the statement *It's useful to hear all the other participants talk about their thoughts concerning the main subject* (77%) compared with their collectively participating counterparts (60%). Unsurprisingly, a higher percentage of individually participating teachers (strongly) agree with the statement *It is useful to get acquainted with other participants,* i.e., 76 percent vs. 58 percent. The tendency for individually participating teachers from one school to appreciate online interactions with other participating SPOC students can also be illustrated by the following quotation: 'It is always an inspiration to discuss with people if you are studying alone.' (Teacher 4). For this individually participating teacher, formal video meetings with her SPOC study group, allowing for oral synchronic interactions, seem to be valuable for her own learning, further illustrated by the following quotation:

> [Video meetings are] very useful, they work quite nicely, and it is exciting to listen to the others. […]. One can listen to what people think and what they do, and it is an inspiration to discuss and exchange opinions. […] We have established a routine, starting the meeting with a formulation of its objective and a brief presentation of each participant's own experiences, followed by a discussion (Teacher 4.).

At the same time, however, this teacher mentioned that she had missed a couple of group meetings scheduled at times when she could not participate. During the interview, she rather downplays the earlier expressed importance of the formal video meetings: 'I do not think that I have missed a lot. I think it works out anyhow.'

In sum, for individually participating teachers, the findings indicate that teachers' professional development in the context of a SPOC is further facilitated by pre-established professional learning groups and non-formal interactions in an online context.

Collectively participating teachers

Among the SPOC students surveyed, 72 teachers (42%) reported participating collectively, i.e., participation with colleagues from the same school. Among the 72 collectively participating teachers, the majority of 48 teachers reported face-to-face collaboration or interactions with teacher colleagues at the same school; 42 teachers stated that it was (highly) important that several teachers from their school participated in the course. At the same time, 35 collectively participating teachers reported not collaborating online, apart from collaboration related to the SPOC study group meetings.

Face-to-face (offline) interactions between peers are still perceived as important for professional development.

Our literature review has revealed that teachers seem to prefer face-to-face interactions for professional development (e.g., McConnell et al., 2013, Kling & Courtright, 2003).

Such interactions might comprise interactions with colleagues and SPOC students from the same school, or those from outside the school. The tendency for teachers to prefer face-to-face interactions for professional learning is supported by both quantitative and qualitative data in our study. Asked in the survey if they collaborate face-to-face with other participating teachers, a majority of 58 (81%) collectively participating teachers reported doing this; 48 reported collaborating face-to-face with colleagues from the same school, while an additional 10 teachers reported collaborating face-to-face with both peers from the same school and peers from other schools. The following quotation illustrates the relative importance of face-to-face interactions among participating colleagues from the same school for professional development: 'It is rather an advantage to be several colleagues participating and who know each other; we can establish our own study group and collaborate. Two of us work at the same grade level, making it easier to collaborate. I am a little bit sorry for those who are alone [the only participant from their school].' (School 2, teacher interview)

Here, this participating teacher stresses the importance of their own professional learning community, implicitly referring to scheduled meetings in their own established study group and informal discussions more generally: 'We are four colleagues from our school, so it is much more natural to communicate face-to-face than to use the online group. It appears to be a little selfish, but for us, this works much better.' (Teacher 9). During the interview, the positive experiences of face-to-face interactions are contrasted with the online study group meetings, which they found have little relevance. Another collectively participating teacher appears to be more satisfied with her study group, even though she expresses a rather critical attitude towards the video meeting. At the same time, however, she refers to non-formal interactions because of the course: 'We have exchanged contact details, we can ask each other, informally. … The online meetings are awkward'. (Teacher 2). It appears that online interactions within a non-formal context are perceived by this teacher as more natural than interactions in formal video meetings.

Face-to-face (offline) interactions between peers who know each other from other settings are perceived as more convenient for professional development

We have found a tendency in the literature review for face-to-face interactions among teacher colleagues, who know each other from other settings, to be perceived as more convenient for professional development compared with online interactions among anonymous course members with no collegial history (e.g., Kling & Courtright, 2003), and that smaller group size might facilitate interactions among group members(e.g., Kreijns, Kirschner, & Jochems, 2003). Comparing three SPOC study group video meetings by participa-

tory observation, we found further support for this trend. In the group of six participating teachers, we observed formal and non-formal interactions developing in a more natural way than in two groups with nine and eleven participating teachers. Group size appears to be an impairing factor on fluent interactions. This was mentioned by several SPOC students during the interviews. At the same time, in the groups of six participants, there were several teachers from the same school. Thus, the combination of small group size and collective participation in the video meeting might have facilitated formal and non-formal interactions among SPOC students.

In sum, regarding collectively participating teachers, our findings indicate that the SPOC course enhances face-to-face interactions (formal and non-formal) in pre-established professional learning communities among teachers at the school level and other settings, such as the municipality level.

Concluding remarks

Our aim was to explore in-service teachers' perceptions of a professional development program organized as a small private online course (SPOC), the Massive Open Online Course (MOOC) in Mathematics Education. We explored how this SPOC might facilitate interactions for both individually participating teachers and collectively participating teachers. In sum, for individually participating teachers our findings show that the SPOC to some degree seems to facilitate interactions (formal and non-formal) with other (individually) participating peers across schools. However, our literature review has shown that small group size and room for non-formal interactions in online contexts are crucial to facilitate interactions among participants in MOOCs (e.g., Kreijns, Kirschner, & Jochems, 2003), in particular for those who lack a collegial history. Thus, in line with previous research, our findings indicate that previously established professional learning communities and face-to-face interactions with acquainted peer teacher-students matter, also for individually participating teachers.

For collectively participating teachers, our findings indicate that the SPOC further strengthens pre-existing face-to-face interactions among colleagues and participating teachers from the same school, which means interaction within pre-existing professional learning communities. The course appears to facilitate formal and non-formal online interactions more easily among collectively participating teachers compared with their individually participating counterparts. Thus, drawing on the core findings of our study and the literature review, we conclude that collectively participating teachers might have a greater spectrum of possibilities to interact offline and online due to their pre-existing relationships with their colleagues. Thus, online courses such a SPOC enhance their potential for interactions and professional development to a greater degree for those teachers already embedded in existing professional learning communities, that is collectively participating teachers.

A strength of our study is the combination of qualitative and quantitative data, informed by a single case study design, which allows for validation across data sources. However, each study has its limitations, as does ours. First, our study was part of a larger formative evaluation study limited to a period of one year, thus limiting the points of measurement. Second, there is an imbalance of the interview sample for individually and collectively participating teachers. Recruiting teachers for our study, in particularly individually participating teachers, was a challenge. Interview data include nine collectively participating teachers, but only two individually participating teachers among those contacted agreed to participate in the study, even though the latter group make up a larger share in the sample of the

teacher survey. Thus, these teachers might have other experiences that we did not collect in our study.

For collective participation, Buczynski and Hansen (2010) found that the number of teachers from a single school involved in professional development had a clear impact on the professional development for that school site. Thus, a follow-up study might more specifically explore knowledge transfer and interactions at school level and include perceptions of school leaders, collectively participating teachers, and their non-participating counterparts.

Small group size and the opportunity for non-formal online interactions have shown to be factors that enhance interactions among our SPOC study group participants. Thus, taking design corrections into account, a follow-up study might more specifically investigate the impact of these improvements for individually and collectively participating teachers over a longer period. Postholm (2012) argues that teachers' reflections on their own practices during professional development might continue after the end of the course, particularly if several teachers from the same school participate.

Finally, even though our findings are drawn from a single case study on how a SPOC in Mathematics might facilitate interactions among in-service teachers at primary school level in Norway, they might inform further research in an international context. Findings might inform similar studies, in particular in comparable countries with similar reforms in higher education that include online learning and professional development for teachers.

References

Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Teaching and teacher education, 27*(1), 10–20. https://doi.org/10.1016/j.tate.2010.08.007

Baklien, B. (2000). Evalueringsforskning for og om forvaltning [Evaluation research for and about management]. In O. Foss & J. Mønnesland (Eds.), Evaluering av offentlig virksomhet. NIBR plus series 4: 2000 (pp. 53–78). Oslo: NIBR.

Bates, M. S., Phalen, L., & Moran, C. G. (2016). If you build it, will they reflect? Examining teachers' use of an online video-based learning website. *Teaching and teacher education, 58*, 17–27. https://doi.org/10.1016/j.tate.2016.04.004

Boyle, B., Lamprianou, I., & Boyle, T. (2005). A longitudinal study of teacher change: What makes professional development effective? Report of the second year of the study. *School effectiveness and school improvement, 16*(1), 1–27. https://doi.org/10.1080/09243450500114819

Buczynski, S., & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and teacher education, 26*(3), 599–607. https://doi.org/10.1016/j.tate.2009.09.006

Cordingley, P., Higgins, S., Greany, T., Buckler, N., Coles-Jordan, D., Crisp, B., . . . Coe, R. (2015). *Developing great teaching : lessons from the international reviews into effective professional development*. Retrieved from London: http://dro.dur.ac.uk/15834/

Dalsgaard, C., & Gislev, T. (2019). Embracing Dropouts in MOOCs: Exploring Potentials of Invisible Learners. Journal of Interactive Media in Education(1). https://doi.org/10.5334/jime.498

Duncan-Howell, J. (2010). Teachers making connections: Online communities as a source of professional learning. *British journal of educational technology, 41*(2), 324–340. https://doi.org/10.1111/j.1467-8535.2009.00953.x

Fuller, E. J., Pendola, A., & Young, M. D. (2018). The Role of Principals in Reducing Teacher Turnover and the Shortage of Teachers. Policy Brief 2018-2. *Online Submission.*

Hayes, S. (2015). MOOCs and Quality: A Review of the Recent Literature.

Jacobsen, D.Y. Dropping Out or Dropping In? A Connectivist Approach to Understanding Participants' Strategies in an e-Learning MOOC Pilot. Tech Know Learn 24, 1–21 (2019). https://doi.org/10.1007/s10758-017-9298-z

Jansen, D., & Schuwer, R. (2015). *Institutional MOOC strategies in Europe. Status report based on a mapping survey conducted in October – December 2014.* EADTU: Brussels.

Ji, Z., & Cao, Y. (2016). A Prospective Study on the Application of MOOC in Teacher Professional Development in China. *Universal Journal of Educational Research, 4*(9), 2016–2017. https://doi.org/10.13189/ujer.2016.040917

Kalman, Y. M. (2014). A race to the bottom: MOOCs and higher education business models. *Open Learning: The Journal of Open, Distance and e-Learning* 29(1): 5–14. https://doi.org/10.1002/9781119081364.ch5

Kellogg, S., Booth, S., & Oliver, K. (2014). A social network perspective on peer supported learning in MOOCs for educators. *The International Review of Research in Open and Distributed Learning, 15*(5). https://doi.org/10.19173/irrodl.v15i5.1852

Kleiman, G., Wolf, M., & Frye, D. (2014). Educating educators: Designing MOOCs for professional learning. *Massive Open Online Courses: the MOOC Revolution*, 117–144.

Kling, R., & Courtright, C. (2003). Group behavior and learning in electronic forums: A sociotechnical approach. *The Information Society, 19*(3), 221–235. https://doi.org/10.1080/01972240309465

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003).Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in human behavior, 19*(3), 335–353. https://doi.org/10.1016/s0747-5632(02)00057-2

Krippendorf, K. (2004). *Content Analysis. An Introduction to its Methodology.* Thousand Oaks: Sage Publications.

Langset, I. D., Jacobsen, D. Y., & Haugsbakken, H. (2018). Digital professional development: towards a collaborative learning approach for taking higher education into the digitalized age. *Nordic Journal of Digital Literacy, 13*(01), 24–39. https://doi.org/10.18261/issn.1891-943x-2018-01-03

Lave, J., & Wenger, E. (1991). Situated learning. Legitimate peripheral participation. Cambridge: Cambridge University Press.

Levy, D., & Schrire, S. (2015). Developing a Massive Open Online Course (MOOC) at a College of Education: Narrative of Disruptive Innovation? *Current Issues in Emerging eLearning, 2*(1), 8. https://scholarworks.umb.edu/ciee/vol2/iss1/8

Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008–2012. *The International Review of Research in Open and Distributed Learning, 14*(3), 202–227. https://doi.org/10.19173/irrodl.v14i3.1455

Macià, M., & García, I. (2016). Informal online communities and networks as a source of teacher professional development: A review. *Teaching and teacher education, 55*, 291–307. https://doi.org/10.1016/j.tate.2016.01.021

McConnell, T. J., Parker, J. M., Eberhardt, J., Koehler, M. J., & Lundeberg, M. A. (2013). Virtual professional learning communities: Teachers' perceptions of virtual versus face-to-face professional development. *Journal of Science Education and Technology, 22*(3), 267–277. https://doi.org/10.1007/s10956-012-9391-y

Musset, P. (2010). Initial teacher education and continuing training policies in a comparative perspective. *OECD Education Working Papers*(48), 0_1. https://doi.org/10.1787/5kmbphh7s47h-en

Norwegian Ministry of Education and Research. (2011). Competencies for Quality. Strategy for Further and Continuing Education 2012–2015. Oslo: Ministry of Education and Research.

Olsen, O. E., Mikkelsen, A., & Lindøe, P. H. (2002). Fallgruver i følgeforskning. [Pitfalls within trailing research trailing]. *Tidsskrift for samfunnsforskning, 43*(2), 191–217.

Postholm, M. B. (2012). Teachers' professional development: a theoretical review. *Educational research, 54*(4), 405–429. https://doi.org/10.1080/00131881.2012.734725

Postholm, M. B., & Wæge, K. (2016). Teachers' learning in school-based development. *Educational research, 58*(1), 24–38. https://doi.org/10.1080/00131881.2015.1117350

Rismark, M., & Solvberg, A. M. (2011). Knowledge sharing in schools: A key to developing professional learning communities. *World Journal of Education*, 1(2), p. 150. https://doi.org/10.5430/wje.v1n2p150

Saadatdoost, R., Sim, A. T. H., Jafarkarimi, H., & Mei Hee, J. (2015). Exploring MOOC from education and Information Systems perspectives: a short literature review. *Educational Review* (ahead-of-print), 1–14. https://doi.org/10.1080/00131911.2015.1058748

Schleicher, A. (2016). *Teaching Excellence through Professional Learning and Policy Reform: Lessons from Around the World, International Summit on the Teaching Profession.* Paris: OECD.

Seaton, D. T., Coleman, C., Daries, J., & Chuang, I. (2015). Enrollment in MITx MOOCs: Are We Educating Educators? https://er.educause.edu/articles/2015/2/enrollment-in-mitx-moocs-are-we-educating-educators

Säljö, R. (2001). *Læring i praksis: et sociokulturelt perspektiv*. Oslo: Cappelen akademisk.

Trust, T., Carpenter, J. P., & Krutka, D. G. (2017). Moving beyond silos: professional learning networks in higher education. *The Internet and Higher Education, 35*, 1–11. https://doi.org/10.1016/j.iheduc.2017.06.001

Tømte, C. E. (2019). MOOCs in teacher education: Institutional and pedagogical change? *European Journal of Teacher Education, 42*(1), 65–81. https://doi.org/10.1080/02619768.2018.1529752

Tømte, C. E., Fevolden, A. M., & Aanstad, S. (2017). Massive, Open, Online, and National? A Study of How National Governments and Institutions Shape the Development of MOOCs. *The International Review of Research in Open and Distributed Learning, 18*(5). https://doi.org/10.19173/irrodl.v18i5.2751

Veletsianos, G., & Shepherdson, P. (2016). A Systematic Analysis and Synthesis of the Empirical MOOC Literature Published in 2013–2015. *The International Review of Research in Open and Distributed Learning, 17*(2). https://doi.org/10.19173/irrodl.v17i2.2448

Vivian, R., Falkner, K., & Falkner, N. (2014). Addressing the challenges of a new digital technologies curriculum: MOOCs as a scalable solution for teacher professional development. *Research in Learning Technology, 22*. https://doi.org/10.3402/rlt.v22.24691

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Cambridge Massachusetts: Harvard university press.

Yin, R. K. (2009). *Case Study Research. Design and Methods*. Los Angeles: Sage.

Zhao, S. (2006). Do Internet users have more social ties? A call for differentiated analyses of Internet use. *Journal of Computer-Mediated Communication, 11*(3), 844–862. https://doi.org/10.1111/j.1083-6101.2006.00038.x

Zhou, Q.-G., Guo, S.-C., & Zhou, R. (2015). Investigation about Participatory Teachers' Training based on MOOC. *International Journal of Distance Education Technologies (IJDET), 13*(3), 44–52. https://doi.org/10.4018/978-1-5225-5631-2.ch071

Zhu, M., Sari, A., & Lee, M. M. (2018). A systematic review of research methods and topics of the empirical MOOC literature (2014–2016). *The Internet and Higher Education, 37*, 31–39. https://doi.org/10.1016/j.iheduc.2018.01.002