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Video-based mind maps in higher education: A design-based research study of pre-service teachers' co-construction of shared knowledge

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ABSTRACT

In this design-based study first-year pre-service teachers co-constructed video-based mind maps as part of a pedagogy course. The students produced self-made group videos and uploaded them to a joint platform before working with peers' group videos in a mind map structure. The course topic was learning sciences research, and the goal was to create a shared understanding about the course content before an upcoming exam. The study has been grounded in a sociocultural perspective on human activity and learning, employing interaction analysis to investigate how digital tools can support students' collaborative reading and understanding of key concepts in academic literature. By scrutinising video recordings of both in-room and on-screen activities, we analyse how five groups of pre-service teachers collaborated during the co-construction of videos, and how they interacted with fellow students' group videos. Findings demonstrate that the students interacted intently with each other's work and constituted the mind map as a point of convergence and resource for meaning making and collaboration within the student class community. The study shows that video-based mind maps can provide material and social structures for collaboration and that fellow students' group videos formed knowledge objects that generated in-depth conversations among peers about the subject matter.

1. Introduction

In the present article, we investigate students' use of group videos for collaboration and meaning-making during academic work. We do this by exploring students' co-construction of *video-based mind maps* for engaging students in critical discussions of academic texts, activities that were part of an ongoing design-based research project (Hoadley, 2004; Krangle & Ludvigsen, 2009).

Engaging students in scholarly dialogue about academic readings is important for their learning in higher education but may be challenging to realize in traditional university settings. The application of technology can play a key role in overcoming some of the social and institutional challenges within university settings that hinder such participation (Damsa et al., 2015). Prior studies have shown that various types of video resources and digital platforms can be valuable tools for promoting dialogue, collaboration and the exchange of ideas among students (Ramos et al., 2021), for example, through student-generated videos (Arruabarrena et al., 2019; Hawley & Allen, 2018), wikis or microblogging tools (Alghasab et al., 2019; Amundrud et al., 2022). However, we find few cases in which such potentially rewarding activities are employed to stimulate dialogues about academic texts. In general, the research on

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students' collaborative work on academic texts is scarce, even though we know students' need to engage in dialogue about their academic readings to create a deeper understanding (Northedge, 2003; Rasmussen & Hagen, 2015). The design-based development of video-based mind maps as a novel method for engaging university students in scholarly dialogue about academic readings enabled us to observe and analyse in detail how students collaborate and use group videos for knowledge development.

The design-based research is grounded in a sociocultural perspective on human activity and learning. Here, students' construction of meaning is regarded as an interactional achievement mediated by cultural tools and constituted in social practice (Vygotsky, 1986; Wertsch, 1998). Combining the sociocultural perspective with interaction analysis (Jordan & Henderson, 1995) has enabled us to investigate knowledge as it is co-constructed by the participants. In *knowledge co-construction practices*, students interact with others to broaden both individual and group understanding (Janssen et al., 2009; Vuopala et al., 2019). Furthermore, these practices can become evident through how interlocutors, for example, share ideas and conceptual understanding, ask questions and elaborate and negotiate meaning (Suthers, 2006). We argue that students' engagement with the video-based mind maps prompts collaboration and discussions about academic texts and constitutes a type of knowledge co-construction practice. Gaining research-based knowledge of how students interact with each other and the videos is key for refining design principles for video-based mind maps, as well as contributing to existing research on video as resources for knowledge development in higher education.

1.1. Video as a resource for sharing knowledge and engaging with peers

In higher education, the use of video has been investigated in various ways, for example, video-based assignments (de Lange et al., 2020), videoconferencing (Al-Samarraie, 2019), video case discussions (Arya et al., 2014), video feedback (Mahoney et al., 2019), video-generation processes (Richards et al., 2021), video podcasts (Kay, 2012) or video reflections (Hontvedt et al., 2020; Stenseth, 2021). Hernández-Ramos (2007) found that, as part of project-based collaborative learning activities, student-produced videos promoted 'deeper engagement with subject matter' (p. 33). Also, student-generated videos created for assessment have been found to support students' development of communication skills, where the active construction of knowledge enhanced students' in-depth understanding¹ (Alpay & Gulati, 2010; Hawley & Allen, 2018). Among the studies opting for a sociocultural or situative approach, van Es (2009)² found that the design of a video club had the central goal of helping teachers learn to notice subject-related thinking and that students' member participation shifted throughout the activities, from different student ideas being introduced, built upon and challenged, hence advancing the group's conversations. The potential of using student-created videos was linked to reflection and engagement in a deep analysis of students' thinking. In addition, Danish et al. (2021) looked at two different research contexts to examine both a video club model and video embedded in a one-on-one coaching model,³ finding that a collaborative review of video cases helped teachers see new patterns and opportunities. The video material used and analysed by the participants in both studies were of situations from professional and pedagogical practices, such as participants interacting with students in schools, which has often been the case in the literature (Arya et al., 2014; Danish et al., 2021; Hernández-Ramos, 2007). Even though these findings show the potential in using video, we have yet to find studies that explore student-generated videos for co-constructing a shared understanding of academic texts in a whole-class setting.

In the context of K12 teaching, researchers and educators strive to understand environments that foster productive or exploratory talk (e.g., Mercer et al., 2019). Rødnes et al. (2021) investigated the educators' role when working with concepts and digital platforms, such as microblogging tools in classrooms; they found that 'the verbal richness and multiple perspectives evoked through the combination of dialogue and technology allowed the students to engage in active exploration of the concept' (p. 1). We have found prior research investigating the use of video in Padlet. For example, De Berg (2016) examined modern foreign language learners' use of Padlets and videos through a student survey ($N = 15$), which indicated a high level of enjoyment but proved low on student awareness of relevance to professional development. The present study extends this research by analysing student–teacher interactions while they co-create and work with videos as shared knowledge in situ. We have yet to find interaction analytical studies of how student engagement with co-created videos is interwoven in meaning-making at a micro level (Steier & Davidsen, 2021) and in relation to the larger system of shared knowledge composed. The video-based mind map intervention allows for investigating these topics further, adding to the literature and developing design principles that can be employed in future teaching and design. Our research questions are as follows:

- How did pre-service teachers interact with fellow students' group videos in a video-based mind map design and integrate these videos into knowledge development?
- What are the key opportunities and challenges when employing video-based mind maps to co-construct shared understanding in teacher education?

¹ Alapai and Gulati's (2010) study has been criticised for not stating whether it was podcasts or video podcasts under inquiry (Hawley & Allen, 2018).

² Studied teacher participation in the context of video clubs, i. e., professional development meetings where the teachers view and discuss excerpts of video from their classroom.

³ Where a teacher and coach watched video of professional practice in a shared digital space.

2. Theoretical approach and design principles

In the present study, *knowledge objects* describe the knowledge co-constructed through interactions, which are developed over time and materialised into a set form. Knowledge objects are considered mediating entities or objects of inquiry that can facilitate exploratory and question-generating characteristics in the educational setting (Damsa & Ludvigsen, 2016; Knorr Cetina, 1997; Nerland & Jensen, 2010). The current study employs this perspective to analyse how students interacted by sharing and working with an online mind map containing their co-constructed group videos. Mind⁴ mapping is a widely used strategy for taking notes, organising concepts, brainstorming, meta-learning and visualising ideas individually or in collaboration with others (e.g., Fu et al., 2019; Merchie & Van Keer, 2016). Mind mapping software commonly allows users to upload videos, but we have not found prior studies that have investigated how groups can co-construct video-based mind maps for collaborative learning.

Theoretically informed by a sociocultural perspective on learning (Vygotsky, 1986; Wertsch, 1998), the following design principles were developed for organising the intervention:

- Facilitate whole-class collaboration, where student groups can learn through interaction to co-construct shared knowledge objects over time (Damsa & Ludvigsen, 2016). The video-based mind map constitutes a point of convergence for developing shared knowledge.
- Orient students towards digital artefacts that support collaboration and mediate knowledge development. The video-based mind map can be built by a range of different artefacts, for example, written text, images or disciplinary video conversations. These artefacts are distributed and made assessable and transparent to all, potentially influencing how the students perceive their surroundings and, thereby, how they act and transform it (Hedegaard, 2004).
- Create explicit focus on subject-specific concepts because they are foundational resources for both professional interaction and individual cognitive development (Bransford et al., 2000; Brown et al., 1989). Here, the core concepts and principles in the subject can function as a joint conceptual frame of references and be structured for knowledge sharing (Collins & Kapur, 2014; Grossman et al., 2009).
- Organise so that the students have time and incentives to read and work directly with the course literature during group work. Summarising and using academic texts actively is vital for in-depth understanding, but relying on materials developed by peers as a substitute for reading themselves is not productive (Bouton et al., 2021).
- Attune the design and structure for organising feedback to the video-based mind map educational setting in how the teacher gives feedback during lectures and provides support when needed, while students give peer feedback through disciplinary video conversations. In doing so, feedback design aims to help students build the capacity to give and benefit from feedback (Boud & Molloy, 2013).

3. Method and materials

3.1. Project background

The present study's design-based approach (Brown, 1992; Hoadley, 2004; Krange & Ludvigsen, 2009) allows the translation of these research-based design principles from designing into researching the video-based mind map activity. The intervention lays the groundwork for empirical investigations of how students create, post and share concept-driven group videos through interaction analysis (Heath & Hindmarsh, 2010), as well as refining the design principles for future interventions. Our theoretical convictions also imply that all educational settings are highly context dependent, making it imperative to observe the practice to better understand the opportunities and challenges it can foster. When conducting design-based research, considering the social context is imperative to understanding the consequences of the educational practice and to improve and generate evidence-based claims about the activities under inquiry (Barab & Squire, 2004; Messick, 1992).

With the present study, we aimed to explore if/how video mind mapping can support students' academic readings and collaborative discussions of course literature while preparing for individual oral exams. The video mind mapping project⁵ was conducted in an introductory course in pedagogy at a higher education institution in Norway. The central aims of the course were to create rich connections between research literature, policy documents, profession-specific terminology and the teaching profession awaiting. The students were also to develop a reflective and critical approach to their own practice and professional community of practice. To create the video-based mind map, the students used an online platform, a Padlet, that enabled them to upload text, images, video and sound and make contributions available for all participants simultaneously. In the end, the mind map was intended to become a joint resource for their upcoming exam.

3.2. Role of the researcher and data collection

Both authors formed the design team and participated as designers and researchers. The first author participated in creating the design, while the second author lectured and mentored the students during the project work.

When video recording the five groups' work, one fixed camera recorded the in-room interactions, while screen recordings on the

⁴ There are variations in terminology used in the literature concerning software mapping tools, such as 'mind mapping', 'concept mapping' and 'argument mapping'. Here, we employ mind mapping because of its free form as it opens for students' creative thinking by encouraging brainstorming and exploring the associations between concepts together (see, e.g., Davies, 2011).

⁵ The project is associated with the project 'Video-based learning activities in professional education' financed by The Norwegian Directorate for Higher Education and Skills, grant number AKTIV-2021/10213.

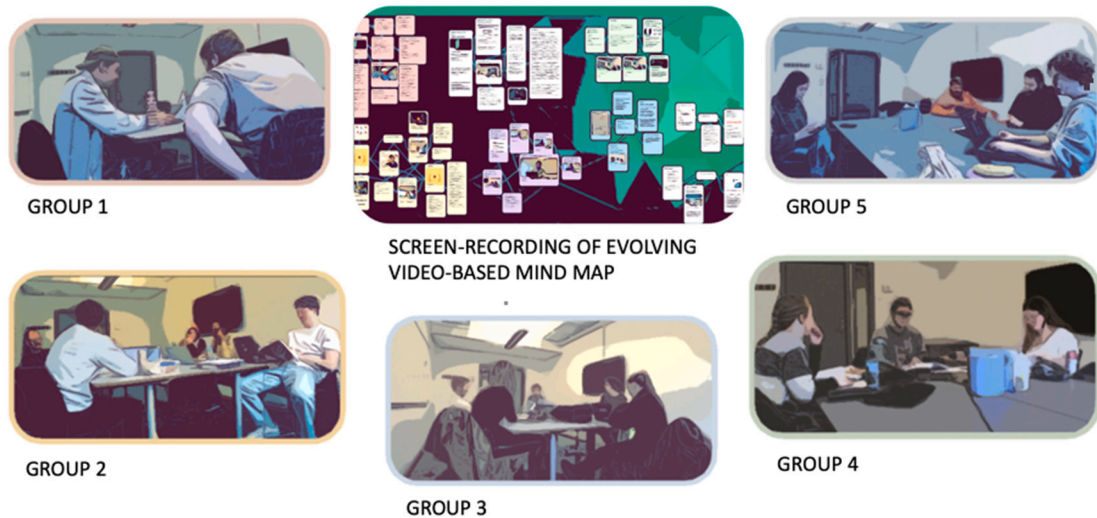


Fig. 1. Video and screen recordings of five groups interacting with the mind map.

students' devices captured the students' on-screen interactions. Combined, this resulted in five cameras and five iPad recordings simultaneously. The positioning of the cameras was chosen to gain access to the students' dialogues, nonverbal interactions and how they engaged with the mind map. Full-class activities were also recorded. Here, two fixed cameras were positioned in the corner of the classroom to get an overview of the teacher educators' presentation of the task description, relevant dialogue concerning the topic at hand and potential use of the mind map in class, serving to contextualise the findings.

There is a fine balance between gathering a lot of information to gain insights into the complexity involved in such settings, as well as considering the principle of data minimisation (entailing that we should not collect more information about participants than what is necessary to realize the aim of our research). This affected technology use and screen recording procedures because we aimed to limit the amount of information collected, leading us to use university-owned iPads instead of the students' own computers. In all, this resulted in approximately 25 h of video recordings of how five student groups engaged with the synchronised platform to co-create and share concept-driven group videos with fellow peers before giving and receiving feedback on their work on the evolving mind map (Fig. 1).

3.3. Participants

Twenty-three first-year pre-service teachers at a Norwegian university were video recorded while they worked in five small groups (three to five students per group) to co-construct a video-based mind map. The students had just started their teacher education programme and were in the beginning stages of their professional development. In general, first-year students are newcomers in need of additional support on how to work as students and get to know the teaching profession in a school system where they will be required to engage in collaborative knowledge sharing practices (Jensen et al., 2022). Participation in course activities was voluntary, and two students chose not to partake, while two other students partook but chose not to be video recorded during the group work. All 23 participants who partook had known each other for a couple of months from taking the same course. The students were randomly assigned to groups based on where they were seated in the classroom by vertically placing one student from each row in one group. Because the project work was part of the students' preparations for their oral exam and took place a week prior to it, the degree to which the students found the task helpful towards this might have affected how and to what degree they engaged in a conversation about the curricular topics and in the co-construction and use of the video-based mind map.

3.4. Data analysis

We have taken an interaction analytical stance when studying the students' group activities and meaning-making as these practices unfolded in situ: their dialogues, nonverbal interaction and use of artefacts and technologies (Jordan & Henderson, 1995). Video allowed for analysing student interaction while they worked, and synchronised screen recording was necessary when the participants use computers (Derry et al., 2010). We have analysed and explored the students' project work multiple times, facilitating a thorough eye on the material (Heath & Hindmarsh, 2002) and inductively mapped what the students were doing and how they interacted while co-constructing and using the mind map by writing thorough annotations. Analytically, we did so by first studying how the five groups conversed individually when making and uploading videos. In the next analytical step, we observed the practice transforming as the group videos were made available for peers, where our analytical foci moved towards a more collective-oriented observation of the groups. Here, the conversations were viewed in relation to the larger system of the mind map. We observed that the group conversations during this latter part of the project work were particularly interesting for closer analysis because the students demonstrated a more reflective and critical approach to the shared knowledge developed in the mind map in relation to their own understanding.

Based on these data mapping procedures, we selected interactional ‘hotspots’ (Jordan & Henderson, 1995) that were prominent throughout the activities and showed variations in how the students interacted with the group videos and integrated them in knowledge development. Here, we focused on sequences where the students engaged with the co-constructed knowledge, either as presented by peers in the video-based mind map or by group members in the room, to explicate or build upon with information and test or advance shared understanding. Following this, we analysed these interactions in relation to how the activity was organised and unfolded as a whole. Finally, we singled out excerpts offering rich descriptions and illustrated key opportunities and challenges that emerged across groups as the students worked.

We transcribed all sequences in Elan, a qualitative transcription software and annotation tool. Group video and screen recordings were viewed and transcribed side by side. To ensure accuracy in our transcriptions, we parsed each turn and used Elan’s segmentation mode to listen to both the students’ individual turns and them as part of the group dialogue multiple times. Raw text files were transported to Microsoft Word, where we applied a modified version of the Jefferson (1984) system (see Appendix A) and added screen shots featuring relevant on-screen interactions. It is relevant to note that, even though we have conducted rigorous transcription procedures, theoretical value judgements were made (Derry et al., 2010). Related to transcribing on-screen interactions, groups of students using various digital tools at the same time resulted in many on-screen interactions occurring simultaneously. In the cases where those interactions were not relevant for analysis (e.g., students eating while talking), they were left out. Student talk was originally in Norwegian because it was the students’ common language of interaction. The transcripts were translated by the first author and later reviewed by the second author. They are presented solely in English for readability purposes. The video data and our analysis have been presented in research groups and at conferences in both languages, where fellow members of our research community have offered valuable insights, increasing the validity of our findings and enriching the analysis presented.

3.5. Research ethics

While conducting this research, the Norwegian Research Council’s guidelines for research ethics were followed. The teacher responsible for the class agreed to participate in our study and gave access to the students. The students were recruited and informed that their participation was voluntary and that their personal data would be treated confidentially and in accordance with privacy regulations. The tool used to create the video mind map was a password-regulated version of www.padlet.com, here in adherence with the General Data Protection Regulation and the institution’s privacy regulations. To uphold the students’ anonymity, all participants were given pseudonyms. To make the participants unrecognisable, filters were added to the video images presented in the group work. During this process, the mind map was recreated, but all content presented was created by the students.

4. Analysis

The video-based mind maps project lasted two days over the course of one week, in addition to voluntary pre- and post-tasks. The instructional design aimed to offer the students an overview of the course literature and establish a joint resource to use when preparing for individual oral exams. The project work consisted of lectures and group work centred around fundamental concepts in the students’ curricula, including the psycho-social learning environment, learning theories, learning theorists’, observation, teacher professionalism, learning and technology and in-depth learning. In sum, these concepts represent a general overview of the subject in relation to the curricula and objectives. In Fig. 2, the trajectory and main elements of the students’ work throughout the week are displayed.

As shown in Fig. 2, on the first day, a lecture was held where the teacher educator (second author) summarised the course literature and expanded on the key concepts and principles that could be fruitful for the students to explore in the mind map. Here, emphasis was placed on connecting theory, white papers and examples from in-service training. Following this, the students were divided into groups. Each group was assigned one of the key concepts mentioned above and given an iPad to use when co-creating the mind map. The students were asked to create ‘clusters’ of posts. The clusters consisted of a group video discussing the concept in light of the course literature, textual descriptions of how such concepts were present in relevant self-chosen research articles and white paper and an example from in-service practice (lower and upper secondary school). By the end of Day 1, the clusters of posts made up a video-based mind map.

When the class met again on Day 2, the teacher led a plenary discussion in which he summarised the group work and the students’ shared experiences with the project work. Following this, and in the same groups, the students got to know the content of the co-created mind map by listening, reading and talking about it. The students then gave peer feedback by further developing the other groups’ work. They did this by adding resources they deemed relevant, for example, written text, illustrations of theoretical models and educational YouTube videos. The main focus of the students’ dialogues on Day 2 was the group videos shared by fellow students. As the student groups engaged with the videos, their discussions evolved, becoming longer and more in depth than during former activities. Therefore, how the groups watched and used other’s group videos constituted an especially productive site of inquiry for detailed analysis (Jordan & Henderson, 1995).

4.1. The student groups’ interactions with group videos

In this section, we provide a moment-to-moment analysis of the diverse ways in which the students interacted while co-constructing the mind map. The first two sequences show the different ways in which the students conversed about the group videos during their initial inspections of the subject matter presented. The latter three sequences are related to object development, showing three ways in which the students engaged while providing feedback to improve and broaden the conceptual understandings provided by peers. Finally, the final version of the video-based mind map is presented as an epilogue to illuminate the complex nature of the knowledge object as co-constructed by the students.

4.1.1. Excerpt 1: group videos prompting exploration of students' understanding

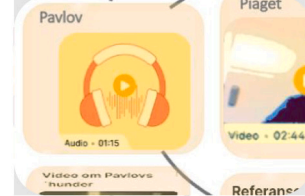
The first excerpt⁶ shows an example of an interaction sequence in which a video prompted students' exploration of their own understanding. They do so in the repetitive manner of first choosing one of the concepts before playing the group video(s) connected to it. In Excerpt 1, Tina, Thea, Tim, Tyler and Thomas's group has just listened to a video about learning theorist Ivan Pavlov. As the video comes to an end, the group engages in a conversation about what they have just seen and heard.

Excerpt 1. Students as they question, listen to and discuss a group video.

In-room dialogue



On-screen group video dialogue



- | | | | |
|----|--------|--|--|
| 1 | Tina | yes, but there were a few words I did not understand [at all] ((looks at Thea)) | |
| 2 | Thea | [then we will go over] it again | |
| 3 | Tim | serves food | |
| 4 | Thea | let's see (.) are you ready? | |
| 5 | | (1.2) | |
| 6 | | | ((talk from sound recording playing on iPad)) so behavioural learning theory put more emphasis on observing behaviour but was not concerned with understanding and knowledge. It is reward and punishment, which is the main reason for rein- reinforcement of behaviour. There exists n- n- no inner motivation it was only passive learning. |
| 7 | Thea | ((she stops video and everybody but Tina starts talking at the same time)) that [Pavlov meant that there were only ex- | |
| 8 | Tyler | [no change motivation just] | |
| 9 | Tina | just? | |
| 10 | Thea | that there were only exterior things that affected what you wanted | |
| 11 | Thomas | no inner motivation | |
| 12 | Thea | [It was exterior learning] | |
| 13 | Thomas | [just what was] comfortable and what was good and what was (x) was painful | |
| 14 | Tyler | Yes: he was very concerned with that one had to see a concrete change | |

The sequence opens with Tina addressing the problem of her not understanding a few words stated in the video (line 1), which seems to spark an idea from Thea, who suggests that the group listen to the recording once more (line 2). Here, the group video is assigned epistemic value because the students use it as a resource to aid in understanding, which is also illustrated by Thea's halt and question in line 4, making sure all group members are ready before replaying it. The long pause in line 5 leaves room for the group to agree, and they listen to the recording again in silence. As the video stops, in overlap, all students but Tina start talking, which illustrates eagerness to help Tina make meaning (lines 7 and 8). Tina rephrases her problem by asking 'just?' (line 9), still requiring elaboration, indicating that she is dissatisfied with both the video and in-room peers' interpretations. Following this, Thea, Thomas and Tyler (lines 10–14) rephrase and jointly formulate an understanding, which, as the sequence ends, is not questioned by Tina.

By sharing her lack of understanding both prior to and after listening to the video, Tina affords her peers the opportunity to help. Thea expands on what has been conveyed in the video about behavioural learning theory with her view of Pavlov's perspective 'that there were only exterior things that affected what you wanted' (lines 7 and 10). Tyler and Thomas jump in with a running commentary about motivation, with Tyler closing the sequence by stating, 'Yes: he was very concerned with that one had to see a concrete change' (line 14). The students' elaborations seem to have clarified the issue for Tina. The video seems to prompt concept-oriented talk among the students, where they became aware of what they knew and what they did not know. As such, the excerpt illustrates how a key opportunity of the video-based mind map design was that the student's engagement with the video led to the group engaging in a joint discussion, negotiating meaning and reaching new understanding as they replayed and engaged in consolidated knowledge-building

⁶ Regarding the first transcripts, on the left, talk from in-room dialogue is presented. On the right, group video dialogue is presented, that is, the sound from a recording playing on the iPad while the groups collaborate. In general, in-room and on-screen interactions are presented in the turn they occurred, meaning that, when sound unfolded simultaneously, they shared a turn.

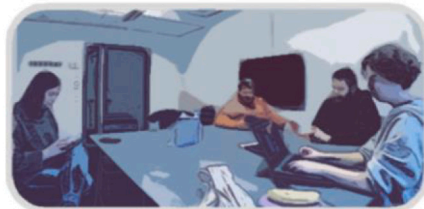
discussion. The excerpt also demonstrates how listening to the group video did not suffice but that it was through engaging with it and each other intently that it became a resource for meaning-making and for gaining a deeper understanding together.

4.1.2. Excerpt 2: Co-construct meaning by combining knowledge conveyed by peers in video and in the room

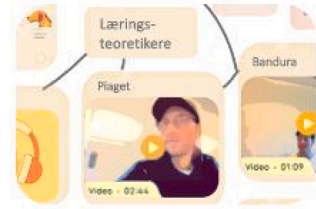
The second excerpt shows how the conceptualisations presented by a peer are under examination as students co-construct meaning by combining the knowledge conveyed in the video with group members' input. Here, Sally, Sebastian, Simon and Susan are listening to another group's video about Jean Piaget. As a peer is talking in the video, students in the room comment on what is conveyed by having a running dialogue as it plays.

Excerpt 2. Students' running dialogue as they listen to, discuss and expand upon a video.

In-room dialogue



On-screen group video dialogue



1 (10.0)

2 Sally yes was he who had schemas

3 Sebastian right

4 (4.6)

5 Sebastian aight

6 (0.6)

7 Simon mh:m mh:m mh:m

8 (0.4)

9 Sally one was to edit the schema the other was to create new ones

10 Sebastian mh:m

11 (32.3)

12 Sally huh (.) I didn't fully understand that (.) But OK

13 (0.5)

14 Simon you have the schema in your head that in a way is what you know from before (.) then you get new information that fits to it, then you just use it together so you expand your schema

15 Susan so it is assimilation that is to expand schema and the other which I have forgotten already is to create new schemas?

16 Sally

17 Simon yes: and that the theory you have in your head is not right then (.) The very nice example is this one with the sun da the sun rises the sun sets and then suddenly the moon appears then there is something or other like there is a very nice example written in that didactic-(x)

to start (.) which involves that one can eh: represent eh: knowledge in the form of schemas eh: and the process of learning itself is then like assimilation and accommodation eh:

which is in a way how one uses these schemas eh: And then there's the motivation

for why in a way people want to learn is that it wants to have equilibrium (.) that is that one wants to achieve those things or easier said to get these schemas to make sense eh: that is one then wants to accommodate, which, in a way, is to change these schemas and assimilate assimilation is that you use the knowledge you already have then that in a way fits with things you already know

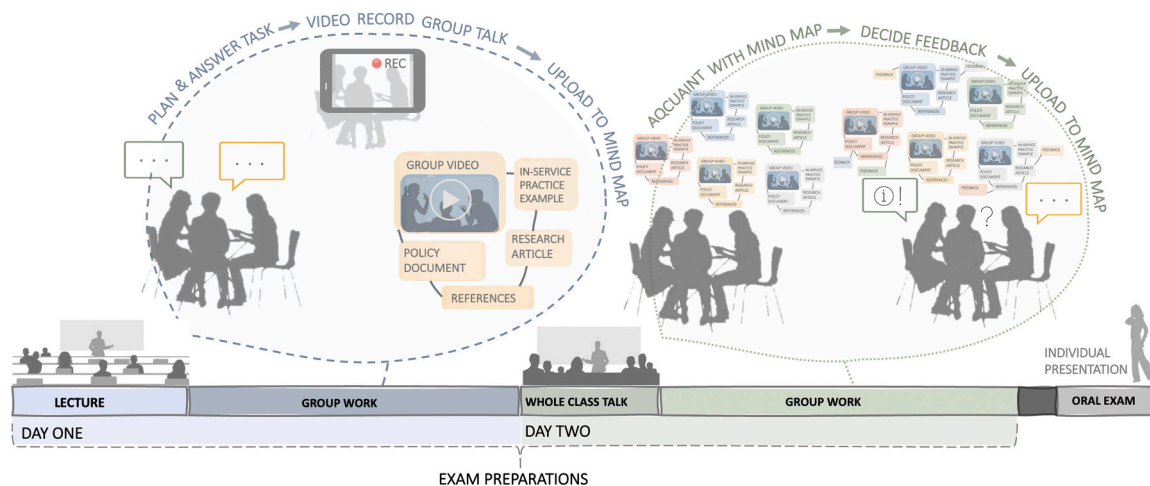


Fig. 2. The video-based mind map instructional design.

The excerpt opens with a video playing of a peer talking about Piaget's schema theory, whereas Sally seems to recollect familiar knowledge as she states, 'Yes was he who had schemas' and Sebastian agrees (lines 2–3). The group continues to agree with the content conveyed as they make confirming accounts such as 'aight' and 'mh:m' (lines 5–7). Sally continues to recollect (line 9) before the group falls silent and leaves the video playing on its own (line 11). As the video comes to a halt, a problem has arisen: Sally states that she 'didn't fully understand that', indicating that she needs further elaboration or that she does not conceive her peer's message as being an accurate or correct enough. Ending her utterance, she states, 'But OK'. After a slight pause (line 13), a discussion is evoked as the group co-constructs meaning (lines 14–17). Simon proposes an explanation (line 14), whereas Susan reformulates his sentence, suggesting more specific terminology that corresponds with that of their academic readings (line 15). Subsequently, Sally connects the knowledge conveyed by Susan to that in the video in a rather advanced way. By putting together 'so it is assimilation' from the video dialogue (line 11) and 'that is to expand schema' (line 15) from her group members' contributions, she demonstrates that her understanding is now co-constructed by the larger system of peers' collaborative work. Finally, Simon references a relevant example in the literature (line 17), connecting their conversation to their academic readings.

In short, the groups' engagement with the video through the running dialogue, where they evaluated the knowledge conveyed in relation to their own understanding, demonstrates a practice where the students' perception of what constitutes knowledge was under debate. The videos can be seen as holding question-generating characteristics, creating opportunities for and facilitating consolidated talk and knowledge co-construction among students. The students questioned their own and peers' understanding and combined the knowledge conveyed in the video with that of peers. By doing so, their understanding was co-constructed by the larger classroom community.

4.2. The students giving feedback to further develop the mind map

This section presents the sequences of how students provided feedback to peers, aiming to improve and broaden conceptual understanding by further developing the mind map. The three following excerpts originated amid their group work on Day 2 after the students had become familiar with all the content posted during Day 1.

4.2.1. Excerpt 3: Reaching common ground when co-constructing the mind map

The following excerpt illustrates how, in some sequences, the increased exploration of concepts unfolded as students strived to develop the mind map, yet they lacked the necessary overview and/or teacher support to do so. In this sequence, a group negotiates what to create as a contribution to the mind map cluster *in-depth learning*. In the Norwegian national curriculum, *in-depth learning* is developed as a key concept that is based on a broad theoretical and empirical foundation (NOU, 2015, p. 8). An important context for this sequence is that, on the first day of the project work, this group split the work on learning theorists between the group members and chose to create the videos of central learning theorists individually before making an additional group video where they discussed the similarities and differences between the theorists' perspectives on learning. In the following sequence,⁷ this becomes evident because some group members seem to be more familiar with, for example, Jean Piaget's or Jerome Bruner's work than others. Luke is looking at the *in-depth learning* cluster in the mind map as he centres the group's attention on the task.

⁷ Here, the transcript of talk is presented in one block because the students did not engage with group videos.

Excerpt 3. Students engage in making meaning of how to develop the ‘in-depth learning’ cluster.**In-room dialogue**

- 1 Luke Eh: but the last task then (.) is that something we know are there any of those we had about of the theorists who, for example, touched upon in-depth learning?
(2.0)
- 2
3 Lucy Maybe Bandura
(2.0)
- 4
5 Liam The question is what is in-depth learning? What do you qualify as in-depth learning?
- 6 Luke Yes that is the question to get on the exam that
- 7 Liam Hehehe
(2.0)
- 8
9 Luke I do think that (x) Piaget stuff it has to be that assimilation then that when you have learned things, and then, you assimilate so that the knowledge becomes more robust
- 10 Lucy Mhm
- 11 Luke then that is in a way the closest in-depth learning he gets I think (.) I don't know if I want can dare to say anything about that being in-depth learning or not.
(5.0)
- 12
13 Luke Are you::?
14 Leo no I am just thinking
- 15 Liam Bruner's spiral curriculum
- 16 Luke is that in-depth learning?
- 17 Liam yes because Jerome Bruner theories ((starts reading)) theories are also relevant for understanding in-depth learning (.) he was concerned with so-called discovery learning (.) that one should learn what is [imp]ortant.
[Huh?]
- 18 Luke
19 Liam In the subjects [not-] ((slight laugh))
20 Luke [can you] write?
21 Liam not- ((slight laugh))
22 Luke yes, [about Bruner and connect it to in-depth learning that is well:]
23 Liam [not a lot of dethatched details]
- 24 Lucy that is very useful yes thousand points (0.6)
- 25 Liam at least his [spiral-thing was was yes that]
26 Lucy [thousand points to him]
- 27 Liam when students understood
- 28 Leo Yes
- 29 Liam subjects they were too they could work on
- 30 Lucy further yes
- 31 Liam further on it
- 32 Lucy build upon ((waves hands))

In line 1, Luke asks his group members if they remember if one of the theorists ‘touched upon in-depth learning?’ Lucy is the one who created the video about Bandura and suggests him (line 3), as Liam states a problem: ‘The question is what is in-depth learning? What do you qualify as in-depth learning?’ None of his group members suggest an answer. Both Liam’s question and Luke’s prompt, ‘Yes, that is the question to get on the exam’, with an ironic tone of voice, suggest they experience it to be a difficult question to answer. This claim is supported by Liam’s slight laugh in return (lines 5–7). Following this, Luke seems to recollect something relevant from making the video about Piaget about assimilation and utters, ‘You assimilate so knowledge becomes more robust’. As he closes his reflection, he makes it clear that he does not know the answer to the question (lines 9–11). After a long pause, Luke looks towards Leo and directs the question to him with a wavering ‘are you::?’ whereas Leo replies that he is thinking. Following this, Liam interrupts them by promptly stating, ‘Bruner’s spiral curriculum’ (lines 13–15), as if that is the answer to the question. Next, the group engages in rapid conversation. In overlap, Liam explains his train of thought and reads from his notes as the others strive to understand and make him write it all down on the mind map (lines 17–23). Subsequently, Lucy salutes her peer by rewarding him, as she states, ‘That is very useful yes thousand points’ (lines 22 and 24). In the few seconds that follow, she adds to Liam’s information by stating ‘further yes’ and ‘build upon’ while waving her hands in eagerness, indicating that she has gained a new insight.

Based on the groups’ collaboration while creating the videos on Day 1 of the project work, they were able to use this knowledge and assigned each other epistemic authority concerning the topic at hand. Luke reflects upon his own knowledge, resulting in his peers following up on his accounts, and based on Liam’s input, they applaud reaching a consensus (line 24). However, it is relevant to note

that we did not observe any of the group members looking up in-depth learning or going into greater detail on the topic. As such, making the videos created the opportunity to work in depth with a concept that, in turn, afforded the group knowledge they found relevant to solve the task, yet they did not tie this into how the concept has been developed in a Norwegian context. Thus, it seems that the focus on one concept and having divided a large extent of that work on Day 1 created a narrow focus because the students strived to find common ground that aligned with the learning objectives in the curricula important for their upcoming exam.

4.2.2. Excerpt 4: Task complexity and student engagement when giving feedback

The first sequence is chosen because it illustrates the challenges that occurred while co-constructing shared knowledge regarding our second research question. We enter this sequence as two students contemplate what to post on the mind map as feedback to a group video about the learning theorist Lev Vygotsky.

Excerpt 4. Students engage with a group video when deciding on feedback.

In-room dialogue



On-screen group video dialogue



- 1 Paul okay Vygotsky (.) (x) did he mention anything about the development of language at all?
 2 (1.4)
 3 Peter don't think so (0.3) can watch the video again, though, doesn't take that long
 4 (2.3)
 5 Paul play (.) Is it I that had oi
 6
 7 Paul yes he did not say anything about language development
 8 Peter no (.) then we add that (.) then that will be done.

Vygotsky was a Russian psychologist who lived from 1896 to 1934 eh: he was central within sociocultural learning theories eh: he meant that much learning happens through social interaction between eh: with the teacher as a facilitator (.) eh: learning is a social interaction with others learning is, therefore, closely tuned to the environment and personal characteristics such as thought and feelings. Eh: he distanced himself from the other learning theories by here being interaction and the social, which was important, in contrast to the other learning theories

In the opening of Excerpt 3, Paul establishes a focus on the task by closing in on the video of 'Vygotsky'. He then proves the task to be a joint endeavour because he asks Peter if the video has mentioned anything about the development of language (line 1). Paul's question indicates that he regards language development as relevant information concerning Vygotsky's work, knowledge likely retrieved from lectures or prior academic readings. Following this, Peter suggests that they listen to the video again to be certain it was not mentioned, seemingly concurring with Paul's analysis (line 3). After a long pause, Paul replays the video (lines 4–5). After listening to the video, the boys are assured as they decide to 'add that' to the mind map. Peter closes the sequence by stating, 'Then that will be done', directing attention at finishing the task (line 8).

The first important feature in the extract is how the group actively engages with the video when striving to give suitable feedback but does not engage in in-depth conversation about it while doing so. Peter introduces a valid question about the development of

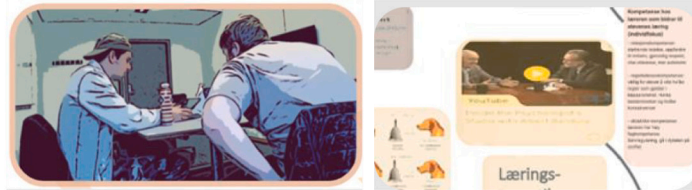
language in relation to Vygotsky's work, which is not negotiated by the group as they post. In the group video, language development is not mentioned explicitly, yet the video appears to be a synthesis of Vygotsky's theories. When observing the group work, it becomes evident that, as their work comes to a halt, it is Paul, alongside directives from the task description, who moves their work forward. The second important feature is Peter's hurrying to finish the task. During the analysis, students' lack of engagement seemed connected to the complexity of the task, and giving feedback to develop the mind map considering the curricula seemed to be a demanding task. For some students, engagement with the group videos became a means to an end—that is, to finish the task rather than to reach learning objectives. The sequence indicates that, as the students followed task directives, they could have benefitted from more support, for example, guidance or modelling of how to engage when striving to produce valuable feedback.

4.2.3. Excerpt 5: Varying engagement with video resources as groups contemplate what to respond to peers

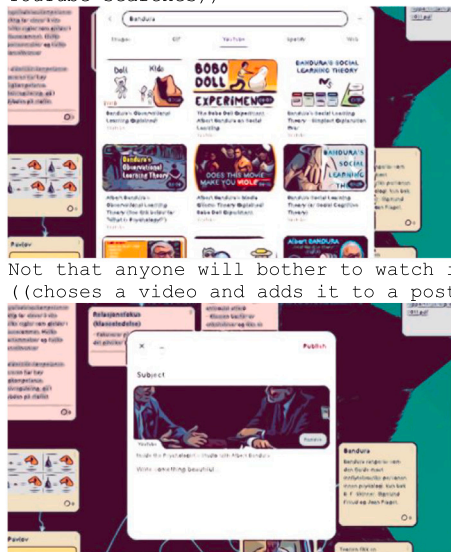
During the observation, it became evident that some students decided to add resources other than those included in their academic readings as feedback, namely YouTube videos created for educational purposes. The last excerpt⁸ demonstrates how their engagement with these types of videos contrasted with the student-created ones. We revisit Paul and Peter, who are both staring at the mind map when a new post appears.

Excerpt 5. Students add YouTube videos created for educational purposes to the mind map.

In-room Dialogue



- 1 Paul Oi now somebody has added
 2 Peter a video about Pavlov's dogs
 3 (2.6)
 4 Paul Important to include dogs
 5 (0.2)
 6 Peter There is also one of those videos
 7 Paul It is from YouTube that is this video here
 8 Peter It is a video of Bandura on YouTube (.) How does one do that then?
 9 (3.6)
 10 Peter YouTube
 11 (14.7) ((searches «Bandura» in the mind map's features which opens for
 YouTube-searches))



- 12 Peter Not that anyone will bother to watch it though (.) 46-minute video
 ((chooses a video and adds it to a post))

The sequence opens by Paul and Peter discovering a group's new contribution. Paul states, 'Oi now somebody has added', as Peter follows with 'a video about Pavlov's dogs' (lines 1–2). Peter then promptly purports, 'There is also one of those videos' (line 6) before he stops talking. Paul then informs Peter that the video uploaded is from 'YouTube', whereas Peter recollects and informs Peter that 'it

⁸ Here, the in-room dialogue and on-screen interactions are presented as intertwined because the students are not listening to video talk but instead interacting with the mind map.

is a video of Bandura on YouTube' (line 8). Following this, Peter requests information about how to add the video from YouTube before a long silence leaves room for him to figure it out by himself, as demonstrated by him stating 'YouTube' as he pushes the YouTube button in the Padlet. This directs him to a channel where he searches for 'Bandura' and finds the video (lines 11–12). Closing the sequence, Peter states, 'Not that anybody will bother to watch it, though'. The on-screen information broadens our understanding because it informs us that the length of the video is 46 min long. Here, two learning theorists engage in conversations about the topic at hand.

In short, the group observes other groups' contributions that influence what they add to the mind map. However, none of the groups listen to or engage with the YouTube videos added in full or have a conversation about the content. The group's engagement with the student-produced videos and YouTube videos created for educational purposes differed, the former leading to knowledge co-construction practices. When analysing the data, we noticed how the students engaged more deeply with videos with a shorter time span, for example, 3 min versus 11 min, and this sequence indicates that a possible reason for this could be that video length affects viewing rate and student engagement.

4.3. Epilogue: the co-constructed video-based mind map after day 2

The excerpts of student talk presented above show variations in how the students engaged in the co-construction of the mind map. We have seen how the participants' thoughts and conversations came together as they engaged with the videos and posted and shared feedback with peers and teachers, here in both student-created and educational videos, imagery, sound and text. In groups, the students engaged in the synchronised activity over time, and as the mind map evolved, new insights were made available to their peers. In turn, the posts generated questions and sparked knowledge-building conversations about the subject matter. Fig. 3 shows what the video-based mind map looked like at the end of the project in relation to how it was available to the student groups as they worked.



Fig. 3. Recreation (The student-created mind map presented here is a recreated version made by the first author during analysis. This had to be done to uphold anonymity and ease readability. The image presented in Fig. 1 shows the original mind map created by the students.) of the video-based mind map the students created in relation to how it was made visible to the five student groups as they worked.

All content in the mind map was created by the students during both days of the project work. The colours in the mind map illustrate clusters of key concepts and how they are connected. The group colours show which group was responsible for the key concepts. For example, yellow colouring shows that the yellow group created the group videos about learning theorists, whereas their peers contributed to the cluster by adding text, images and YouTube videos when providing feedback. Here, the students' feedback was made visible to peers and teacher educators and became part of the mind map as a finished product. As students created clusters of posts, their contributions seemed to influence what their peers uploaded to the mind map. Thus, their feedback functioned both as resources aimed at improving or broadening their overall shared understanding of key concepts in the learning sciences and as a way to model various strategies to employ when doing so. In general, the overall characteristics of how the students interacted with the mind map were that they did not seem to conceive of the knowledge conveyed by peers as being in a set state as they critically assessed their contributions and own understanding. Throughout the analysis, we have demonstrated how smaller parts of the knowledge object came together as a whole, from how students uploaded self-generated content to them interacting with it, at the end forming a co-constructed joint knowledge base imperative for their upcoming exam.

5. Discussion

The present study is based on the premise that student collaboration and scholarly dialogue about academic readings is important for learning in higher education. The design-based research project was initiated, and data were collected and analysed to explore if/how video mind mapping could support students' academic readings and collaborative discussions of the course literature. Interaction analysis of five excerpts demonstrated that students' co-construction of video-based mind maps established a joint conceptual frame of reference for knowledge development, creating opportunities where students explored their own understanding, co-constructed meaning through critical engagement, were afforded epistemic authority by peers, and made meaning together based on the co-constructed shared knowledge in the mind map. Yet the analysis also revealed challenges in the task design: dividing concepts between groups created a narrow focus on their academic readings, and giving feedback to further develop the mind map was a demanding task, affecting student engagement. In the following section, we return to the study's research questions and dig deeper into the relevance of these findings for future research and practice.

- How did pre-service teachers interact with fellow students' group videos in a video-based mind map design and integrate these videos into knowledge development?

The students engaged actively in group work and used other groups' videos as resources for generating questions and reaching a joint understanding. Creating situations that allow students to collaboratively make sense of a knowledge domain is important for pre-service teachers' professional training (Grossman et al., 2009), and our findings add to and support prior studies that have shown that the use of video can promote dialogue and a discussion of new ideas (Ramos et al., 2021). However, what was distinctive in our data material was that the students' interactions with videos prompted in-depth discussions about theories and concepts among students sitting face to face. The students' discussions were closely tuned to the task for the mind map: to create an overview of the curricula and prepare for individual oral exams. In Extracts 1 and 2, we saw how the group video opened up students' engagement in knowledge building and concept-driven dialogue. When watching and listening to the videos, both Tina (Extract 1, line 1) and Sally (Extract 2, line 12) experienced challenges in understanding the content. In the first extract, the group used the video as a resource because they decided to replay it, which sparked further investigation of the subject matter. In the second extract, the video prompted new questions, leading to consolidated talk in which the group combined information from video and in-room talk and reached new insights together. When working to acquire certain skills, it is important to facilitate interactions with significant members who are part of collective practices because knowledge is socially constructed through active interaction (Säljö, 2021; Vygotsky, 1986). A prominent finding in our study is that the thinking and reasoning of the participants were influenced by peers' asynchronous conversations materialised into knowledge objects as the students used them to reconstruct perspectives.

Prior studies investigating student interactions while engaging with knowledge object development have found that those who engaged in co-construction had deliberate collective strategies, such as engaging with concepts and structuring meaning (Damsa, 2014). Studies have purported that knowledge objects can play multiple functions and have several purposes that become important during co-construction (Damsa & Ludvigsen, 2016). Relatedly, in the present study, video-based mind maps have provided an environment in which knowledge building could be made and shared simultaneously. Here, we applied the knowledge object as a theoretical concept to describe the video-based mind map practice, as an entity holding smaller entities both constituted by and constituting students' conception of knowledge—through social interaction. The concept contributes to explaining what constitutes knowledge at a given time in the continuously evolving practice shaped by and shaping the students' meaning-making. On the one hand, the group videos materialised the outcome of the students' meaning-making as they uploaded them to the mind map. On the other hand, they mediated meaning and shaped peers' future talk and thinking regarding how they were integrated in and influenced their conversations and the knowledge development. The students' knowledge development practices resulted in a platform of group videos becoming means for collaborative knowledge co-construction that, combined, formed a whole-class knowledge object, extending, supporting and challenging their understanding of the course literature and collaborative learning processes.

The current analysis zoomed in on those situations in which the students were required to watch student-created videos to provide feedback to further develop the mind map and knowledge constructed in it. When working with the video mind maps in the second half of the project work, all groups paid more attention to the student-produced videos than to the uploaded YouTube videos and web resources. There may be different reasons behind this, but we have found it likely that the students' familiarity with their co-students

and the symmetrical relationship between students prompted this critical engagement. These findings demonstrate some affordances of co-creating group videos and supplement prior studies that tend to focus on students working with video from professional and pedagogical practice (Arya et al., 2014; Danish et al., 2021; Hernández-Ramos, 2007). Yet the students did not integrate these videos in knowledge object development, implying that student-generated videos held greater value for collaborative negotiation of the students' academic readings and understanding of information from text than videos collected from other sources.

We also posed the following research question:

- What are the key opportunities and challenges when employing video mind maps to co-construct shared understanding in teacher education?

In the present research, the mind map was established as a point of convergence for the student groups. Prior research has pointed out that, to successfully use video, it is crucial to consider the choice of video format that aligns with the desired learning outcome, content, technology and pedagogical knowledge and institutional framing (Hawley & Allen, 2018). The larger system of group talk made available through the digital platform was shown to prompt subject-oriented meaning-making regarding the students' academic readings. While the students watched, listened to and engaged with the videos, critical discussions emerged. In essence, the videos helped lay the premise for the ongoing conversation, which, in turn, was closely intertwined with the project work's task description: listening to the videos to give feedback. By co-creating and sharing videos, they became acquainted with what their peers deemed relevant in the subject; at the same time, they were able to influence each other's group talk and thinking because the videos were shared and commented upon. In Excerpt 4, we can see how Liam introduces knowledge that the student group deems relevant and that they later incorporate into the mind map (e.g., lines 13–15). Through this instructional design, the data show that the students shaped the ongoing academic and professional talk to a large extent and were afforded epistemic authority among their peers.

In this study, we took an interactional analytical approach to analysing the students' work. Among the study's limitations is that we do not measure learning effect. However, all students who participated passed their exam. They also answered evaluation forms at the end of the project work, offering valuable feedback. Even though we have limited the analysis to mainly reporting on the video data, the students' remarks were viewed side by side to corroborate with our suggestions for future refinement of the design principles. Prior studies have suggested that student-generated video creation for assessment offers students opportunities to develop digital and communication skills, as well as to create enjoyable and motivating learning environments (Alpay & Gulati, 2010; De Berg, 2016; Hawley & Allen, 2018). In the evaluation forms, the students were generally very positive towards the activity and found it beneficial for their development in the course. However, some students reported wanting more practice in communicating using video and finding the format awkward, while others stated that they would have benefitted from more time to prepare for the activity in advance. Although we focus solely on the transcripts of video data in the analysis presented above, these findings are interesting for conducting future video mind mapping designs because this was one week ahead of the students' exam, confirming the relevance of conducting activities that support students' academic readings and collaborative negotiation of them.

The analysis has provided insights into a complex practice in which the teacher educator strives to utilise video in a pedagogical setting, hence helping pre-service teachers gain a deeper understanding of the learning sciences. In extract 3, as Paul learns how to add YouTube videos to a Padlet, Peter's actions indicate that he wants to finish the task, seemingly finding it challenging (lines 8–12). In addition, as various groups negotiated and made meaning of what to add to the mind map, their negotiation was not shared with the rest of the class as posts on the mind map. To a large extent, the affordances of the design seemed connected to what the mind map, as an evolving knowledge object, generated regarding productive and consolidated talk in the room. The video-based mind map enabled students to materialise knowledge that, in return, sparked their peers' meaning-making.

5.1. Practical implications and future research

The findings highlight key considerations for future design principles of video-based mind maps in higher education. The analysis has shown that video-based mind maps can offer a structure for engaging with a knowledge domain through peer videos. It seems that the videos created by peers prompted critical engagement among the students. However, our analysis also shows the complex and demanding nature of having to critically analyse peers' work to provide feedback that broadens conceptual understanding. The interactional sequences presented concerning object development clearly indicate that the students needed additional support because they struggled to draw meaningful lines across knowledge and new areas within the learning sciences that were important for their exam (Excerpt 3). Thus, it is important for the teacher educator to follow the students' work closely over time because the students would have benefitted from, for example, thorough guidance on how to embark on their academic readings earlier in the semester. Because our design aimed to help students build the capacity to give and benefit from feedback (Boud & Molloy, 2013), the analysis has indicated that students struggled to do so with their academic readings. In addition, to the best of our knowledge, they did not work with the feedback videos received, even though it was implied they should do so in the design. Creating a firmer structure for how the students work when giving feedback and incorporating reading activities earlier in the project could be a way of meeting these challenges.

For future research, our findings align with prior studies stating the necessity of exploring how knowledge objects are used over longer periods of time in relation to the learning process and teacher support (Damşa & Ludvigsen, 2016). For future interventions, it would be beneficial to investigate students' dialogues about academic texts as part of longer trajectories of learning, where individual and group work are intertwined with whole-class knowledge development. For teachers, coordinating video-based mind map activities with a whole class of students is time-consuming work, yet the analysis has revealed it as being a rewarding entry point to understand

in greater detail how to advance and bring forward students' collaborative learning processes.

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Appendix A. Transcription key

Sign	Explanation
(.)	Noticeable pause shorter than 0.2 s
(0.5)	Pause measured by tenths of a second
[Indicates where an overlap occurs
]	Indicates where an overlap ends
:	Prolonged sound
<u>word</u>	Emphasis on word
WORD	Louder volume than normal
word-	Sudden break
?	Indicates question being asked
(x)	Inaudible
(())	Nonverbal activity

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