Knowledge Co-Construction Activities and Task-Related Monitoring in Scripted

Collaborative Learning

Essi Vuopala, Piia Näykki, Jaana Isohätälä & Sanna Järvelä

Department of Educational Sciences and Teacher Education

University of Oulu, Finland

Corresponding author: Essi Vuopala, PhD, is a university lecturer at the Learning and Educational Technology research unit in the Department of Educational Sciences in University of Oulu, Finland.

Contact information:

Essi Vuopala, Department of Educational Sciences and Teacher Education, University of Oulu, P.O. Box 2000, University of Oulu FIN-90014, Finland. Tel: 358 40 5470778.

Email: essi.vuopala@oulu.fi

Piia Näykki, Email: piia.naykki@oulu.fi

Jaana Isohätälä, Email: jaana.isohatala@oulu.fi

Sanna Järvelä, Email: sanna.jarvela@oulu.fi

This work was supported by the Academy of Finland [grant number 273970]

Abstract

This study explores teacher education students' knowledge co-construction activities, task-related monitoring and script use in collaborative learning situations. The specific aims are to investigate how students engage in knowledge co-construction activities and to compare task-related monitoring and script use in groups with active and passive knowledge co-construction. The participants of this study were five small groups of teacher education students (N = 19); collaborative learning in these groups was supported with a designed script for regulation of learning over a six-weeks environmental science course. The data was collected by videotaping the groups' face-to-face interaction, and analysed by focusing on verbalised knowledge co-construction activities, task-related monitoring and script use. The results show that there were differences in the quantity and quality of knowledge co-construction activities, task-related monitoring and script use between the groups. Compared to groups with more passive knowledge co-construction, the group with more active knowledge co-construction also showed more task-related monitoring, particularly monitoring of content understanding, and more thorough use of the script for supporting their learning. Based on the findings, it was concluded that qualitative differences between groups in collaborative learning extend from differences in knowledge co-construction activities to differences in monitoring processes and the use of script.

Keywords: Collaborative learning, knowledge co-construction activities, scripting, social interaction, task-related monitoring

Knowledge Co-Construction Activities and Task-Related Monitoring in Scripted Collaborative Learning

1. Introduction

The aim of training teacher education students in collaborative learning is to prepare them for 21st century. Participation in productive knowledge co-construction activities in collaborative learning is one of the key competences in today's society, since solving problems together is an essential part of daily life. Future teachers, especially, are often required to be able to work in various teams, and they also need the knowledge and skills required to support collaborative learning between their pupils (Aggarwal & O'Brien, 2008; French & Kottke, 2013; Häkkinen et al., 2017). Furthermore, there is an evidence that knowledge co-construction can have positive effects on individual learning outcomes (Howe & Zachariou, 2017; Light, Littleton, Messer, & Joiner, 1994; Roschelle & Teasley, 1995). However, group's efforts to co-construct knowledge provide opportunities for individuals to learn but does not guarantee it (Van den Bossche, Gijssels, Segers, & Kirschner, 2006). Individual learning outcomes depend on how individual learners' commit to collaborative activities like explaining and argumentation which are enhancing their understanding. Therefore learning outcomes between individual group members might differ considerably (Dillenbourg, 1999). Taken together, we argue that collaborative learning can be, in general, a powerful approach for educating future teachers (Häkkinen et al., 2017).

The individual skill to engage in productive interactional processes, i.e. interaction that fosters learning in groups in knowledge co-construction situations is critical factor in successful collaborative learning (e.g. Enyede & Stevens, 2014; Kreijns, Kirschner, & Jochems, 2003). Knowledge co-construction refers to collaborative process where learners are interacting with each other in order to build new knowledge and to extend the knowledge and understanding of each individual student (Janssen, Erkens, Kirschner, & Kanselaar, 2009). These productive

interactional processes include sharing ideas, negotiating, asking thought provoking questions and providing justified arguments in order to build new knowledge (Arvaja, Salovaara, Häkkinen, & Järvelä, 2007; Dillenbourg, 1999; Roschelle & Teasley, 1995; Sawyer, 2006). In addition to the knowledge- and content-level activities, productive interactional processes in collaborative learning require the ability to regulate group work by planning, monitoring, controlling and evaluating joint learning (Järvelä & Hadwin, 2013; Näykki, Järvenoja, Järvelä, & Kirschner, 2017b; Rogat & Linnenbrink-Garcia, 2011). Especially task-related monitoring, referring to reflection of one's own and one's peers' content understanding, overall progress of collaborative task as well as reflection of challenges, is vital for collaborative learning. (De Backer, Van Keer, & Valcke, 2015; Khosa & Volet, 2014; Rogat & Linnenbrink-Garcia, 2011.) However, as previous studies have shown, collaborative learning is not a spontaneous process, and productive interactions can be difficult to achieve (Barron, 2003; Kuhn, 2015; Näykki, Järvelä, Kirschner, & Järvenoja, 2014).

One way to promote productive collaborative learning is the use of a pedagogical script that explicitly guides learners during their shared learning processes. Scripts can, for example, structure and direct interaction to commit learners into such forms of interaction, like questioning and argumentation that are associated with productive collaborative learning (Dillenbourg, 2002; King, 2007). Studies have shown that applying pedagogical scripts can improve the productive interactions in collaborative knowledge construction (Fischer, Kollar, Stegmann, Wecker, & Zottmann, 2013; Stahl, 2013) and also in teacher education (Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen, & Häkkinen, 2017a).

There is proof that active participation in knowledge co-construction activities, can lead to high-quality learning outcomes (e.g. Wang, 2009). Previous research has suggested that knowledge co-construction activities can have a positive impact on both group productivity and learning outcomes (Weinberger, Stegmann, & Fischer, 2007). Some prior studies have

also explored how knowledge co-construction and regulation activities co-occur during collaborative learning (De Backer, Van Keer, & Valcke, 2015; Goos, Galbraith, & Renshaw, 2002; Molenaar & Chiu, 2014). Therefore, this study is interested in exploring how active knowledge co-construction is related to other types of activities, which predict a high level of collaborative learning, namely involvement in task-related monitoring and active use of pedagogical scripts.

Although there are a number of studies that explore knowledge co-construction (i.e. Roscoe & Chi, 2008), group regulation (i.e. Hadwin, Järvelä, & Miller, 2011; Khosa & Volet, 2014; Kwon, Hong, & Laffey, 2013; Lee, O'Donnell, & Rogat, 2014; Näykki et al., 2017; Rogat & Linnenbrink-Garcia, 2011; Saab, van Joolingen, & van Hout-Wolters, 2012), and the effects of using pedagogical scripts (i.e. Kollar, Fischer, & Slotta, 2007; Wang, Kollar, & Stegmann, 2017; Weinberger, Ertl, Fischer, & Mandl, 2005) in collaborative learning, there is less research that combines these aspects. For example, it is still unclear whether and how knowledge co-construction activities are related to script use and key learning regulation activities, such as task-related monitoring. In order to support collaborative learning, it is essential to understand how groups engage in knowledge co-construction activities and monitoring processes and how they make use of scripts to support their learning in authentic learning contexts. In addition, previous scripting approaches in collaborative learning have paid little attention to the support of groups' regulation processes with the attempt to enhance students' engagement in monitoring and controlling activities, and to the potential connection between effective script use, task-related monitoring and knowledge co-construction activities. This study qualitatively investigates teacher education students' knowledge co-construction activities in collaborative learning and compares task-related monitoring and script use in groups that were most frequently (later referred as the 'active group') and least

frequently (later referred as the ‘passive group’) involved in knowledge co-construction activities.

1.1 Knowledge Co-Construction Activities in Collaborative Learning

The concept of knowledge co-construction refers to a process of an improvement of ideas as compared to knowledge possession when the knowledge is seen to exist only in the mind of individuals and is expected to be transmitted and revealed (Beers, Boshuizen, Kirschner, & Gijselaers, 2005; Scardamalia & Bereiter, 2014). In this light, the goal of collaborative learning is to develop learners’ understanding and to construct new knowledge through social interaction (Janssen et al., 2009). Social interaction is a key factor in determining the level of one’s own learning, and the ongoing interaction processes are considered to be more important factors associated with learning rather than the learning outcomes (e.g. Dillenbourg, 1999; Howe et al., 2007; Mercer & Howe, 2012; Scardamalia & Bereiter, 2006).

Beers et al. (2005) define four interaction processes, which form the pathway from individual and unshared to co-constructed knowledge, namely, externalization, internalization, negotiation and integration. In collaborative learning, these processes can take the form of sharing one’s own knowledge, providing questions and answers, and synthesizing the contents of joint discussions. These knowledge-oriented processes require learners to share views relevant to the topic at hand (Webb, 1989) and to focus on presenting their reasoning and justifying arguments (Oliveira, Tinoca, & Pereira, 2011). By sharing knowledge in a group, learners share their expertise and give content to the joint discussions. However, in collaborative learning providing information is not enough, and in order to reach a deep understanding of the topic at hand, the information provided needs to be further elaborated in terms of commenting, presenting questions and summarizing (Arvaja et al., 2007). Summarizing the elaborated discussions can signal how well the contents are

understood and if there are errors in understanding (King, 2007). Such group discussions have been shown to enhance students' deep learning and achievements (Garrison & Cleveland-Innes, 2005). In general, it can be stated that the more engaged group members are in ongoing and constant elaboration of collaborative tasks, the higher is the quality of learning they achieve (Barron, 2003). For example, Jeong and Chi (2007) reported that active interaction among group members leads to an increase in their common knowledge. In addition, Howe and her colleagues (2007) state that collaborative activities are likely to be effective when students actively participate and share ideas and provide explanations and reasoning for their ideas. Therefore, on the basis of earlier evidence of knowledge co-construction activities, the present study focuses on content-related interaction forms, or more specifically, on providing information, questioning, answering, and summarizing.

1.2 Task-Related Monitoring in Collaborative Learning

Task-related monitoring is vital for productive collaborative learning, as is active coordination of group interaction and group working (Barron, 2003; Kuhn, 2015; Janssen et al., 2009; Näykki et al., 2017b). Research on regulation of collaborative learning has shown that in productive collaborative learning, learners plan, monitor and evaluate joint learning processes (e.g. Khosa & Volet, 2014; Lee et al., 2014; Näykki et al., 2017b). In other words, group members need to discuss and negotiate at the meta-level to become aware of their group's progress and to increase the possibilities of coordinating to achieve their goals, plans, and strategies (Järvelä & Hadwin, 2013).

Task-related monitoring is regarded in this study as a fundamental coordination process in collaborative learning (Janssen et al., 2009; Kwon, Liu, & Johnson, 2014; Saab, et al., 2012). Monitoring includes quality control of learners' progress with the aim of identifying inconsistencies in the learning process (De Backer et al., 2015). Monitoring in group interaction involves reflecting on one's own and one's peers' understanding, thinking and

overall progress during the group task (Goos et al., 2002; Näykki et al., 2017a). Effective and continuous task-related monitoring is essential for encouraging group members to become aware of each other's understanding of the task, of the content they are working with as well as the skills and strategies that are needed in the task (De Backer et al., 2015; Khosa & Volet, 2014; Rogat & Linnenbrink-Garcia, 2011). With regard to group regulation, the focus of the present study is on task-related monitoring and its relation with knowledge co-construction activities.

Previous studies of our own and other studies in this field have shown that groups in which learners monitor their own and their peers' thinking and understanding engage in deeper-level learning processes compared to groups in which there is no active monitoring of tasks (Authors, 2017; Goos et al., 2002; Hurme, Palonen, & Järvelä, 2006; Iiskala, Vauras, Lehtinen, & Salonen, 2011; Lee et al., 2014). Further, recent findings from our own study (Authors, 2017) as well as from Lee and colleagues' study (2014) have shown that monitoring functions in parallel with high-level knowledge co-construction processes and involves higher-level questions and answers.

1.3 Scripts to Support Knowledge Co-Construction Activities and Task-Related Monitoring

Pedagogical use of scripts can support productive collaborative learning by structuring and specifying the activities and responsibilities that students are expected to employ during their group work (Hämäläinen, 2007; Kollar, Fischer, & Hesse, 2006). Scripts aim at shaping the way learners interact in a group and engaging learners in discourses that are associated with high-level collaborative learning (Dillenbourg, 2002; King, 2007). Pedagogical scripts provide external support for a group of learners to clarify the type of activities and timing of the activities in order to accomplish the task at hand (Weinberger et al., 2007). The core component of scripts is promotion of learners' activity (Kobbe et al., 2007), which can

involve cognitive processes (e.g. explaining, asking, and summarizing), metacognitive processes (e.g. planning and monitoring) or social processes (e.g. managing role distribution) (Mäkitalo-Siegl & Kollar, 2012).

A recent meta-analysis of scripting (Vogel, Wecker, Kollar, & Fischer, 2016) indicates that learning with scripts can have a positive effect on collaboration skills and on domain-specific knowledge compared to unscripted collaborative learning. Hämäläinen and Häkkinen (2010) found that applying a macro script supported collaboration by giving group members a specific reason to interact and by assisting learners to solve the learning task. However, depending of the degree of coercion, scripts are challenging to design. Too detailed scripts can hinder the spontaneous interactions while too flexible scripts can promote irrelevant interactions (Dillenbourg, 2002).

When a script is used to guide regulation processes in a group, learners can focus on cognitive activities without being overwhelmed by the pressure to plan or monitor the collaborative learning process on their own (Wang et al., 2017). In our previous study (Authors, 2017) we directed the script to the regulation processes by supporting students' engagement to planning, monitoring and evaluating activities. In other words, the aim was not to free students from regulation activities, but to give them a specific time and space within the group work, which they could become more aware of the need for regulation and the type of regulation that would make their group work more productive.

This study continues the previously reported line of reasoning that regulation activities can be supported with a script. Regulation scripts are essential because prior research has proved that regulation activities, such as task-related monitoring, are not self-evident in group interactions and that learners in groups are sometimes not aware of when and how they should be regulating their learning and group interaction (Janssen et al., 2009; Malmberg, Järvelä, & Järvenoja, 2017; Näykki et al., 2017a). Therefore, it is important that students get

first-hand experience in regulation processes within real collaborative learning situations (Belland, Kim, & Hannafin, 2013 Näykki et al., 2017a).

2. Aim

The aim of this study is to explore teacher education students' knowledge co-construction activities in collaborative learning and compare task-related monitoring and script use in groups with active and passive knowledge co-construction. The specific research questions are:

1. How did the groups differ from each other in terms of knowledge co-construction activities?
2. How did the groups with active and passive knowledge co-construction differ in terms of task-related monitoring and script use?

3. Methods

3.1 Context and Participants

The study was implemented in a Finnish University among first-year teacher education students. Since collaborative learning is strongly emphasized in the national curriculum in primary education, future teachers were chosen as participants in order to get knowledge about their collaborative learning skills, and how these skills can be supported during their education. This is also because in order to be able to support collaborative learning of their pupils in future, teacher education students in themselves need a first-hand experience in such learning practices. The participants ($N = 19$) of the study included 12 women and 7 men whose mean age was 23 years. The students participated in a six-week environmental science course. During the course, the students worked face-to-face on five complex and authentic collaborative tasks in environmental science dealing with species, eco systems, map, planetary phenomena, and climate. Each lesson lasted for 90-minutes. The collaborative learning task required students to negotiate and collaboratively design a lesson plan for

teaching the topics for elementary school pupils. The aim of the tasks was to enhance students' conceptual and pedagogical understanding of the environmental science topics. Each task required students to utilize their prior knowledge, and to critically reflect their understanding and the relevancy of each topic from pupil's perspective. To give an example, following instructions were given for the task concerning Ecosystems: "Discuss and plan how to teach forest ecosystems to fourth graders. Save your plan to Google Drive. Complete the following steps: (a) Define core content, complementary content, and specialized content in relation to the topic. (b) Read Bloom's revised taxonomy of cognitive domains. Create educational objectives and tasks for activating both high-order and low-order cognitive processes. (c) Share your plan with the other students in the class. Evaluate the plan of another group and give feedback using the Comment tool in Google Drive. Read and discuss the feedback your group has received."

Mixed-gender groups of three or four students were formed based on their responses to a pre-questionnaire, which assessed their dispositions towards collaboration (Wang, 2009). Items such as 'I enjoy exchanging thoughts' and 'I am open to all sorts of opinions' were scored on a Likert scale. Based on the students' responses, the three student profiles were formed: students who were the most positive towards collaboration, students who were the least positive towards collaboration, and students who were in between. Each small group comprised members of all three profiles.

To support small-group collaboration, a regulation script was used (Authors, 2016; Authors, 2017). Each two-hour study session included three scripted study phases, namely: orientation, check-up and reflection that were prompted via iPads. The orientation phase asked students to set goals and plan their group work at the beginning of each session. In the middle of each session, the students were asked to monitor their progress and plan how they will finish the task (the check-up phase). At the end of the session, the students were asked to

reflect and evaluate their collaborative learning activities. In each phase the script, delivered to students with tablets, included question prompts presented in Table 1. These question prompts were formed based on an understanding of the characteristics of effective regulation in collaborative learning (Hadwin, Järvelä, & Miller, 2011). The groups were instructed when they had to start the scripted discussion, and they could themselves decide how thoroughly they used the script and when they continued with the task work. In practice, the teacher of the course informed when groups could start the script discussions. The teacher ensured that all groups opened the script on the iPad. All groups started the script discussions at the same time. But how thoroughly each group discussed the prompt questions was left to the groups themselves to decide. Therefore, the duration as well as the focus of the scripted discussions varied between the groups.

3.2 Data Collection and Analysis

The study was conducted in a classroom-like setting, and all the face-to-face study sessions were recorded on video tracks with a spherical 360-degree point of view (25 h of video data, mean duration = 1 h 9 min). The data was analysed with the nVivo analysis software. First, the video data were segmented into 30-s events, and content log descriptions were written for each event. The segments provided an analytical focus point for the analysis (Miles & Huberman, 1994; see also Authors, 2017). Second, each event was observed to see if specific knowledge co-construction or monitoring activities were enacted in students' verbal interaction. The coding categories for knowledge co-construction activities were: sharing information, asking questions, providing answers, and making summaries (Table 2). These coding categories were selected as indicators of productive knowledge co-construction based on the findings of previous research (i.e. Chi, 2000; Chinn, O'Donnell, & Jinks, 2000; Loh & Smyth, 2010; Roschelle & Teasley, 1995; Roscoe & Chi, 2008; Volet, Summers & Thurman, 2009; Webb, 1989). The coding categories for task-related monitoring were:

monitoring progress, monitoring content understanding and monitoring task difficulty. These coding categories were based on prior studies on group regulation (Khosa & Volet 2014; Kwon et al., 2014; Lajoie et al., 2015; Lee et al., 2014; Näykki et al., 2017a; Rogat & Linnenbrink-Garcia, 2011; Saab et al., 2012; Ucan & Webb, 2015). The codes were not mutually exclusive; thus, the same segment could be coded under several categories. This possibility for overlapping is based on the assumption that group interaction includes both knowledge co-construction and monitoring aspects. In those segments that included overlapping of the coding categories the groups, for example, expressed lack of content understanding while they simultaneously brought new information into the discussion. Moreover, events which included scripted discussions were coded to determine if different task-related monitoring occurred during scripted studying phases (orientation, check-up and reflection). In practice, each segment including discussion promoted by the regulation script was coded under category the 'Script-use'. The groups had script discussions three times during each study session, namely in the beginning, in the middle, and in the end. On average, the length of script discussions in the entire dataset was 7 min per task. However, the groups themselves decided how thoroughly they used the provided script.

In order to determine differences between groups and the variation between different forms of interaction, in the next phase of the analysis, the qualitative data were quantified: that is, the duration and frequencies of the segments that included knowledge co-construction activities or task-related monitoring were calculated (Chi, 2000; Strijbos, Martens, Prins, & Jochems, 2006). The first and the second authors were responsible for the coding of this study, and refined the coding system. Reliability analysis was used to refine the coding scheme and the analysis. All the knowledge co-constructing activities were analysed by the first author of this article, the second author was responsible for the analysis of task-related monitoring activities. The 25% of the data was used in inter-coder reliability analysis by an

independent researcher. Reliability coding was conducted to the sub-categories of knowledge co-construction and task-related monitoring by the same coder. Since segmenting the data was a purely mechanical operation, no reliability coding was conducted for segmentation. Time-based coding reduced the challenges related to pinpointing the exact second of the beginning or end of the observed phenomenon. Using segments as units of analysis was considered a sufficient means of providing the timing of the coding categories within the 30-s timeframe. The timeframe of 30 s was chosen, because it was long enough to observe several conversational turns but short enough to make detailed and moment-by-moment observations. Cohen's kappa coefficient was selected as a statistical measure for evaluating interrater agreement for qualitative items. Cohen's kappa showed good reliability of the coding for all the categories (see Table 2).

In the next phase of the analysis, those tasks in which all five groups participated were selected for more detailed analysis (see Figure 1). This was done to identify the active and passive groups (in terms of knowledge co-construction activities) for a particular session, ie. groups with highest and lowest number of events including knowledge co-construction. Sessions 2 and 3 were the only ones in which all the group members in five groups were present. When defining the most active and passive group, the number of events that included different forms of knowledge co-construction activities was calculated. Group 5 was the most active group in knowledge co-construction in both of the sessions. Group 4 was the most passive group in the second session, and group 3 was the most passive one in the third session.

This study is descriptive by its nature, since the main aim is to give insights of what is happening in active and passive knowledge co-construction situations. Therefore, the qualitative examples are described in detail to illustrate the results of the quantified analysis.

Qualitative examples show in particular how the different forms of knowledge co-construction, task-related monitoring and script use were evidenced in this study.

4. Results

4.1 How Did the Groups Differ From Each Other in Terms of Knowledge Co-Construction Activities?

The results show that the groups spent, on average, 38 min (52.7%) of their total group working time in sessions 2 and 3 for knowledge co-construction activities. The rest (47.3%) of the working time was divided across activities such as reading learning material, discussing personal issues and a teacher led instruction. However, there were differences between groups: while the group 5 spent 60% (average of sessions 2 and 3) of their group working time on knowledge co-construction activities, the percentage in group 3 was 42%.

The results of the type of knowledge co-construction activities show that overall, the groups in this study were more active in information sharing ($M = 38.4$ events) and questioning ($M = 38$ events) than in answering ($M = 33.4$ events) and making summaries ($M = 19.6$ events).

Active and passive groups in terms of knowledge co-construction activities. There were differences in the number of events involving knowledge co-construction activities between the groups (see Figure 2). The most active group was Group 5, which had the highest number of events involving knowledge co-construction activities ($f = 163$). The most passive group was Group 3, which had the least number of events involving knowledge co-construction activities ($f = 108$). However, when sessions 2 and 3 were considered separately, it was noted that in session 2, Group 4 was the most passive one instead of Group 3 (see Figure 3).

In session 2, the groups differed in terms of both the total amount and the proportion of the different types of knowledge co-construction activities (min = 35, max = 71). The active

group, namely Group 5, had the highest number ($f = 71$) of events involving knowledge co-construction activities, but it also showed a high frequency of all the different types of knowledge co-construction activities: information sharing ($f = 19$, 27% of all codings for knowledge co-construction), question asking ($f = 19$, 27%), providing answers ($f = 17$, 24%) and summarizing ($f = 16$, 23%). The passive group, namely Group 4, showed a considerably low frequency ($f = 35$) of the different types of knowledge co-construction activities: information sharing ($f = 10$, 29%), question asking ($f = 12$, 34%), providing an answer ($f = 8$, 23%) and summarizing ($f = 5$, 14%). As the data show, compared to Group 5, Group 4 was especially more passive in terms of summarizing previous discussions. In Group 5, 23% of the coded knowledge co-construction activities involved summarizing, while in Group 4 only 14% involved summarizing. Table 3 illustrates these differences in the types of knowledge co-construction activities between the active and passive group.

In the third session, group 5 was again the active one, but unlike the observation in session two, group 3 was the most passive one in session 3 in terms of the total number of events involving knowledge co-construction activities (group 5, $f = 92$; group 3, $f = 50$) and the frequency of different types of knowledge co-construction activities. The active group was actively engaged in different types of knowledge co-construction activities: information sharing ($f = 29$, 32% of codings to knowledge co-construction activities), question asking ($f = 26$, 28%), providing an answer ($f = 21$, 23%) and summarizing ($f = 16$, 17%). In contrast, the passive group was less actively engaged in different types of knowledge co-construction activities: information sharing ($f = 16$, 32%), question asking ($f = 15$, 30%), providing an answer ($f = 14$, 28%) and summarizing ($f = 5$, 10%). Likewise in the session 2, the active group showed a higher frequency of events involving summarization of the discussions than the passive group.

4.2 How Did the Groups with Active and Passive Knowledge Co-Construction Differ in Terms of Task-Related Monitoring and Script Use?

Task-related monitoring in groups with active and passive knowledge co-construction. In general, the active group was more actively involved in monitoring the task during collaborative learning (see Table 4). All the groups engaged in monitoring, but differences between the active and passive groups were found in terms of the frequency and types of monitoring activities. The active group, namely Group 5, monitored the task more actively in both sessions compared to the passive group (Group 4 in session 2 and group 3 in session 3). The active group also concentrated more on monitoring content understanding in both sessions than the passive group. Further, while both groups actively monitored their progress, the passive group was relatively more active in this type of monitoring than the active group.

Especially in session 2, the frequency of task-related monitoring events was higher in the active group (Group 5, $f = 40$) than in the passive one (Group 4, $f = 22$). Moreover, the frequency of the different types of task-related monitoring was also different between the active and passive groups in session 2. For example, the active group concentrated more on monitoring content understanding than the passive group (28% and 5%, respectively). Within an active group, task-related monitoring and knowledge co-construction activities alternated and co-occurred, i.e. while the group members were constructing knowledge together, they also monitored the task actively as shown in Figure 5. The active group was monitoring their progress as well as their content understanding and task difficulty throughout the session.

Next we present a case example to increase an in-depth understanding on how the task-related monitoring and knowledge co-construction activities alternated in the interaction (see Table 5). Our case example illustrates how group members monitored task difficulty in an elaborative way, how they reflected why task was challenging for them. Likewise, the case example shows how monitoring content understanding also lead to a progress in knowledge co-construction.

While the active group concentrated more on monitoring content understanding during session 2, the passive group concentrated more on monitoring task difficulty (36% vs. 22%). Group members expressed their concerns about the task difficulty throughout the session 2 (see Figure 5). In contrast, the passive group had only two moments when they elaborated their content understanding.

As seen in a Table 6 the discussion of group 4 was not as focused as the discussion by group 5. Task-related monitoring did not necessarily lead to more elaborated knowledge co-construction. For example, monitoring task difficulties mainly concerned short statements like ‘This is difficult’ instead of elaborating the difficulty further like in the active group: ‘it is challenging to draw a line between basic and supplementary knowledge’.

Script use in active and passive groups. The results show that the active and passive groups differed in the ways they used the provided script for collaborative learning. In both sessions 2 and 3, the passive group spent less time in the scripted discussion than the active group. In session 2, the active group spent 14 min in scripted discussions while the passive group spent 5 min. In session 3, the active group spent 6 min in scripted discussions and the passive group spent 4 min. However, there were also similarities in script use between the groups: namely, both groups spent more time in the orientation and check-up phases than in the reflection phase (see Table 7).

In addition to the differences in time spent on the scripted discussions, there were also differences in the focus of the scripted discussions. In the session 2 among the active group, 44% ($f = 11$) of the events involved monitoring content understanding, 36% ($f = 9$) involved monitoring progress, and 20% ($f = 5$) involved monitoring task difficulty. In the passive group, 9% ($f = 2$) of the events involved monitoring content understanding, 31% ($f = 4$) involved monitoring progress, and 60% ($f = 7$) involved monitoring task difficulty. In the session 3 the total amount of events (active group, $f = 19$; passive group $f = 16$) including

task-related monitoring didn't differ as much as they did in the session 2, there were differences of the focus of the scripted discussions. Among the active group 42% of the events coded for task-related monitoring included monitoring content understanding, 32% monitoring progress and 26% monitoring task difficulty, while among the passive group percentages were 37, 13 and 50. In both sessions, the most active group concentrated more on monitoring content understanding than the most passive group:

I think we have progressed well. The only thing is this understanding...I think I fully don't have it. The concepts we use are ok, but now we should construct an overall understanding of this issue, because I feel that I can't teach this to the pupils, if I don't fully understand it. It would be easier for me to teach if I understand what the ecosystems in the forest are and how the food chain influence to it. But we have progressed well. (Anni, session 2, Group 5, check-up phase)

While the active group had more events involving the monitoring of content understanding, the passive group had more events involving the monitoring of task difficulty during the scripted studying phases in both sessions:

Piia: Now this is a little bit challenging...

Virpi: This is a same phenomenon every time when you have to start to think something teaching related issue from point zero when you don't know how to... At least I don't have a realistic idea what it will be in the school...

Piia: It would require time and that we could visit there (in the school) (Session 3, Group 4, check-up phase)

Based on the contents of different scripted studying phases (orientation, check-up and reflection), it can be concluded that the active group monitored their progress in all the scripted studying phases while the passive group monitored their progress only in the check-

up phase (see Figure 6). On the other hand, the passive group monitored task difficulty during all three scripted studying phases, while the active group monitored task difficulty only in the orientation and check-up phases. Both groups monitored content understanding more at the beginning of the session, during the orientation and check-up phases, but not in the reflection phase.

In session 2, the active group had already started to monitor their progress in the orientation phase by discussing how they needed to proceed with the task (see Table 8). In the check-up phase, they monitored the current stage of progress, and in the reflection phase, they monitored issues that affected their progress.

In session 2, the passive group monitored task difficulty during all the scripted studying phases (see Table 9). In the orientation phase, after familiarizing themselves with the task, they started monitoring its difficulty. In the check-up and reflection phases, they examined in more detail the reasons why the task was challenging for them.

5. Discussion

This study explored knowledge co-construction activities, task-related monitoring and scripted interaction in collaborative learning among first-year teacher education students. The study focused on the different types of knowledge co-construction activities (sharing information, asking questions, providing answers and making summaries) that take place in small groups, and task-related monitoring and script use in groups that were the most actively and least actively involved in knowledge co-construction activities. To summarize, the results indicate that overall, all small groups spent only half of their working time on knowledge co-construction activities. There were differences between the most active and least active groups in terms of the frequency of knowledge co-construction activities. The study shows that the most active group was more active throughout the different types of knowledge construction activities, and particularly more frequently involved in

summarization of the group discussions than the passive group. Moreover, the active group used the script more frequently and engaged in more task-related monitoring activities. Furthermore, the active group was more involved in monitoring their content understanding both in the scripted studying phases and during task working, and they also monitored their progress throughout the sessions. On the other hand, the passive group was more focused on monitoring task difficulty both during and between scripted discussions, indicating the observation of challenges their group was currently facing.

In this study, the participant groups spent approximately half of their group working time in knowledge co-construction activities during the two-hour study sessions. The rest of the working time was spent on activities such as reading learning materials and having discussions related to social issues. Previous research (e.g. Hou & Wu, 2011; Janssen et al, 2009; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003) has also evidenced that a relatively small part of the interaction between small group members focuses on the exchange of or questions about task-related information. However, off-task behaviour like joking and discussing personal issues may also be an indicator of a trustful group atmosphere, which in turn is one important prerequisite for productive knowledge co-construction (Authors, 2016).

The findings of the present study are in line with the earlier studies (e.g. Hmelo-Silver & Barrows, 2008; Khosa & Volet, 2014; Summers & Volet, 2010), which have reported that groups that actively participate in collaborative learning are more likely to be engaged in high-level knowledge construction than passively participating groups. In this study, especially during the second session, the active group was engaged in elaborative discussions by providing answers and summaries related to the preceding discussions. This kind of exploratory discussion has been shown to be essential for effective collaborative learning (Wegerif et al., 1999). Especially the importance of summary making is highlighted in earlier studies on knowledge co-construction, since summarizing requires learners to integrate and

organize different perspectives and ideas presented in the discussion (De Wever, Van Keer, Schellens, & Valcke, 2010; Schellens, Van Keer, De Wever, & Valcke, 2007). In the present study, the active group summarized the discussions almost twice as actively as the passive group. Summarizing might have promoted their content understanding and assisted the group to proceed with the collaborative task.

This study indicates that active group in terms of knowledge co-construction was active also in terms of task-related monitoring. In agreement with this finding, the study of De Backer et al. (2015) shows a positive correlation between group members' adoption of regulation activities and content-processing strategies and transactive content-related discussions where students elaborate on each other's contributions. De Backer with colleagues (2015) also found that monitoring of activities was strongly related to knowledge co-construction activities such as questioning and explaining.

In the present study, the active group was more engaged in monitoring activities, especially in monitoring content understanding, than the passive groups; this is also reported in the study of Khosa and Volet (2014). Further, both the active and passive groups monitored their task progress quite often, although the active group monitored their progress in all studying phases while the most passive groups monitored their progress only when it was requested in a provided script in the middle of the session. This result is in line with the study of Janssen et al. (2009), which also found that monitoring task progress was one of the most common regulation activities among students while working on a collaborative task. In general, there were differences in both the quantity and quality of task-related monitoring among small groups.

The importance of task-related monitoring has been highlighted in prior research, which has reported that small groups need support in regulating collaborative efforts, and that this support might have a positive impact on cognitive interaction in collaborative learning

(Näykki et al., 2017b; Polo, Lund, Plantin, & Niccolai, 2016). In this study, monitoring activities were supported with a regulation script. The results indicate differences in script use, as also evidenced in the study of Hämäläinen and Häkkinen (2010), who examined the differences between ideal and actual script use. Their study indicated that different groups act differently despite using a similar script, and that using a collaboration script does not guarantee high-level collaboration. The present study indicates that in terms of knowledge co-construction activities, the active group used the script more for monitoring activities than the passive group did. However, all groups only used a limited amount of time, on average 7 minutes, for scripted discussion per task, which might indicate that they did not need it, or they did not understand its benefits. Despite the benefit of the script, it can also harm collaboration by guiding students' focus away from the actual on-task contents (Weinberger et al., 2007). Although this study assumed that first-year teacher education students' regulation skills are not fully developed and therefore they need external support for promoting task-related monitoring, the script might have cut the collaboration flow especially as all the groups were asked to have the scripted discussions at the same time.

6. Conclusions

This study contributes to the current discussion concerning productive collaborative learning by providing a holistic view of authentic collaborative learning situations based on the combined aspects of knowledge co-construction, task monitoring, and script use. This study provides evidence to explain how groups that are active or passive in knowledge co-construction use script as a support for their group learning and engage in key regulation activities, such as the different types of task monitoring, namely, monitoring content understanding, progress, and task difficulty. This study also provides an example of process analysis focusing on the interaction related both knowledge co-construction and task-related monitoring. In addition, this study contributes to research on collaborative scripting by

paying attention to the regulation processes of groups and the relationship between effective script use and knowledge co-construction activities.

Our contribution extends the findings of previous studies of knowledge co-construction by evidencing that groups who actively participate in knowledge co-construction are also more active in monitoring their learning. The findings of this study suggest that those groups whose knowledge co-construction is passive, might need other kind of supportive activities, like more specific support for task-related monitoring and increasing their awareness of effective knowledge co-construction. In addition, this study contributes to the script discussion by offering an authentic example of how groups of teacher education students use external support during an extended period of time (six weeks). Our study indicated that the script prompted task-related monitoring in general, and especially the more active group used the provided support more thoroughly. This supports evidence that scripting on its own may be insufficient for some groups, possibly because of differences in how students appropriate scripts (Stegmann, Kollar, Weinberger, & Fischer, 2016; Tchounikine, 2016).

Finally, the present study highlights the importance of empirical studies that analyze higher education students' collaboration on open-ended knowledge problems that require critical thinking and an analytical approach. Such studies give an insight of how students work in a specific context, in this case teacher education, and therefore provide realistic understanding about the possibilities and challenges faced by students in their collaborative learning.

There are practical implications of this study with the regard to designing collaborative activities for teacher education and higher education students. For example, this study shows that active and high-quality knowledge co-construction is not self-evident, and that skills for productive knowledge co-construction activities need to be developed by training students how to summarize discussions and how to present thought-provoking questions. By

prompting regulation activities among students, such as task-related monitoring, teachers can support students to engage in metacognitive processes that are related to high-level knowledge co-construction.

This study has certain limitations, such as its small sample size. In order to conduct statistical analysis to strengthen the present findings, more participants and more data is required. Although no generalizations can be made based on the present data, this study contributes to the field of process-oriented research by presenting findings from real-life collaborative learning situations (Fischer & Järvelä, 2014; Järvelä, Järvenoja, & Näykki, 2013). In addition, based on the results of earlier studies, it was assumed that active knowledge co-construction activities, task-related monitoring and script use lead to better learning outcomes. However, more research is needed to determine whether active participation and high quality of knowledge co-construction activities and task-related monitoring actually lead to better learning outcomes. In addition, future research should explore the reasons why some groups participated actively both in knowledge co-construction activities and task-related monitoring whereas other groups were less active.

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Table 1

Question prompts in three scripting phases

Script phase	Orientation	Check-up	Reflection
Script questions	What is the purpose of the task? What kinds of feelings does the task arouse? What kinds of strengths does your group have? What is the goal of your group work?	How has your work progressed? What kinds of feelings does your work arouse? What kinds of challenges are you currently facing? How will you proceed from here? on?	How would you evaluate your work as a group? How did you reach your results? What helped or hindered reaching your goals? How did you overcome? possible challenges?

Table 2

Coding rules and examples of analysis

Code	Coding rule	Example from the data	Cohen's κ
Knowledge co-construction activities			
Sharing information	Introducing new information or concepts into the discussion. The information is either based on one's own experiences and references, or it is a generally known fact.	"This is related to what is said in the curriculum about taking care of the environment, this is related to ecosystems, in the curriculum they are talking about global and multicultural issues... so this is related to the uniqueness of one's own ecosystem, that something is unique in our ecosystem."	.90
Asking questions	Presenting content-related questions that clearly require an answer and which are related to the task (not, for example, to the working methods, such as making notes). The question can be: a new question a statement followed by related question a question that repeats a question which is already presented a confirming question a suggestion that is in the form of a question.	"There is not only forest ecosystem, but it is linked to the water ecosystem, they are not functioning separately." "So which new contents there will be in grade four?" "The best place for the first graders to do orienteering is their own school yard, but is it too big for them?" "Was it so that...', 'Have I now understood this correctly..." "Or should we start with an ecosystem that is already familiar with them?"	.86
Providing answers	Presenting a content-related answer, which can be: new answer answer that continues previous answers or specify them.	"So, in the grade three they have already gone through the ecosystems, the single actors." "...so those single actors which actually are part of different ecosystems."	.88
Making	Summarizing or reviewing	"So the main point in our discussion	.93

summaries	previous discussions, for example, in a situation where the group is making notes.	was, that pupils understand the special characters of the environment near to them and environment in general.”
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Task-related monitoring

Monitoring progress	Students voice their perceptions of their progress in task completion and their goals.	“This has not been very fluent for us.”	.93
Monitoring content understanding	Students explicitly express or discuss their understanding of the content.	“This is not at all clear to me. You obviously had an idea about that.”	.95
Monitoring task difficulty	Student express their thoughts about challenges, problems, or difficulties related to conducting a task.	“These learning objectives are really hard to set in this lesson plan.”	.90

Figure 1. Research design.

Figure 2. Number of events involving knowledge co-construction activities in sessions 2 and 3 in total per group.

Figure 3. Number of events involving knowledge co-construction activities in sessions 2 and 3 per group.

Table 3

Data on knowledge co-construction activities in the active and passive group

Task: Creating a lesson plan for 4th graders about ecosystems	Knowledge co-construction activity	Time
Active group		
Jonna: "Consumers are eating..."	Sharing information	25:30
Pekka: "... other living organisms."	Sharing information	25:45
Jonna: "Ok, then we move to the decomposers..."	Sharing information	26:00
Anni: "So, by the way, should we also define... or did we already define what is ecosystem?"	Asking questions	26:04
Maria: "Yes, we did, well, it consists of living and non-living nature..."	Providing answers	26:10
Pekka: "It is important to highlight, related to decomposers, that they are decomposing dead organic material, and use that as their nutrition."	Sharing information	26:25
Jonna: "In other words they are heterotrophic organisms, which are decomposing dead material."	Making summaries	26:30
Liisa: "But do they teach the concepts 'heterotrophic' and 'autotrophic' already in the fourth grade?"	Asking questions	26:35
Anni: "Yes I think they do. I remember from my own school time that I have been studying these concepts. I remember that teacher explained us, that consumers are autotrophic..."	Providing answers	26:40
Passive group		
Hanna: "What it comes to applying knowledge, here (in the curricula) is a verb 'interpret'..."	Sharing information	43:30
Virpi: "Yes, it is, if you show some pictures to him (pupil), that he is able to interpret that these pictures actually illustrate ecosystem."	Sharing information	43:40
Hanna: "It seems to me that understanding and applying knowledge go hand in hand because if you don't understand you can't apply, or, I don't know... you are able to apply via understanding."	Sharing information	43:50
Virpi: "Is this 'analysing' already related to food chain? It is said in the book that 'decompose information into component level and search the connections between them'."	Asking questions Sharing information	44:27
Hanna: "Yes, understanding the organizational structure, yes I think it is that. And maybe still about the concept 'analysing', I think it is important to go out from the most nearest environments and the nearest ecosystem, and through that start constructing..."	Providing answers Sharing information	44:30
Virpi: "Yes, and it is a very good base when a child is able to see, that this is a reality, and after that starts to construct so called	Sharing information	44:50

wider awareness.”

Virpi: “But what curricula emphasizes is experiencing and acting.”	Sharing information	45:26
Hanna: “In the curricula it is said that teacher’s role is to guide a child.”	Sharing information	45:32
Virpi: “That pupils are provided possibilities to discover. And via that they will have questions... ”	Sharing information	45:40

Table 4

Frequency and types of task-related monitoring activities in the active and passive groups

Group	Session	Content understanding	Progress	Task difficulty	Total
5 (active)	2	11 (28%)	20 (50%)	9 (22%)	40
4 (passive)	2	1 (5%)	13 (59%)	8 (36%)	22
5 (active)	3	8 (40%)	10 (50%)	2 (10%)	20
3 (passive)	3	4 (27%)	10 (67%)	1 (6%)	15
Total (n)		24	53	20

Figure 4. Example of the density of knowledge co-construction and monitoring activities among the active group in session 2.

Table 5

Data example how the task-related monitoring and knowledge co-construction activities alternated in the interaction within an active group

Task: Creating a lesson plan for 4th graders about ecosystems	Category	Time
Active group		
Jonna: "We still need to think the aims of the lesson."	Monitoring progress	43:30
Pekka: "Yes, ok, what it comes to the aims of supplementary knowledge we have already written the food chain and food web."	Making summaries	
Pekka: "But what else is included in the supplementary knowledge?"	Asking questions	
Anni: "Add also the key species there."	Providing answers	
Jonna: "This is quite a challenging task because basically you know these contents but you don't have a knowledge about pupils' prior knowledge."	Monitoring task difficulty	44:30
Anni: "Yes, and also it is challenging to draw a line between basic and supplementary knowledge."	Monitoring task difficulty	
Pekka: "So we can say that the basic knowledge is living and non-living nature, and producers, consumers and re-composers."	Making summaries	45:30
Jonna: "I think our task here was to write only the basics here, and a teacher could verbally explain the examples of living and non-living nature."	Monitoring content understanding	
Pekka: "What could be an example of non-living nature then?"	Asking questions	
Maria: "Stones and soil for example. "	Providing answers.

Figure 5. Example of the density of knowledge co-construction and monitoring activities among the (passive group) in session 2.

Table 6

Data example how the task-related monitoring and knowledge co-construction activities alternated in the interaction within a passive group

Task: Creating a lesson plan for 4th graders about ecosystems	Category	Time
Passive group		
Hanna: "We are not progressing."	Monitoring progress	38:30
Virpi: "Let's see what we already have there."	Monitoring progress	39:30
Hanna: "We have producers, consumers and decomposers, yes, that is important."	Making summaries	
Martta: "Yes, I think that is enough what it comes to aims."	Monitoring progress	
Virpi: "Write there that a pupil is able to compare forest ecosystems."	Sharing information	40:30
Hanna: "Is it lower level knowledge still?"	Asking questions	41:30
Virpi: "I think comparing belongs already to advanced level knowledge."	Providing answers	
Hanna: "How about when a pupil already can interpret the features of forest ecosystem, that there are unique species already?"	Asking questions	
Hanna: "Oo, how this can be so difficult."	Monitoring task difficulty	
Martta: "Is that already applying?"	Asking questions	42:30
Hanna: "I have to admit, this is too difficult, way too difficult for me."	Monitoring task difficulty	
Martta: "Yes, this is difficult."	Monitoring task difficulty	

Table 7

Percentage of time spent in each scripted studying phase in sessions 2 and 3

	Orientation	Check up	Reflection
Session 2			
Active group	41%	49%	10%
Passive group	24%	57%	19%
Session 3			
Active group	37%	44%	19%
Passive group	61%	26%	13%

Figure 6. Number of events involving different types of task-related monitoring during scripted studying phases in total in sessions 2 and 3.

Table 8

Data examples on monitoring progress in each scripted studying phase in the active group in session 2

Session 2, Group 5 Task: Lesson plan about ecosystems	
Orientation	<p>Maria: “What we have to do now is to figure out what ecosystems are, and elaborate which contents does they include.”</p> <p>Anni: “An also, we need to discuss, what are the contents which are appropriate for the pupils.”</p>
Check-up	<p>Heidi: “I think we have progressed quite well, we can do this.”</p> <p>Jukka: “Yes, if we think what we have done so far, so we have now the contents and aims (for the lesson plan), which means that we are approximately in a midpoint.”</p> <p>Maria: “In the beginning this task was a little bit confusing, but now I think we have achieved more clear understanding about it.”</p>
Reflection	<p>Anni: “We had some moments when we did not progress but instead we just repeated what we already had discussed earlier, and we also lost the focus. We also had barely enough time to do this task.”</p> <p>Heidi: “Yes, hurry drove us to ‘quick fix’ solutions.”</p> <p>Jukka: “Hurry hindered us to achieve some of our tasks, we did not get as thorough lesson plan as we would have wanted to.”</p>

Table 9

Data on monitoring task difficulty in each scripted studying phase in the passive group

Session 2, Group 4 Task: Lesson plan about ecosystems	
Orientation	Jari: "This is not an easy task to do. Today's task is not easy at all: How to teach ecosystems to 4 th graders?"
Check-up	Piia: "This is really wide topic." Jari: "This is challenging task. Now they have wanted to challenge us." Piia: "It's challenging to think this issue as a coherent content set, even the curriculum is too wide to study in such a limited time." Pekka: "Concept is really wide, especially when we have to study it only from the perspective of 4th graders."
Reflection	Jari: "Technical problems with the tools disturbed our progress, but luckily we found the solutions for this." Pekka: "And did we also have some challenges with the concept, because the phenomena we were studying is so broad? But we managed to work with it quite well, didn't we?".