Deep learning evaluation in vocational teacher education: Conducted on the principles of authentic and dialogical collaborative knowledge construction

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Abstract

The vocational education system is being challenged to achieve a greater amount of deep learning. To facilitate the inclusion of more deep learning in the teaching and learning process, curriculum restructuring is required. This article reports the results of a study that investigated the kind of authentic and dialogical collaborative knowledge construction toward which the DIANA model (Dialogical Authentic Netlearning Activity) directs vocational student teachers (n=76). The results indicate that using authenticity as the basis for a learning process enabled individual study circles (f=19) to define questions that were meaningful to them but mainly directed the learners toward superficial learning-oriented activities. Notably, despite engaging primarily in superficial learning-oriented activities, the results indicate that dialogical collaborative knowledge construction still directed the learners toward deep learning, demonstrating how learning changed and was enriched during the process. The framework re-designed for evaluating superficial and deep learning will facilitate the examination of vocational teacher education learning activities in the future.

Keywords: deep learning evaluation, authentic and dialogical collaborative knowledge construction, vocational teacher education, DIANA model

Introduction

To achieve a greater amount of deep learning in the vocational education system calls for competence in complex, collaborative, and technology-driven global thinking. Moreover, the demands of vocational and professional work require graduates of the system to be competent in higher-order thinking skills (see Brookhart, 2010; West, 2015). A focus on these skills has far-reaching implications for the quality of education (Teräs, 2017). Interdisciplinary pedagogy requires integrative and transdisciplinary learning; this is closely entwined with collaborative thinking and problem-solving that are independent of culture, subject matter, or field of study (Stokols, 2014). Essentially, the higher-order thinking skills in question include evaluating information and arguments, understanding connections, constructing meaningful knowledge, and applying that knowledge to work. Facilitating deep learning requires restructuring the curriculum of the teaching and learning process by introducing a wide range of open and technology-driven collaborative learning opportunities. The sociocultural approaches to learning have had an impact on research in this area and the wider discussion by focusing on the interplay between digital technologies and learning (Ludvigsen, Lund, Rasmussen & Säljö, 2011, p. 3), and it is obvious that those tools affect the depth of learning. To complement other competencies, students should be capable of collaboratively dealing with the complexity of the tasks in which they will engage in professional situations.

Sociocultural theory, which provides the explanatory framework for this study, sees learning as a social (e.g., Lave & Wenger, 1991; Vygotsky, 1978), authentic (Herrington, Reeves & Oliver, 2010), and dialogical collaborative knowledge construction (Aarnio & Enqvist, 2002; Bohm, 2004; Enqvist & Aarnio, 2004; Lave & Wenger, 1991; Paavola, Lipponen & Hakkarainen, 2002; Sfard, 1998). Sociocultural theory also provides a theoretical framework for the assumptions that support three metaphors of learning: learning as individual knowledge acquisition, as participation in dialogue in a community (Sfard, 1998), and as knowledge creation (Paavola et al., 2002).

This article presents a study based on the Dialogical Authentic Netlearning Activity (DIANA) model (Aarnio & Enqvist, 2002, 2016) in a vocational teacher education programme provided by the Häme University of Applied Sciences, School of Professional Teacher Education, Finland. Previous studies (Aarnio, 2006; Enqvist & Aarnio, 2004) have indicated that authentic and dialogical learning is difficult to achieve in online settings and that knowledge construction should be structured more deeply in the learning processes of teacher education. Our work as teacher educators has raised questions about the kind of learning in which current vocational teacher education results. The preliminary results of studies on online learning in teacher education by Aarnio and Enqvist (2007, p.

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152) indicate that dialogical knowledge construction is rarely linked to conceptual knowledge and is not deepened through thinking or argumentation on one's own. However, little research has focused on the learning outcomes of authentic and dialogical knowledge construction. This study provides new insights into research on the evaluation of deep learning and what kind of learning outcomes may result from authentic and dialogical collaborative knowledge construction settings.

This research aims to investigate what kind of authentic and dialogical collaborative knowledge construction vocational student teachers are directed to by the DIANA model when the learning goals of the study module require considerable deep learning. The case study examines vocational student teachers' (*n*=76) learning activities that are involved in constructing authentic and dialogical collaborative knowledge in the study module 'Networks in Vocational Education' (2014–2016). The learning design of the module was based on the DIANA model. The vocational student teachers were divided into study circles in the each implementation. The term study circle refers to a small study group in a learning community. Firstly, we quantified the qualitative data, i.e., the authentic learning questions (*f*=350) that had been defined by student teachers collaboratively at the beginning of the learning process. Secondly, through abductive analysis, we explored the qualitative differences in study circles' (*f*=6) authentic and dialogical collaborative knowledge construction. The material for the study was gathered from the online blog diaries of the study circles. An evaluation framework for deep learning activities (Figure 1) was used for the quantification and analysis of the data. The results of the research explicitly indicate additional elements of the DIANA model, some or all of which should be implemented to facilitate deep learning.

Theoretical framework

Framework for evaluating deep learning

Previous studies in the literature have defined deep learning as the achievement of higher-order thinking skills, such as analysing, interpreting, inquiring, comparing, evaluating, producing understanding, and creating knowledge (Anderson et al., 2001; Nelson Laird, Seifert, Pascarella, Mayhew & Blaich, 2014; Paavola, et al., 2002; Schraw, Flowerday & Lehman, 2001). According to Lucas (2001), superficial learning is associated with mere memorisation, and lower-level cognitive processes (i.e., recalling and comprehending facts) tend to be involved. In previous research, students who searched for underlying meaning were said to be engaging in a deep learning process. Biggs and Tang (2011, p. 26) concluded that deep learning arises from a need to engage in a task meaningfully and when students try to use the cognitive activities most appropriate for the task (cf. Garrison & Cleveland-Innes, 2005). Other studies have indicated that learning as

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knowledge construction is a process that will enrich itself or change considerably during the process (Paavola et al., 2002). It has also been observed that community-based learning results in deep learning (Ryan & Deci, 2000; Bereiter, 2002; Enqvist & Aarnio, 2004; Näykki, 2014). The shift from passive, teacher-centered pedagogy to active, learner-centered activities promises to help students achieve deeper levels of understanding, thinking, and reasoning as the students apply what they learn to real work situations (Cho & Rathbun, 2013).

Several frameworks for measuring deep learning (Anderson et al., 2001; Biggs, 1992; Entwistle, 2005; Marzano & Kendall, 2008) have been developed. The one most widely used is the framework developed by Bloom (1956), which has been updated to reflect 21st-century learning and teaching (Anderson et al., 2001). This framework classifies the knowledge that students are expected to acquire or construct and remember, understand, apply, analyse, evaluate, and create.

Based on a synthesis of all of the above through adaptation of Bloom's (1956) framework as revised by Anderson et al. (2001, p. 31) and grounded in our long experience as teacher educators, we re-designed a framework for evaluating deep learning activities (Figure 1). Unlike Bloom in his framework, we think that, in the context of vocational teacher education, the level of applying knowledge already demonstrates a deep learning activity.
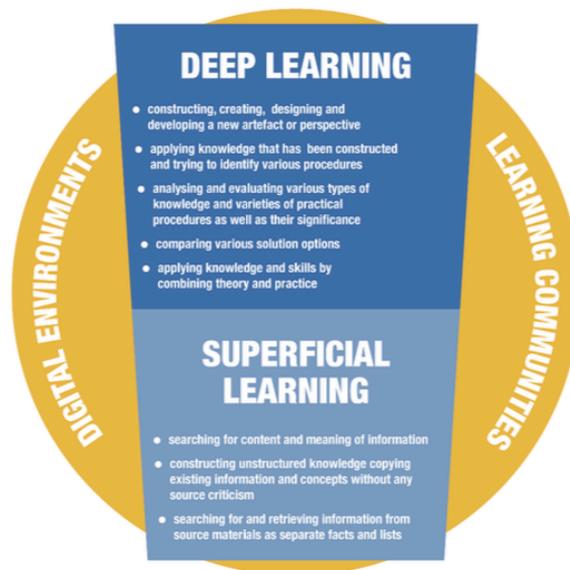

Figure 1. An evaluation framework for deep learning activities through authentic and collaborative knowledge construction (see also Anderson et al., 2001, p. 31; Bloom, 1956).

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The re-designed framework distinguishes between the nature of deep versus superficial learning by the presence of authentic and dialogical collaborative activities of knowledge construction in a learning community. In this re-designed framework, superficial learning activities are understood as retrieving separate, previously existing, unstructured knowledge and transferring it to the group's virtual learning environment. In contrast, deep learning activities require knowledge to be applied, compared, analysed, and evaluated; procedures are identified and constructed; and new knowledge and skills are developed. Figure 1 describes authentic and dialogical collaborative knowledge construction as a deepening learning process and categorises the learning activities in a learning community. The funnel depicts how the activities of collaborative knowledge construction deepen and expand. The term *group* refers to a study circle or other small group in a learning community. We believe that this re-designed pragmatical framework for evaluating deep learning (Figure 1) is a potential tool for teacher educators to assess deep learning activities.

Deep learning through authentic and dialogical collaborative knowledge construction

We approach authentic and dialogical collaborative knowledge construction from the perspective of sociocultural theory. Furthermore, we understand learning as participation in a community and as the knowledge construction and knowledge creation that take place there (Lave & Wenger, 1991; Paavola, Lipponen & Hakkarainen, 2004; Sfard, 1998; Vygotsky, 1978). This is in line with previous research that has seen dialogue as a key factor in supporting and encouraging deep learning in a learning community (Aarnio, 2006; Chapman, Ramondt & Smiley, 2005; Enqvist & Aarnio, 2004; Mercer & Howe, 2012; Ruhalahti, Korhonen & Rasi, 2017; Smith & Colby, 2007).

In authentic learning, learners are engaged in an inventive and realistic task that provides opportunities for complex collaborative activities (Herrington, Reeves & Oliver, 2010, p. 1; Shaffer & Resnick, 1999). Recent vocational teacher education studies have revealed that students have difficulty understanding the concept of authenticity (Ruhalahti, Korhonen & Ruokamo, 2016; Teräs, 2016). In addition, scaffolding is seen as crucial for generating authentic learning (Aarnio, 2006). Authentic learning promotes deep learning (cf. Czerkawski, 2014; McGee & Wickersham, 2005) as well as authenticity in knowledge sharing when learners collaboratively create conceptual artefacts (Tillema, 2006).

Unique products, dialogical artefacts (Kloetzer, 2017), and new knowledge are results of dialogical collaborative knowledge construction. Their creation, however, requires reciprocal, committed, goal-oriented, and shared activities as well as commitment to such activities (Resnick, 1991). Students should employ approaches that facilitate deep learning by creating and constructing meanings through collectively shared artefacts that expand their expertise (Paavola et al.,

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2004; Paavola, Engeström & Hakkarainen, 2012). Collaboratively constructed real-world and open-ended problems engage students in the process of developing new artefacts (Eklund, Mäkitalo & Säljö, 2011, p. 124; Fredriks, 2014; Muukkonen, Lakkala & Paavola, 2011, p. 172). In research on higher education, Aarnio (2015) concluded that students cannot achieve deep learning without skills of collaborative knowledge construction.

Engeström and Toiviainen (2011, p. 33) challenged learning designers to consider how to integrate the demanding theoretical principles of productive learning, communities and practices, and technological solutions into one process and a meaningful product. Technology is seen to offer possibilities of enhanced collaborative knowledge construction, engagement, and learning through dialogical interaction that can result in better collaboratively shared artefacts (Aarnio & Enqvist, 2016; Enqvist & Aarnio, 2004; Gibson, 2013, pp. 459–460; Wegerif, 2006).

Learning according to the principles of the DIANA model (Figure 2) requires higher-order thinking as it is based on constructing authentic and dialogical knowledge in a learning community. The entire learning process has been designed to encourage learners to act in ways that direct them toward deep learning (Aarnio & Enqvist, 2002, 2016).
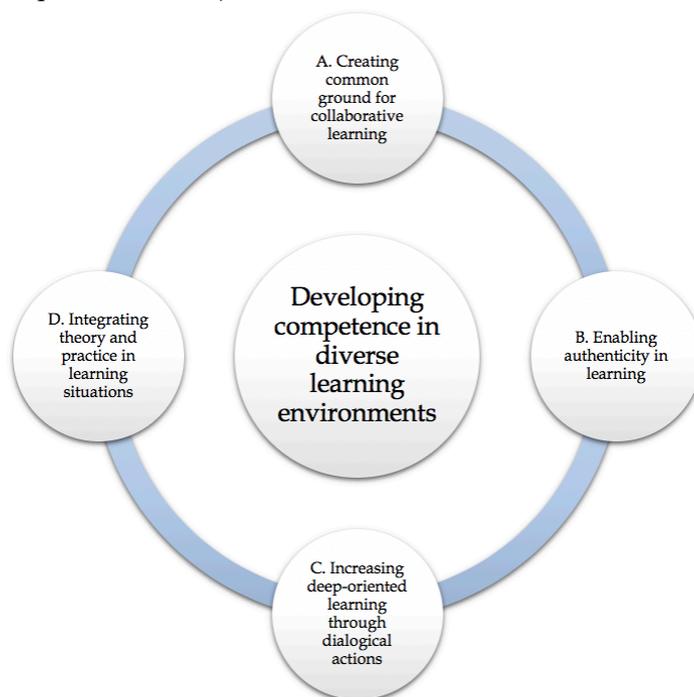

Figure 2. The structure of the DIANA model (Aarnio & Enqvist, 2016, p. 44).

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The study module presented here was designed and implemented using the DIANA model (Aarnio & Enqvist, 2002, 2016), which combines the abovementioned concepts. The revised DIANA model's (Figure 2) operational dimensions begin from Cornerstone A, which creates a common ground for learning collaboratively and dialogically in the learning community. Dialogue lays the groundwork for a learning process where, for example, field-specific knowledge from various disciplines is combined. Cornerstone B aims to establish personal or group-specific authenticity by using real-life problems and formulating authentic learning questions or assessments that are connected to and derived directly from the learning objectives of the study module. The teacher's role is to scaffold and steer the students' learning in the right direction. The students themselves together define the authentic learning questions. They search for meanings and research phenomena and principles individually and in groups by familiarising themselves with the theory and by applying it to practice. Deep learning, with its specific dialogical actions and collaborative knowledge construction, is at the heart of Cornerstone C, which in practice entails seeking answers to the questions and problems that have been set earlier, providing individual contributions, clarifying and opening the meaning of utterances, continuing the utterances of others, engaging in collaborative knowledge creation, and construction of a shared understanding. Students collaboratively analyse, compare, evaluate, and test new knowledge and procedures in real-life situations, evaluate what they have learned by formulating new learning questions, and construct syntheses and artefacts. Dialogue is seen as a habit that supports deep learning in a way that helps students construct knowledge together. The knowledge is constructed in diverse digital learning environments (Figure 2), which increases its transparency for the other students. Cornerstone D integrates theory into practice and invites students to weave a collaborative synthesis from the knowledge they have accumulated, to create a shared artefact, and to collaboratively define new learning questions based on missing pieces of information pertaining to the learning goals of the study module. Self-evaluation or evaluation by a teacher can also be used to examine individual learning activities, results, and products (Aarnio & Enqvist, 2016). To summarise, when a learning process is based on the DIANA model, the process potentially includes elements that comprehensively facilitate deep learning.

Aim and methods

The aim of this study is to investigate vocational student teachers' learning activities that are based on authentic and dialogical collaborative knowledge construction. The main research question is as follows: Toward what kind of authentic and dialogical collaborative knowledge construction does the DIANA model direct students? In order to answer the main research question, we have specified

two sub-questions: (1) What kind of authentic learning questions are formulated collaboratively by the study circles? (2) What kind of learning activities and results does authentic and dialogical collaborative knowledge construction prompt in superficial and deep learning-oriented study circles?

In this case study qualitative methods were used to explore the main research question and the sub-questions. To make the case study more relevant and broadly applicable (Yin, 2009, p. 133), data were analysed quantitatively to interpret and describe the case study and to make internal generalisation procedures more explicit.

The research context

The Finnish vocational teacher education entrance demand at least master or bachelor level education completed, some exceptions may be accepted. Furthermore, at least three to five years of working experience is required in their own specialty or discipline. The setting of this research was the study module 'Networks in Vocational Education' (four European Credit Transfer System [ECTS] credits) in the Teacher Education programme (1–1.5 years, 60 ECTS) of the HAMK School of Professional Teacher Education. The aim of the module is to prepare students to (1) build and utilise different national cooperative networks in the field of vocational education and training, (2) function in international networks, (3) understand the administration, finances, and management of an institution of vocational education, and (4) apply in his or her work various plans and documents guiding the activities of such organisations (HAMK School of Professional Teacher Education, 2013). In the multidisciplinary study circles, the student teachers participated in a learning process that was based on the DIANA model. In practice, it has become evident that vocational student teachers from various professional fields must proceed from their own substantial cognitive schema to an entirely new and different pedagogical conception of learning and teaching. Applying knowledge is already, in many phases of the student teacher's learning process, a part of deep learning activities.

The study module was designed and implemented using the DIANA model (see Table 1). The first author worked as a teacher during two of the five implementations. The main components of the learning environment provided by the teachers consisted of an open course blog (containing free and open educational resources) and open blogs for the study circles. The module was designed so that each digital application (e.g., Whatsapp, Google Drive, Blogger, Facebook) could be used via mobile devices. Four of the five module implementations included contact teaching (1 + 1 days) at the beginning and end of the learning process, while the remaining course was solely based on online and mobile learning environments. The actual online work on the blog and in other collaborative online learning environments took place between the contact teaching days. The learning processes included step-by-step descriptions of the learning activities during

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the various cornerstones of the process (Table 1). The participants were given four to five weeks to finish this four-ECTS-credit study module.

Table 1. The learning structure and activities of the 'Network in Professional Education' module, based on the DIANA model (Aarnio & Enqvist, 2016, p. 44). Adapted and reproduced with permission.

Cornerstones of the DIANA model	Operative dimensions	Teaching and learning activities	Place	Used mobile applications
A. Creating a common ground for collaborative learning	A1. The idea of authentic and dialogical learning A2. Preparing for dialogical participation in the learning community A3. Structuring and starting the collective work	A1. Introducing the idea of authentic and dialogical learning A2. Preparing for the dialogical participation, starting a blog, introducing mobile applications A3. Organising, scheduling and starting the collaborative knowledge construction	Classroom session	Blogger Whatsapp
B. Enabling the authenticity in learning	B1. Deriving authentic learning tasks, learner-centered from real life and work situations, formulating and inquiring open learning questions using the language used by students, the starting point being their everyday conceptions B2. Using authentic sources and materials or data to create content and products	B1. Formulating authentic learning questions, categorising into themes and posting them in the blog B2. Using authentic sources, society´s demands for teachers' network, dialogically designing the collaborative artefact	Online scaffolding	Blogger Whatsapp Google Drive (Facebook)

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C. Increasing deep-orientated learning through dialogical actions	C1. Inquiring and constructing knowledge through dialogical actions C2. Working as equals, participating reciprocally and symmetrically, listening to others, open and constructive inquiry, and weaving syntheses C3. The focus is on open, inquiring questions which are used to find solutions and create content	C1. Finding knowledge and information to formulated questions, constructing dialogically collaborative knowledge C2. Working online though dialogical actions C3. Inquiring dialogically and constructing collaborative knowledge	Online scaffolding	Blogger WhatsApp Google Drive (Facebook)
D. Integrating theory and practice in learning situations	D1. Alternating theory and practice, weaving a synthesis, finding gaps in thinking and actions, formulating new questions on the basis of those gaps D2. Continuous reflection and evaluation throughout the learning process – individually and collectively	D1. Alternating theory and practice, creating a synthesis, finding missing pieces (knowledge cap), formulating new learning questions to the blog D2. Self- and peer evaluations, finding own development areas	Classroom session	Blogger Google Drive

Table 1 describes learning situations in digital environments and in the various stages of a learning process based on the DIANA model. After creating common ground for dialogical knowledge construction, the study circles defined their own authentic learning questions that were derived from the study module's learning objectives. Every study circle was free to define its own questions, and the number of questions was not limited. Examples of these questions include

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the following: What are collaboration networks? What is the administration of an educational organisation like? How can a vocational teacher use networking to influence regional development and the development of international education? Each student's existing skills and knowledge were taken into consideration when the open questions were defined by the study circles, thus creating a foundation for constructing authentic and collaborative knowledge. During the online segment of the course, knowledge was constructed dialogically and collaboratively from the authentic starting situation of each study circle. In addition, a shared artefact was designed. The students in the study circles worked collaboratively but only within the scope of the dialogical competence that each member had gained through previous knowledge. In practice, this involved providing individual contributions, clarifying and opening the meaning of utterances, continuing others' utterances, and engaging in creating knowledge collaboratively and constructing a shared understanding.

The goal of the learning process was to link theory with practice and to require the students to construct a dialogical collaborative synthesis of knowledge they had constructed as well as to collaboratively search for 'missing pieces' of their competence regarding the authentic questions and the learning goals of the study module and then to formulate new questions based on these 'missing pieces.' In addition, the study circles presented a collaboratively developed and constructed artefact whose purpose was to help the students achieve the learning goals for networking in vocational education. When the artefact was created, the authentic situation of the study module-related knowledge in each study circle was taken into account. The artefacts included, for example, a theory-based self-evaluation questionnaire concerning vocational networks, a chart that helped a new teacher to network, an online synchronisable calendar to aid teachers' networking, and an instruction manual on how to use the LinkedIn networking service to foster professional networking.

Participants, data collection, and analysis

The participants in this study were 76 student teachers (53 women and 23 men) in the HAMK School of Professional Teacher Education. Participants' age varied from 28 to 57 years, and all were participants in one of the five implementations (see Table 2) of the module between 2014 and 2016. The data for this study were gathered from 19 study circles (three to six persons per group) which the students themselves formed at the beginning of the studies. Study participants were informed of how their data would be used and that their participation was entirely voluntary. The student teachers were from various fields of vocational education. Those who were specialists in competence-based qualifications or had previously acquired skills and knowledge (through, e.g., work experience) in areas defined in the learning objectives of the study module received credit for the module.

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Table 2. Summary of the implementations and data collection.

Module imple-mentations and time frames	Implemen-tation 1 03–04/2014	Implemen-tation 2 08–09/2014	Implemen-tation 3 03–04/2015	Implemen-tation 4 09–11/2015	Implemen-tation 5 02–04/2016
Participants (*n*=76)	16	16	16	15	13
Study circles per implemen-tation (*f*=19)	4	3	4	4	4
Quantified data collection: authentic and collaboratively constructed learning questions pertaining to the learning objectives of the study module (*f*=350)	Study circle's authentic learning questions (74)	Study circle's authentic learning questions (28)	Study circle's authentic learning questions (106)	Study circle's authentic learning questions (60)	Study circle's authentic learning questions (82)
Qualitative data from the study circles (*f*=6): Blog en-tries	Collaborative knowledge construction Synthesis Artefacts	Collaborative knowledge construction Synthesis Artefacts	Collaborative knowledge construction Synthesis Artefacts	Collaborative knowledge construction Synthesis Artefacts	Collaborative knowledge construction Synthesis Artefacts

In this case study, data were collected from the study circles' online open blog entries. The unit of the analysis was the study circle. According to Yin (2009), the aim of a case study is to describe a particular situation to get an understanding of the specific case by making direct observations. The quantified qualitative data included the authentic learning questions (*f*=350) formulated collectively by the study circles (*f*=19) comprised of student teachers (*n*=76). As mentioned, every study circle was free to define its own questions. In the second part of this case study, abductive analysis (Tavory & Timmermans, 2014) was used to answer the question of the kind of learning activities and results that authentic and dialogical

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collaborative knowledge construction prompts in superficial versus deep learning-oriented study circles. According to Tavory and Timmerman (2014), observation of the data is the key in abduction and it can be seen in four intertwined activities: gathering observations, extensive reading of theories, working with observation data, and actively inquiring. They argue that abduction makes the movement between theory and observation more explicit. Six study circles (f=6) were chosen for the abductive analysis. Three study circles whose questions were entirely or nearly entirely superficial learning-oriented and three study circles that formulated mainly deep learning-oriented questions were selected for the analysis. The data used in this study included dialogical knowledge construction in the blogs of the study circles, the syntheses of knowledge construction, and the collaboratively created and constructed artefacts.

The evaluation framework (Figure 1) for deep learning activities was used to analyse the data. The analysis began with a reading of the data to obtain an overall picture of the study circles' materials and blog entries. The quantified data were derived from the analysis of the authentic learning questions (f=350). Next, the first and second authors read the data independently and categorised the questions using the evaluation framework (Figure 1). Both authors were responsible for the reliability of the categorisation, which was performed as a blind evaluation; that is, the researchers took into account only the products and not the general performance of the study circles. At the end of this stage, the categories were compared, and the reliability was determined to be .924 (Cohen's kappa).

In the second part of the study, the first and second authors read printouts of the blog entries first separately and then together. Next, the authors familiarised themselves in detail with the artefacts produced by the study circles. Once familiar with the artefacts, the authors used abductive reasoning to jointly interpret the data while striving to comprehend and understand it. In addition, the evaluation framework for deep learning activities was used for the analysis.

Results

The results are based on an analysis of the study circles' blog entries. The first part of the data consists of study circle-specific (f=19) collaboratively defined authentic learning questions (f=350). In the second part of the study, we analysed the dialogical collaborative knowledge construction, syntheses, and artefacts of the study circles whose learning was either mainly superficial learning-oriented (f=3) or mainly deep learning-oriented (f=3). The abductive analysis was based on the authors' observations about the data selected from the study circles' blog entries, knowledge of the related theories presented above, as well as their endeavours to understand and interpret them. Answers to the research questions were sought through context-dependent case observations.

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What kind of authentic learning questions are formulated collaboratively by study circles?

The student teachers' (*n*=76) collaboratively defined learning questions (*f* =350) formulated based on the learning goals of the study module were analysed quantitatively (see Table 3). Table 3 also shows some examples of how formulated learning questions were set on. The evaluation framework (Figure 1) was used as a basis for the analysis.

Table 3. Examples from quantified data analysis.

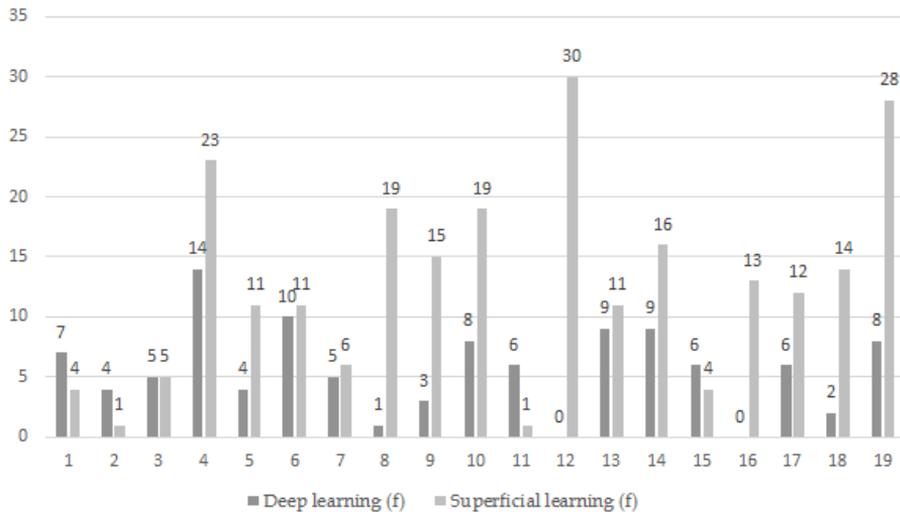| Superficial learning-oriented questions (*f*=243)	Deep learning-oriented questions (*f*=107)
What are collaboration networks?	How could networking between teachers, students, and employers be made more efficient?
What does the funding of a university of applied sciences consist of?	How can a professional teacher use networking to influence regional development and the development of international education?
What is the administration of an educational organization like?	How can a teacher's work in a professional institute be developed in the future?
What is included in local networks?	How can a networking attitude in a teacher community be turned into concrete actions?

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Figure 3. Comparison of the frequency of superficial (f=243) versus deep (f=107) learning-oriented authentic learning questions of study circles (f=19).

The results presented in Figure 3 indicate that the authentic questions formulated by four study circles (1, 2, 11, and 15) clearly directed learners to construct knowledge through deep learning-oriented activities. The phrasing of these deep learning-oriented questions directed learners to apply, compare, analyse, and evaluate information and experiences and to construct new knowledge (see Table 3).

Four study circles (3, 6, 7, and 13) formulated the same or almost the same number of questions (deep and superficial learning-oriented). Eleven study circles formulated learning questions that were clearly superficial learning-oriented, while four study circles formulated questions that were mostly deep learning-oriented.

Two study circles (12 and 16) formulated only superficial learning-oriented questions (Figure 3). These questions directed learners to memorise and repeat existing information (see Table 3). Overall, the analysis indicated that of all the authentic learning questions, less than half (*f*=107) were deep learning-oriented.

What kind of learning activities and results does authentic and dialogical collaborative knowledge construction prompt in superficial and deep learning-oriented study circles?

The abductive analysis of the data was based on each study circle's (f=6) dialogical collaborative knowledge construction and artefacts. In the following, we describe the level and quality of learning in superficial (f=3) and deep (f=3) learning-oriented study circles as demonstrated by their collaborative knowledge construction and artefacts. The framework for evaluating superficial and deep learning-oriented activities (Figure 1) was used in the analysis.

Study circles (12, 16, and 8) with questions entirely or nearly entirely superficial learning-oriented

Study Circle 12 (30 superficial learning-oriented questions) defined six learning themes while collaboratively constructing knowledge based on the learning goals of the study module. Regarding five of the themes, the study circle used deep learning-oriented knowledge construction activities; that is, information was analysed and compared and information was connected to practical applications in teaching. In addition, the study circle's existing expertise in vocational education was used to enrich the way these five themes were addressed. Knowledge construction was superficial learning-oriented for only one theme. The artefact was created based on an authentic need, namely, the kind of networking the student teachers themselves felt they needed, especially during the early stages of their studies. The study circle established a national Facebook group for professional networking of student teachers and also generated an idea for a peer-support pop-up café for Educa, a nationwide education and training sector event. Through these activities that reinforced the sense of community, the study circle demonstrated that they had achieved deep learning by identifying various practical procedures.

Study Circle 16 (12 superficial learning-oriented questions and one deep learning-oriented question) dealt with four themes while answering their authentic learning questions and constructing knowledge. Regarding all four themes, the study circle attempted to apply their skills and knowledge, which demonstrates deep learning-oriented knowledge construction. The group's artefact described the current changes in professional education. The construction of the artefact involved activities characteristic of superficial learning-oriented, namely, the presentation of existing concepts.

Study Circle 8 (18 superficial learning-oriented questions and two deep learning-oriented questions) constructed knowledge about six themes. Regarding five of the themes, the study circle's work demonstrated deep learning-oriented activities in the form of applying theory to practice. The study circle's existing networking skills in professional education were used, and knowledge construction was enriched by multilateral experiences. During the learning process, the study

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circle assembled midpoint syntheses, but their understanding of the final synthesis remained superficial. With one of the themes, their knowledge construction consisted of copying existing knowledge to the blog. The study circle produced a synchronisable e-calendar for use by professional teachers. The calendar included networking events, and networking activities for the following year had already been entered in the calendar. For instance, the calendar included research days and conferences in various fields as well as events and continuing education for professional education. The use of this artefact enables faster and more efficient networking, and it concretises networking in various environments. Most aspects of the artefact were conventional, but displaying the networking events in a digital form helps users become aware of these events. Constructing the artefact in a digitally integrable form promoted deep learning in the study circle.

Study circles (11, 2, and 1) that mainly formulated deep learning-oriented questions
Study Circle 11 (one superficial learning-oriented question and six deep learning-oriented questions) formulated questions that were almost exclusively deep learning-oriented. The questions were not grouped by theme, but the study circle constructed knowledge about the seven questions they had formulated. The study circle constructed knowledge based on literature and theory as well as by striving toward deep learning. However, regarding the study module as a whole, the study circle's knowledge construction through individual questions did not result in deep learning. The artefact constructed by the study circle is a mind map chart about education collaboration networks, to which information has been added as lists.

Study Circle 2 (one superficial learning-oriented question and four deep learning-oriented questions) formulated five questions based on the learning goals of the study module. Four questions were deep learning-oriented. The study circle addressed each question such that one student teacher gathered information about the topic and the others commented on the text dialogically by adding to the information and continuing with open questions. Finally, a synthesis about the process was assembled. The approach adopted by the study circle showed characteristics of deep learning-oriented activities as the gathered information was applied and analysed and meanings were searched for. As their artefact, the study circle presented a photo collage of their questions and the syntheses assembled from those questions. Although the process itself can be called deep learning-oriented knowledge construction, the product clearly represents a superficial orientation.

In Study Circle 1 (three superficial learning-oriented questions and eight deep learning-oriented questions), the questions were formulated by individual student teachers. The study circle's blog mainly demonstrated knowledge construction by individual members who answered the 11 disconnected questions that the members had formulated. The artefact was a networking graphic created by

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one of the student teachers and commented on by only one person. Therefore, collaborative knowledge construction could not be evaluated.

Toward what kind of authentic and dialogical collaborative knowledge construction does the DIANA model direct students?

In summary, the results indicate that the student teachers (*n*=76) constructed dialogical knowledge in ways that demonstrate characteristics of deep learning when considered from the authentic starting points of the study circles. The study circles constructed knowledge that at the time was new to the group members. The open, authentic learning questions (*f*=350) formulated at the beginning of the process and derived from the learning goals of the study module mainly directed the students to construct knowledge using learning activities that were superficial. This, however, was not the case in the superficial learning-oriented study circles (*f*=3) chosen for the case analysis, where the students used deep learning-oriented activities: applying, analysing, inquiring and constructing knowledge that was new to them. That students applied collaboratively constructed knowledge and identified various procedures was evident in the study circles' blogs. They also wanted to concretise various forms of networking activities. In study circles (*f*=3) that formulated deep learning-oriented questions, collaborative knowledge construction hinged entirely on individual questions, and these study circles never grouped their questions by theme. Furthermore, in these study circles, the construction of artefacts demonstrates a superficial learning-oriented approach. The number of questions formulated early in the learning process and the process of grouping them by theme seemed to be connected to the construction of deep learning-oriented knowledge and artefacts. Thus, if the questions were not grouped by theme or if their number was small, categorising them into themes was an important step in initiating dialogical collaborative construction of knowledge. The DIANA model as a learning process design does not automatically direct students toward deep learning-oriented authentic and dialogical collaborative knowledge construction; therefore, using the model requires more scaffolding in this regard. Collaboratively defined authentic learning questions that form a learning goal require a teacher's robust input in scaffolding and steering the students. Such input is also needed for dialogical knowledge construction to become deep learning.

Discussion and implications

The primary aim of this study was to investigate the kind of authentic and dialogical collaborative knowledge construction toward which the DIANA model directs students. The results of this study indicate that using authenticity as the basis for a learning process enabled each study circle to formulate questions that were meaningful to its members (cf. Shaffer & Resnick, 1999) and also produced

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information about the learners' current competence (Aarnio, 2006). Authenticity in learning was discerned through the perspectives defined by Aarnio and Enqvist (2016), in which knowledge is constructed from authentic sources and based on learners' current competence. The results indicate that scaffolding is especially necessary to create a firm basis for authenticity (e.g., Aarnio, 2006) so that dialogical collaborative knowledge construction can produce and direct learners toward learning activities that are deep learning-oriented, such as analysing, interpreting, researching, comparing, evaluating, and constructing (e.g., Anderson et al., 2001). The authentic learning questions defined at the beginning of the process mainly directed the learners toward superficial learning-oriented activities, which can be considered natural when the topic is new to learners. Regarding the study circles that mainly used superficial learning-oriented activities, the results indicate that dialogical collaborative knowledge construction still directed the learners toward deep learning during the process, and exactly as stated by Paavola et al. (2002) in their study, learning changed and was enriched during the process. This tendency was further reinforced by the number of questions which helped learners direct themselves toward deep learning activities. The results are consistent with the results of previous studies (e.g., Blumenfeld et al., 1991; Eklund et al., 2011; Muukkonen et al., 2011) that suggest that solving complex, open problems and building artefacts demonstrate achievement of deep learning.

Learning is seen as a process that deepens through dialogue and through participation in a community, and during the third stage of the DIANA model, knowledge is constructed collaboratively in digital learning environments. This study did not focus on the role of teaching technology, although open learning environments were used, as is typical of a learning process based on the DIANA model (Aarnio & Enqvist, 2016). Our understanding is that the central elements of deep learning are a learning community that has committed to a common goal, an authentic starting point for learning, and dialogical skills that enable collaborative knowledge construction. It is also important to take into account that the student teachers received no particular scaffolding in dialogical collaborative knowledge construction.

This study's main limitation was the researchers' roles and their potential impact on the research (see Yin, 2009). The first author of this study was involved in designing and implementing the module as well as in the data analysis. The second author is one of the developers of the DIANA model. Therefore, their assumptions and actions may have influenced the research process, especially the case analysis, and the results may not be generalisable to other contexts where researchers do not have such a direct influence on the proceedings (Barab & Squire, 2004). However, the involvement of the third author can be regarded as having increased the reliability of the study, since she did not participate in de-

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veloping the model or in designing the study module. Another limitation is related to the qualitative data gathered from the study circles' blog diaries. Not every aspect was documented there. In addition, this study would have benefited from the use of interviews (see Williams, 2005). The reliability of the study would be enhanced if the data were analysed by someone not connected to the study, that is, someone not working as a teacher or a developer. Regarding the process of defining authentic questions that direct learning, reliability would have been enhanced by a teacher's scaffolding concerning the number of questions and categorising them by theme. In addition, the study module's content was extensive, high goals were set, and the majority of the student teachers studied alongside their work (blended learning). The data were gathered from groups taught by two teachers, which means that the teaching and its emphasis varied for the groups. According to the principles of the DIANA model, teaching ought to involve dialogical scaffolding. In this respect, the data were insufficient, for the material gathered from the blogs did not include this aspect. Instead, guidance and knowledge construction took place in many different digital learning environments.

This study has several practical implications. First, a learning process based on the DIANA model should be designed so that it does not enable students to simply transfer and copy information to a collaborative online learning environment. In addition, deep learning-oriented activities should be reinforced by a period of individual study during which each student familiarises himself or herself with the topic (e.g., Paavola et al., 2004; Sfard, 1998; Turkle, 2015, p. 61). The results show that for authentic learning to direct students toward deep learning, scaffolding is necessary as are dividing the topic into themes and providing a chance for students to reorient. Furthermore, learning assignments ought to be formulated in a manner that directs learners to use deep learning-oriented activities. This requires a teacher's scaffolding, which is why resources ought to be allotted to that guidance at various stages of the process. Furthermore, if the goal is deep learning, the learning process should be more clearly structured, for example, one theme per study week. A teacher's presence and scaffolding are necessary in the various stages of the learning process. In addition, the learning goals of teacher education ought to be reconsidered regarding study modules that facilitate deep learning, and the scope of these modules should be determined accordingly. Student teachers need to gain experience in collaborative learning processes that require deep learning, and these experiences should preferably be positive. In this way, expertise in designing learning processes will answer the complex competence demands of professional education and today's working world.

To conclude, this study indicates that deep learning-oriented activities in authentic and dialogical collaborative knowledge construction offer a promising approach for developing learning processes in professional teacher education. In

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addition, the evaluation framework for deep learning-oriented activities that was a product of this study lays the groundwork for redesigning the curriculum of teacher education, as well as the module's learning objectives and learning processes and for evaluating deep learning-oriented activities. Although the study was conducted in the Finnish context, the pragmatical and re-designed framework is applicable to other countries, especially those with a sociocultural theory orientation. In conclusion, authentic and dialogical collaborative knowledge construction can engage student teachers in the development of the very deep learning competencies that drive their own vocational teaching forward.

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