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Vocational education approach: New TEL settings—new prospects for teachers' instructional activities?

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Abstract This study focuses on vocational education teachers' instructional activities in a new technology-enhanced learning (TEL) setting. A content analysis is applied to investigate teachers' and students' interactions in a 3D game context. The findings illustrate that when teachers' and students' interactions are mediated by a game, teachers seem to apply different discussion activities to empower vocational learning than they do in traditional classroom settings. Additionally, the present study shows that teachers spontaneously develop new ways of supporting vocational learning processes. In more detail, two main types of instructional activities were identified: a "knowledge-providing" approach and a "joint problem-solving" approach. Additionally, findings illustrate how teachers using different types of instructional approaches are followed up with different processes by students. The article is concluded with a general discussion of the emerging challenges regarding the technological and pedagogical development of vocational education and teachers' instructional activities in new TEL settings based on a more long-term design-based research project (ongoing since 2004).

Keywords Vocational education · Teachers' instructional activities · 3D game · Design-based research

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Introduction

The role of the teacher is currently a primary concern of CSCL-oriented research and has been much debated within the research community (see e.g., Dillenbourg et al. 2009; Dimitriadis 2010). Active teacher orchestration has also been discussed as one potential solution to increasing technology-enhanced learning (TEL) and its applicability in modern

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education (Dillenbourg et al. 2013, in press; Looi et al. 2011; Pérez-Sanagustín et al. 2012; Prieto et al. 2011). According to Dillenbourg (2012), teacher orchestration refers to teachers' activities in the classroom context, i.e., managing activities of different students, groups, and technological tools in the context of classroom activities. However, this view on orchestrating learning focuses only on face-to-face activities in the physical classroom context. At the same time, teacher-student interactions in vocational education are increasingly taking place in spaces other than traditional classrooms (such as virtual spaces and work contexts). In line with that, it can be presumed that the teacher's role takes on different forms, since TEL contexts and learning situations vary greatly in various learning settings and spaces. Thus, it is not obvious what teachers' role should be in diverse TEL-settings (e.g., in virtual settings; which can be asynchronous discussions or real-time discussions in a 3D environment). A crucial question for vocational teachers involves whether and how instructional activities are beneficial in new TEL settings.

Additionally, the role of teachers may be unique for each level of schooling (i.e., pre- and elementary school, vocational education, high school, and post-graduate studies). Related to the teachers' role in CSCL contexts, the vocational context stands out significantly (for example, from the higher education context). Elsewhere, CSCL is often offered in response to the desire to have small-group interactions in situations where it is not practical to have a teacher present in every group. The typical challenge for collaborative learning in the higher education context is finding ways to make use of the learners' personal resources (Arvaja 2012) or their personal learning environments (PLE) (Dabbagh and Kitsantas 2011) as Q5 grounds for shared knowledge construction. This can happen practically by having students solve tasks in virtual spaces, for example, based on specific collaboration scripts (De Wever et al. 2010; Fischer et al. 2007; Kobbe et al. 2007) or theoretical models (e.g., using jigsaw-based discussions in web-based environments instead of reading a book and taking a test) to narrow the teachers' role to pre-planning and guiding the groups' inner processes in real-time when necessary. With regard to vocational contexts, CSCL may be implemented in other ways. According to Baartman and de Bruijn (2011), learning in vocational contexts Q6 differs from learning in academic settings in that the former addresses concrete professional tasks associated with performance in social practices. Therefore, vocational education may benefit more from a master-apprentice approach grounded in cognitive apprenticeship theory in which students are active in an authentic learning environment (Brown et al. 1989).

So far, technology-supported vocational learning has been under-represented in this field of study (e.g., on September 30, 2012 only three studies conducted in vocational education contexts were found for the search term "vocational" in *ijCSCL*). This is critical from the viewpoint of empowering vocational education, as it is possible to say that technology has an explicit role in supporting collaborative activity (e.g., in demonstrating and practicing work-life situations, such as avoiding the danger of electric shocks, see Hämäläinen 2011). In such uses, technology can upgrade the traditional ways of learning. In line with that, simulations have been successfully used to support the development of individual skills (De Jong and van Joolingen 1998), such as rehearsing how to drive forestry machines (Salonen et al. 2011). This alone is nevertheless insufficient for the purposes of CSCL, since it is becoming increasingly important for students to develop the capacity to work in groups and solve upcoming problems in authentic work-life situations. Also according to Do-Lenh et al. (2011), learning to collaborate is an important competence for vocational learners to acquire. However, the problem is that with respect to workplace learning, research findings on vocational education have reported that learning still takes place more often as a result of working alone than from working in groups (see Virtanen et al. 2009). In line with that, vocational students often have fairly good skills related to their own professions, but in their

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future work-life situations, such content knowledge needs to be integrated with the collaborative work practices of other workers (e.g., HVAC as part of hospital construction; see also Interprofessional Education Collaborative Expert Panel 2011). At the same time, the fast development and generalization of technology offers diverse opportunities to support vocational students' collaboration skills and professional development (Do-Lenh et al. 2011; Motta et al. 2012).

While there are optimistic ideas of new learning spaces in empowering vocational learning, there is also a critical idea that much of the research has focused on students' learning outcomes or shared collaborative processes; leaving the teachers' role in collaboration less studied (Webb et al. 2008). According to Crook et al. (2010), collaborative knowledge construction activities in TEL settings are often managed by the students themselves and teachers have little (if any) real-time involvement in empowering these learning processes. In addition, new TEL settings for vocational learning, such as 3D games have typically been applied to educational settings with no teacher-student interaction. Due to this, an important question remains unanswered: How can teachers support vocational learning processes in 3D settings? Within the field of CSCL, different forms of content analysis are often used to investigate interactive processes (e.g., De Wever et al. 2006). However, there is a critical idea that despite its assumed potential to reveal information on synchronous interactions in 3D settings, few studies[1] have applied content analysis in these settings. Q7

This study continues the design-based research (DBR) project (see Design-Based Research Collective 2003) focusing on designing and investigating instructional approaches to support collaborative learning in vocational contexts, based on authentic needs (ongoing since 2004; for further descriptions, see Hämäläinen 2008; Hämäläinen 2011; Hämäläinen and Oksanen 2012). In our previous study (Hämäläinen and Oksanen 2012) we investigated whether teachers' participation in 3D settings increases the quality of the knowledge construction of vocational students working in small groups. More specifically, we focused on differences in knowledge construction processes in 3D game settings with and without real-time teachers. The purpose of having a condition in which a teacher participated in the problem-solving activities was to respond to the authentic need rising in the vocational context: to find scientific insight on whether, and how, the real-time participation of teachers may simulate the empowerment of students' inter-professional working skills. The findings indicated that students in settings with a teacher invested more effort in the knowledge construction processes that can be considered productive (i.e., asking contextual questions and explaining their own activities) and spent less effort engaging in off-task conversations. As a result, we collected further data with a focus on teachers' and students' interactions. In the present study, we will focus on how a mediating tool—a scripted 3D game—shapes teachers' instructional activities in a vocational education setting. In sum, our approach highlights creative and situated interaction processes mediated by the present technological

[1] A literature search (on November 10, 2012) in peer-reviewed journals through the database of Education Resources Information Center (ERIC) revealed only six articles related to the application of content analysis in 3D settings for collaborative learning (Bouta et al. 2012; deNoyelles and Seo 2012; Fominykh and Prasolova-Forland 2012; Huang et al. 2010; Peterson 2010; Underwood et al. 2008). More specifically, electronic searches in ERIC by means of the search terms "content analysis," "3D game," and either "collaboration" or "collaborative" revealed one reference; "content analysis," "3D environment," and either "collaboration" or "collaborative" revealed six references; and "content analysis," "3D space," and either "collaboration" or "collaborative" revealed no references. Additionally, further investigation of these six studies revealed that only Peterson (2010) reported results on the application of content analysis in a 3D setting.

environment (John-Steiner 2000; Miell and Littleton 2004; Sawyer and DeZutter 2009; Wegerif 2007).

Aims

In this study, the overall aim was to investigate teachers' instructional activities in a new 3D setting for vocational learning. Due the lack of empirical studies applying content analysis in synchronous 3D settings[1], the methodological aim of this article was to identify a model for content analysis to study teachers' and students' interactions. The empirical part of the present study furtherer focuses on teachers' and students' interactions and aimed to identify:

- How teachers' and students' discussions differed from each other?
- What kinds of instructional activities the teachers spontaneously applied?
- How students responded to what teachers did?

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Method

A DBR approach (Barab and Squire 2004; Bell 2004; Chan 2011) was used to combine instructional approaches to enhance TEL, authentic vocational learning needs, and theoretical knowledge of collaborative learning as a basis for empowering high-level knowledge construction. The study followed the iterative structure of DBR in the sense that the improvements of previous interventions interact with instructional approaches to enhance educational practices. There are three essential ways in which our previous design-experiments grounded this study. First, the 3D game environment developed for the previous study will be used as a setting for the present study as well. Second, our previous studies have indicated the need for a better methodological understanding of how content analysis can be used as a means of gaining insight into teachers' and students' interactions in a 3D game environment for vocational learning. Third, our previous study indicated that there is potential for teachers to engage in real-time activities in a 3D game context. Thus, to enhance our understanding of teachers' instructional activities in 3D game settings, we examined teachers' and students' interactions. We will next describe the main starting points of the 3D game context and then move on to describe the methodological background and empirical conduction of our study.

The introduction of a 3D game

This learning game draws on RealXtend Technology (an Open-Source Platform for interconnected virtual worlds http://www.realxtend.org/) (see Fig. 1). When playing the game, each player has a first-person view on the 3D game environment. The players are interconnected via a server, which runs the virtual world where everything happens. The game can be accessed online and interpersonal communication is supported by the VoIP speech system. The design of the game used in this study has been grounded on the continuous iterative collaboration of teachers and work life instructors (N=8) who defined inter-professional collaboration as one of the main challenges that students meet in their further work life and which is currently weakly supported in vocational schools. Therefore, the constitutive idea of the scripted game is to offer added value to vocational education by

Fig. 1 Screenshots of the 3D game environment

narrowing the gap between current vocational education practices and the demands of the employment field. In more detail, currently, work tasks are becoming more and more complicated, and work is typically based on inter-professional expertise, as well as the shared construction of new knowledge (Paloniemi and Collin 2012). At the same time, a recent Eurydice report from the European Commission (2012) highlights that not all competencies are treated equally at school; while basic skills (e.g., literacy, science) are well-rehearsed, the teaching and learning of transversal skills is lagging behind. Thus, grounded on the Finnish national core curricula of vocational education the aim of the game is to enhance inter-professional knowledge construction in the area of human sustainability (see National qualification requirements for vocational education and training 2010).

The game story consisted of inter-professional tasks, and collaboration scripts (Kobbe et al. 2007) integrated within the game's puzzles to support shared problem solving among students. In practice, the plot includes three scripted tasks (with inter-professional roles of the roadies, the receptionist, the workman, the waiter, the waitress, and the cook), in which players are preparing for a rock festival. At the beginning (scripted task 1), the aim is to become familiar with shared problem solving and to practice coordination (Brown and Campione 1994). Thus, the multi-player task is simply to enter the festival area by inputting in the correct (distributed) numbers into the combination lock. The next level (scripted task 2) takes place in the festival restaurant, and the players' shared problem-solving is challenged by their distributed expertise, mutual dependency, and the integration of solo and group activities (Price et al. 2003). Groups need to serve 15 customers and five band members (players have different predefined collaborative roles that determine the challenges that the game offers to each player, i.e., the receptionist, the server, the cook). Additionally, based on authentic work-life needs, the task includes additional duties that hamper puzzle solving (i.e., the generator running out of fuel, answering phone calls, reporting the number of prepared and served meals, helping an angry customer). After groups serve 15 customers successfully, the rock band then comes for a meal. The vocalist has special needs (the band's requirement list indicating the vocalist's nut allergy has been delivered to the receptionist), and while ordering, the vocalist says something ambiguously that is quite difficult to understand. At the same time, the server gets the information that the vocalist likes to have curry chicken (this dish usually includes nuts). If the team serves the vocalist a normal curry chicken dish, the vocalist refuses the meal and orders again. This loop goes on until team servers deliver the proper chicken dish without nuts. After they serve the correct dish, the players are able to move to the third level. At the final level (scripted task 3), players enter into a situation involving socio-cognitive conflict (Moscovici and Doise 1994). In practice, the group needs to identify band members and organize their equipment in the proper positions. Socio-cognitive conflict is created by simultaneously giving various players different and partly contradictory information (each player receives tips and, in total, the group gets 25 tips). There are eight piles of boxes (five belong to the band and three belong

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to the warm-up band) on the stage, and the players can change the owner of each. The group is supposed to identify the band members according to the clues and pictures on the boxes. However, boxes cannot be placed in their correct places without shared knowledge construction. Additionally, the conflicting information they receive forces players to re-examine their existing knowledge in order to solve the task. After they have organized all of the boxes, the group has completed the game.

Participants, context, and data collection

The empirical part of the present study was conducted in an authentic situation. From fall 2010 to spring 2012, 16 vocational students studying general studies for the component of complementary skills (20 credits - for all vocational education and training students) between the ages of 16 and 18 and four teachers (from different vocational fields) participated in the study; in total there were four groups of five people (N=20, n=4 teachers, two males, two females; n=16 students, 11 males, five females). The students were randomly divided into four groups while one teacher was randomly assigned to each group. In line with the idea of Sawyer (2004) that expert teachers may have better abilities to foster students' collaboration processes than novice teachers, all the teachers had several years teaching experience – but no previous experience of empowering vocational learning processes within a game setting. Thus, the teachers' activities were grounded on the idea of facilitating collaboration through the joint construction of knowledge in which teachers and students work together on a common product and goal (Mercer et al. 2010). In general, teachers' attitude toward technology can be considered fairly positive, as they had embedded other new TEL environments into teaching. Additionally, none of the participants (neither students nor teachers) had earlier experiences with the 3D game environment. Moreover, no specific instructions were given to the participants (neither students nor teachers) before the working period; however, the teachers were told in advance that the purpose of the game was to enhance the future working skills of their students.

The empirical study included a two-hour working period in a scripted 3D game environment in the Colleges of Jyväskylä and Äänekoski in Finland. To avoid compromising the research setting, the participants were isolated from one another physically. Cubicles were arranged so that the participants were not disturbed by the outside world and could only communicate through the VoIP speech system. This setting made it possible to capture all the required data from different collaborative situations. In addition, one video camera and four recording systems were used in each setting. Each video camera was positioned to capture video feed from a virtual camera from an observer's point of view. The data collection included taking observational notes on the sessions, as well as videotaping and recording the groups' discussions (7 h, 51 min). These discussions were recorded straight from the VoIP speech system using the software "Audacity."

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Data analysis

In this study, content analysis (Neuendorf 2002) was applied. The analysis was targeted towards creating a picture of teachers' and students' interaction processes in a 3D game setting. Therefore, after conducting the empirical study, all video data (with four groups and a total of 8331 utterances) were transcribed and read through several times. Of those, 144 utterances were excluded (by joint negotiation of the three researchers coding the data) from

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the analysis because they were unclear, due to overlapping speech acts, laughing, or individuals' own soliloquies that were unrelated to shared knowledge construction.

Identifying the unit of analysis Knowledge construction processes were analyzed using utterances (i.e., typically one turn of speech of transcribed data) as the unit of analysis (Chi 1997). (e.g., Joel: "They want a hammock and they want their food soon"). On 166 occasions (2 % of all the speech turns), we combined two utterances into one unit of analysis, since the content of the utterances only became meaningful through this combination. In practice, two researchers (coders 1 and 2) negotiated about the cases in which grammatical utterances did not constitute semantic units of knowledge construction (for example: Nina: "Now I have the chicken curry, but it contains nuts. Do we serve it anyway?; contextual questions; reasoning), whereas the first part ("Now I have the chicken curry, but it contains nuts.") included the contextualization of the question necessary to understand the knowledge construction process (see the introduction of the game; as the key for the task solution was to serve a curry chicken without nuts). Each unit of analysis received one code.

Developing the coding scheme The previous coding schemes in the 3D settings have concentrated on students' interaction processes. However, in order to analyze the interaction processes in the present study, a coding scheme that focuses specifically on the teacher-student interaction was needed to identify different types of teacher activities in 3D settings. In this respect, Vosniadou et al. (2001) approach to classroom discourse analysis informed our analysis of teachers' and students' interactions. We grounded our analysis on this a priori developed scheme (see Table 1). Although it was originally developed in an elementary school context, we opted for this approach as it was grounded on the idea that learning is greatly facilitated by interactions with peers and, in particular, teachers acting in the zone of proximal development (Vygotsky 1978). However, the interpretation of the analysis was further developed contextually (new categories were deduced from the empirical material) as

t1.1 **Table 1** Main categories

	Main category	Description	Confluence to the work of Vosniadou et al. (2001)
t1.2			
t1.3	1. Providing knowledge	Bringing in new knowledge related to learning contexts and/or task solving (e.g., giving advice, explaining one's own situation, giving opinions)	Providing information—statements through which the teachers explain, describe, clarify, or provide information
t1.4	2. Contextual questions	Asking questions related to context (e.g., new openings, specifying and reasoning in the form of questions)	Asking questions—questions asked by the teachers related to subject matter
t1.5	3. Shared problem solving	Knowledge construction that relates to others' discussions (e.g., reasoning, clarifying, specifying)	
t1.6	4. Management of interaction	Developing strategies for future activities (e.g., planning upcoming work)	Management of interaction— statements concerning the management of the class
t1.7	5. Summing up/ discovering a solution	Summarizing previous information, verifying understanding, discovering a solution	
t1.8	6. Other input	Speech acts related or not related to task solving that are part of the discussions with others	

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interaction activities were mediated by the scripted 3D game that was seen as influential to knowledge construction (Sawyer and DeZutter 2009; Wegerif 2007). In practical terms, contextual adaption of the analysis was the result of actual teachers' and students' activities taking place in this 3D setting in which the teachers' role was quite different from that in traditional classroom settings. Thus, to describe the dynamic interactions that occurred between teachers and students, the categories of *shared problem solving, summing up/discovering a solution,* and *other inputs* were added as interaction activities that were manifested in solving the game tasks (see Table 1).

Coding the data A quantitative-based qualitative approach (Chi 1997; Kiili 2012) of applied content analysis was used to analyze 8188 utterances. This means that the coding of evidence was based on applied qualitative analysis after which the codes' frequencies were analyzed quantitatively (for a detail description of the method, see Chi 1997) for the purpose of understanding knowledge construction (Berelson 1952). In practice, the discussions were analyzed in two phases. In the first phase, discussions were placed into the following six theory-based main categories: providing knowledge, contextual questions, shared problem solving, management of interaction, summing up/discovering a solution, and other inputs (represented and described in Table 1).

The second phase aimed to further develop an understanding of teachers' and students' interaction processes. Here, the aim was to gain a more detailed understanding of exchanges between the group members. The utterances were further sorted into the following 25 different data-driven subcategories within the six main categories (e.g., Beers et al. 2007) according to the more detailed functions of the interactions (see Table 2 for more detailed descriptions). The subcategories were developed to create further understanding of how knowledge construction was built on others' ideas and thoughts (see also Arvaja 2007).

Checking reliability Three raters coded all 8188 utterances. To ensure impartial coding, the coders could not see whether the speaker was a teacher or a student during the coding process. The transcripts were coded by the first author of the paper (coder 1), by one researcher (long-term colleague of coder 1 that has been actively developing game environments in this design-based study since 2006) (coder 2), and by one trained coder working in the area of collaborative learning (coder 3). Thus, coders 1 and 2 have been developing and elaborating coding schemes for several years. In practice, this means collaborative discussions during the development of this method of analysis. Coder 3 was trained on the content analysis method. Additionally, coders 1 and 2 coded transcripts together with coder 3 for five hours. Afterwards, coder 3 coded transcripts independently. However, regular (about one-hour) Skype meetings were held throughout the coding processes. During these meetings, coders 1, 2, and 3 discussed excerpts of transcripts to increase the coders' shared understanding of the coding processes. Therefore, although the raters coded the data independently, the coding process was not totally independent as a result of such periodic meetings. Despite this fact, inter-rater reliabilities were calculated. The overall inter-rater agreement between the three coders was 7733/8188 (94.45 %). More specifically, the agreement between coders 1 and 2 was 7934/8188 (96.90 %), between coders 1 and 3 was 7890/8188 (96.37 %), and between coders 2 and 3 was 7829/8188 (95.62 %). Krippendorff's alpha coefficient was 0.96, indicating excellent agreement (Krippendorff 1980). However, it has to be noted that this was likely influenced by the Skype-meetings organized during the coding process with coder 3 and by the fact that coders 1 and 2 have several years' shared background in developing this method to analyze collaborative knowledge construction in 3D game settings.

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Table 2 Subcategories

	Subcategories	Descriptions
1	**Providing knowledge**	
1A	Contextual advice	Advice for task solving
1B	Technical advice	Advice for technical issues
1C	New information	Introducing new information
1D	Explaining one's own situation	Explaining one's own situation
1E	Justified opinion	Providing an opinion with reasoning
1 F	Non-justified opinion	Providing an opinion without reasoning
2	**Contextual questions**	
2A	New openings	Bringing in new information or giving suggestions in question form
2B	Technical	Asking about technical issues
2C	Specifying	Asking for specific knowledge
2D	Reasoning	Reasoning about knowledge in question form
2E	Opinion	Expressing an opinion in question form
3	**Shared problem solving**	
3A	Continues one's work	Continuing shared knowledge construction begun by other group members
3B	Answers	Answering a question or giving clarification
3C	Disagrees/argues	Expressing disagreement or arguing
3D	Reasoning	Reasoning about knowledge or task solution
4	**Management of interaction**	
4A	Group organization	Organizing group activities
4B	Planning upcoming activities	Giving suggestions, advice, or clarification about an upcoming activity related to group work
4C	Organizational questions	Organizing group work in question form
4D	Support	Supporting shared knowledge construction/task solving
5	**Summing-up/discovering solutions**	
5A	Based on group activities	Summarizing a previous discussion/discovering a solution based on group activities
5B	Based on one's own actions	Summarizing a previous discussion/discovering a solution based on own activities
5C	Based on unknown reason/s	Summarizing a previous discussion/discovering a solution based on an unknown reason
6	**Other input**	
6A	Other input—related to task solving	Other speech activities related to shared knowledge construction and/or task solving
6B	Describing technical problems	Describing technical problems of the 3D environment
6C	Off task—not related to environment	Other interactions that are not related to task solving

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Exploring participation in a 3D game setting Next, the discussion data (8188 utterances) were examined according to the participant type (teachers, n=2125 utterances, and students, n=6063 utterances) to explore how the teachers' and students' utterances differed from one another. In practice, teachers' and students' discussion activities were coded in main- and subcategories and the differences and similarities with respect to the relation between participants' role and these main- and subcategories were explored. A Pearson's chi-square test of independence was performed to examine the relation between participants' roles (i.e., teacher or student) and the different types of discussion utterances. Additionally, all of the teachers' utterances were analyzed along with the students' utterances immediately following the teachers' specific statements or questions to determine what types of teacher activities elicited specific types of student activities. Finally, different teachers' utterances (along with the students' utterances immediately following them) were compared.

Results

This section revealed our new understanding of the instructional activities that teachers introduced to the classroom when teachers' and students' interactions are mediated by a scripted 3D game. The findings indicated that in the 3D game setting observed in this study, teachers and students engaged in rather similar discussion activities. Thus, teachers acted more as fellow collaborators when resolving problems in this setting than they typically do in traditional classroom settings. The following section is divided into three parts according to the research questions. In the first part, we highlight the differences and similarities of teachers' and students' discussions while working in the game environment. In the second part, we focused on teachers' instructional activities. In practice, we identified different ways that teachers applied to empower vocational learning in this 3D setting. Finally, we reported on how students responded to teachers' activities.

Interaction similarities and differences between teachers and students

The discursive activity of 8188 utterances enhances our understanding of teachers' instructional activities in the 3D game setting (see Table 3 for an overview of the descriptive results). The analysis indicated that although teachers and students showed rather similar discussion patterns in the 3D game setting, statistically significant overall differences ($\chi2=65.2$, df=5, $p<.001$) were found. The main differences observed between teachers' and students' interactions involved the ways in which they asked contextual questions, provided knowledge, and continued engaging in shared problem solving when trying to complete game tasks. As we can see from Table 3, teachers exerted more effort asking contextual questions (teachers=21.1 %, students=16.0 %) and engaging in shared problem solving (teachers=33.0 %, students=30.2 %) than students, while students were more active in providing knowledge (teachers=24.2 %, students=27.4 %).

Table 3 Categorization of teachers' and students' utterances

Main categories	Teachers N (%)	Students N (%)
Providing knowledge	515 (24.2 %)	1661 (27.4 %)
Contextual questions	449 (21.1 %)	970 (16.0 %)
Shared problem solving	702 (33.0 %)	1831 (30.2 %)
Management of interaction	153 (7.2 %)	390 (6.4 %)
Summing-up/discover solutions	44 (2.1 %)	124 (2.0 %)
Other input	262 (12.3 %)	1087 (17.9 %)

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A more detailed data-driven analysis indicated differences between teachers and students at a more specific level (for each main category, the distribution between the subcategories was presented as a percentage). Between the subcategories within each main category, significant differences were also found with respect to providing knowledge ($\chi 2$=74.7, df=5, p<.001, Cramer's V=.19), contextual questions ($\chi 2$=10.8, df=4, p=.029, Cramer's V=.09), shared problem solving ($\chi 2$=78.0, df=3, p<.001, Cramer's V=.18), and management of interaction ($\chi 2$=10.4, df=3, p=.015, Cramer's V=.14).

First, within the main type of discussion, *providing knowledge*, teachers more actively introduced new information (teachers=47.2 %, students=33.2 %), while students' activity was higher in giving contextual (teachers=4.9 %, students=16.1 %) and technical (teachers=0.4 %, students=3.8 %) instructions to other group members. Second, all participants applied several different means of *asking contextual questions* when trying to solve the tasks in the 3D game setting. However, as indicated by the effect size Cramer's V, there were only small differences between teachers' and students' utterances within this category. Third, one of the main differences concerned the level of persevering in *shared task solving*; teachers used 55.8 % of their shared problem solving utterances to continue a knowledge construction process initiated by another group member(s), and the students used only 39.6 % of their shared problem solving utterances for this. In addition, although none of the participants had earlier experiences with the game environment (and therefore teachers did not even know the correct answers to the problems), students provided more direct answers to the questions than teachers (teachers=32.3 %, students=46.5 %). Furthermore, students were more active in expressing disagreement and presenting arguments (teachers=2.7 %, students=7.5 %), while teachers applied more reasoning than students (teachers=9.1 %, students=6.4 %). Fourth, both teachers and students *managed interactions*. The largest differences between teachers and students were that teachers asked more organizational questions (teachers=30.7 %, students=18.7 %), while students were more active in group organization (teachers=50.3 %, students=61.3 %). However, teachers and students equally supported shared problem solving and planned upcoming activities.

Two different types of instructional activities

The content analysis revealed that the teachers mainly contributed by (1) providing knowledge, (2) asking contextual questions, and (3) taking part in shared problem solving. The teachers focused, to a lesser extent, on the other activities, namely (4) the management of interactions, (5) summing up, and (6) other inputs. In this regard, at first glance it would seem that their activities in all groups were rather similar. However, our comparison of teachers revealed that only contextual questions were quite similarly applied by all the teachers (cf. all participants; also students applied various means of asking contextual questions rather equally). Despite this similarity, further analysis revealed that the actual participation activities that the teachers used in their discussions differed. A "knowledge-providing" approach was applied by two teachers (see Fig. 2, teachers in groups 1 and 2; (1) providing knowledge), and a "joint problem-solving" approach, in which shared problem solving was actively used to empower vocational learning, was employed by two teachers (see Fig. 2, teachers in groups 3 and 4; (3) shared problem solving). A more detailed investigation highlighted that the two "knowledge-providing" teachers (teachers 1 and 2) used different instructional activities, while the two "joint problem-solving" teachers used similar types of instructional activities for the most part. In practice, teachers 3 and 4 used the same activities but applied them in a slightly different way. Thus, teacher 3 focused a bit more on asking for specifying knowledge (20.3 %) and continuing one's work (18.9 %),

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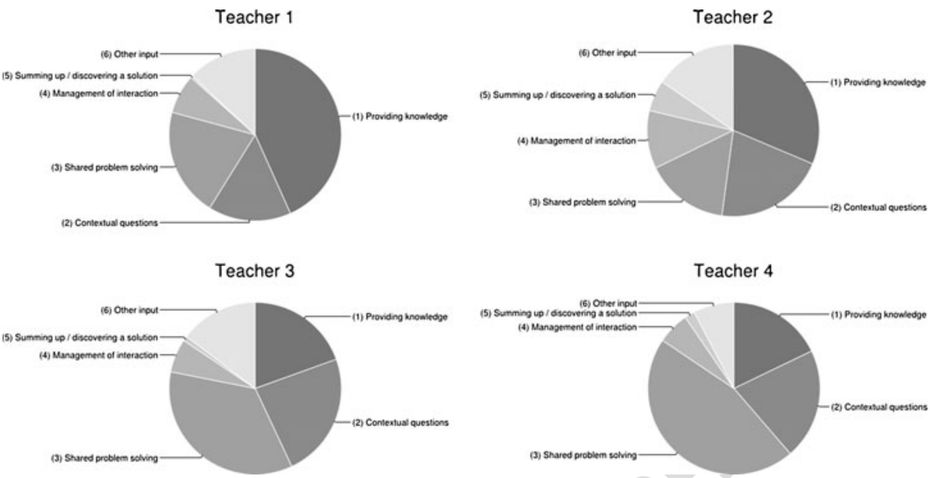

Fig. 2 Overview of the teachers' discussions Q12

while the teacher 4 was asking for specifying knowledge (19.2 %) and continuing one's work (28.4 %). Greater variation was found between "knowledge-providing" teachers. Therefore, in the following we took a further look at their differences.

As can be seen from Fig. 2, providing knowledge, asking contextual questions, and taking part in shared problem solving were the three most frequently used main categories by both "knowledge-providing" teachers (teachers 1 and 2). Additionally, providing knowledge was the most actively applied instructional activity for both. However, their activities differed in terms of how they provided knowledge. In group 1, the teacher focused more on explaining situations (26.7 %) (see Fig. 3 -sections 1D; Explaining one's own situation), whereas in group 2 the teacher focused more on introducing new information (23.5 %) (see Fig. 3 -sections 1C; Introducing new information). The other main differences between these two teachers (as Fig. 3 illustrates) is that teacher 2 actively presented opinions in a question form and asked specifying and organizational questions more than frequently teacher 1, while teacher 1 applied more non-justified opinions and new openings in a question form than teacher 2.

In conclusion, the teachers in groups 1 and 2 asked students for specifying knowledge and encouraged them to continue their work less frequently than teachers in groups 3 and 4. However, this does not mean that their activities did not relate to students' knowledge construction. While all of the teachers solved problems together with the students, teachers 1 and 2 applied a well-known "knowledge-providing" approach by actively introducing new information (based on their internal resources, e.g., work-life knowledge) and explaining their own activities. In addition, the two teachers who applied "joint problem-solving" strategies employed the rather typical instructional activity of asking specifying questions, but they also made a concerted effort to apply an alternative type of instructional activity, namely, continuing shared problem solving, with students.

Students' responses to the teachers' contributions

In general, our findings indicated that when teachers were providing knowledge, the next student utterance was most likely to focus on providing knowledge as well. On the other hand, the next student utterance was more likely to focus on shared problem solving when

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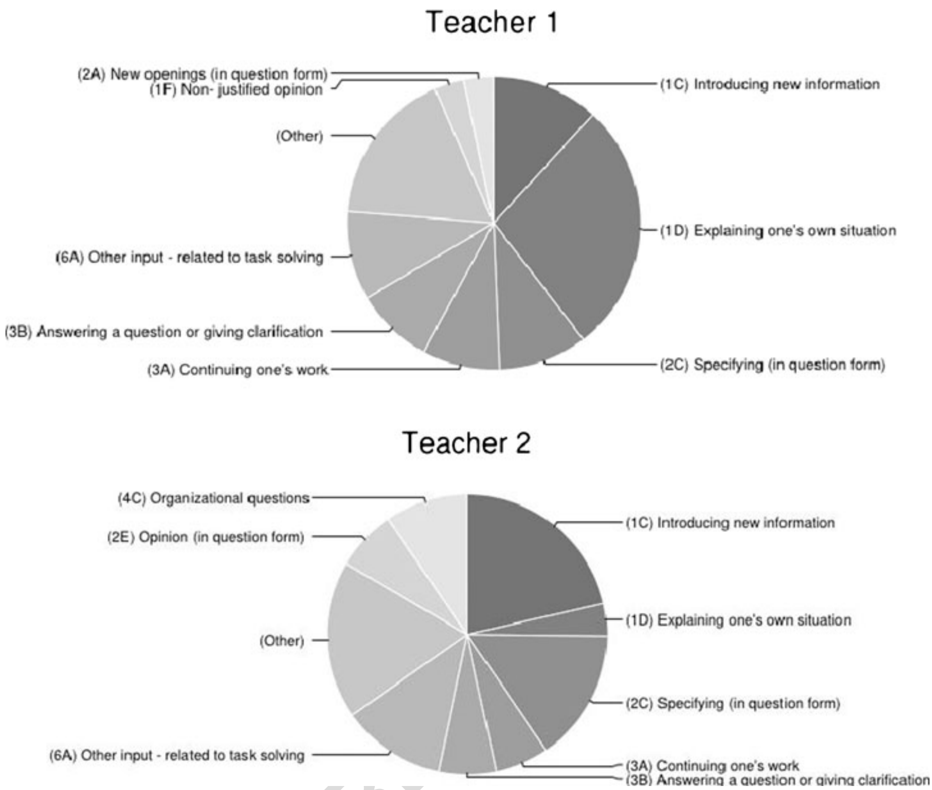

Fig. 3 "Knowledge-providing" teachers' discussions Q13

teachers either asked contextual questions or contributed to the shared problem solving process (see the percentages in bold in Table 4). Furthermore, a more detailed investigation illustrated that when teachers asked specifying questions, the students' next utterances most frequently involved direct answering or clarification, or proposing a new specifying question. Finally, when teachers continued in shared knowledge construction, students kept continuing that shared knowledge construction process.

The findings provided information about how students responded to "knowledge-providing" teachers' (in groups 1 and 2) and "joint problem-solving" teachers' (in groups 3 and 4) contributions. More specifically, the teachers in groups 1 (n=231 utterances) and 2 (n=240 utterances) had fewer utterances, and thus also fewer utterances that elicited utterances (or more discussion) from students, than the teachers in groups 3 (n=701 utterances) and 4 (n=669 utterances). As explained earlier, the teachers in groups 1 and 2 focused more on providing knowledge (104 out of 231 and 71 out of 240 utterances, respectively), which, in line with the overall observations discussed above, resulted in students providing knowledge in their subsequent utterances. The teachers in groups 3 and 4 also focused on providing knowledge—they had even more utterances related to the provision of knowledge (141 out of 701 and 119 out of 669, respectively) than teachers in groups 1 and 2. However, since they contributed more to the discussion than the teachers in groups 1 and 2 and thus had significantly more utterances overall, it was not their most frequent form of utterance. The discussion activities of the teachers in groups 3 and 4 mainly involved asking contextual questions (166 out of 701 and 142 out of 669 utterances, respectively) and shared problem

Table 4 Overview of teachers' utterances and the next student utterance divided by group

Teachers' Utterances by category	Group	Following students' utterances by category						
		(1)	(2)	(3)	(4)	(5)	(6)	Total n
(1) Providing knowledge	Group 1	49 %	18 %	5 %	8 %	6 %	14 %	104
	Group 2	52 %	7 %	11 %	4 %	0 %	25 %	71
	Group 3	33 %	21 %	9 %	11 %	1 %	26 %	141
	Group 4	37 %	18 %	26 %	6 %	1 %	13 %	119
	Total	**41 %**	17 %	13 %	8 %	2 %	20 %	435
(2) Contextual questions	Group 1	23 %	9 %	60 %	6 %	0 %	3 %	35
	Group 2	18 %	10 %	62 %	2 %	0 %	8 %	61
	Group 3	19 %	16 %	51 %	5 %	1 %	9 %	166
	Group 4	20 %	11 %	54 %	4 %	1 %	10 %	142
	Total	20 %	13 %	**54 %**	4 %	0 %	9 %	404
(3) Shared problem solving	Group 1	37 %	11 %	24 %	9 %	2 %	17 %	46
	Group 2	23 %	23 %	37 %	9 %	3 %	6 %	35
	Group 3	14 %	22 %	40 %	5 %	0 %	19 %	243
	Group 4	23 %	15 %	43 %	3 %	3 %	12 %	304
	Total	21 %	18 %	**40 %**	5 %	2 %	15 %	628
(4) Management of interaction	Group 1	35 %	6 %	24 %	24 %	0 %	12 %	17
	Group 2	19 %	16 %	45 %	0 %	0 %	19 %	31
	Group 3	23 %	21 %	21 %	16 %	2 %	16 %	43
	Group 4	32 %	20 %	32 %	10 %	0 %	7 %	41
	Total	27 %	17 %	30 %	11 %	1 %	14 %	132
(5) Summing-up/discovering solutions	Group 1	100 %	0 %	0 %	0 %	0 %	0 %	1
	Group 2	30 %	10 %	20 %	20 %	0 %	20 %	10
	Group 3	14 %	14 %	29 %	14 %	0 %	29 %	7
	Group 4	15 %	0 %	54 %	0 %	0 %	31 %	13
	Total	23 %	6 %	35 %	10 %	0 %	26 %	31
(6) Other input	Group 1	50 %	11 %	7 %	4 %	0 %	29 %	28
	Group 2	25 %	16 %	9 %	6 %	0 %	44 %	32
	Group 3	22 %	28 %	15 %	7 %	2 %	27 %	101
	Group 4	22 %	18 %	22 %	10 %	2 %	26 %	50
	Total	26 %	21 %	15 %	7 %	1 %	29 %	211

Note: Numbers in bold are discussed in the results section

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solving (243 out of 701 and 304 out of 669). A large proportion of these two types of utterances preceded student utterances focusing on shared problem solving as well. In conclusion, there were difference in students' follow-up utterances in response to "knowledge-providing" teachers and "joint problem-solving" teachers.

Conclusions and discussion

Due to the lack of empirical research, the context of vocational education can be considered one of the challenges from the viewpoint of CSCL research. At the same time, with respect to the application of new TEL environments in vocational education, the rapid advance of technology creates new hopes for empowering learning and professional development. However, what teachers actually can and should do in various new TEL settings for vocational learning remains unclear. This study was one attempt to respond to the current challenge of enriching TEL, as there is a paucity of academic knowledge on the teachers' role in TEL settings (Lund and Smørdal 2006). Thus, the study focused on teachers' and students' interaction processes in a synchronous 3D game setting for vocational education, with the goal of gaining a more comprehensive understanding of how teachers support students' vocational learning processes in new TEL settings.

Identifying a model for content analysis

Several CSCL studies have shown that content analysis techniques may be useful in understanding collaborative interactions (De Laat and Lally 2004; De Wever et al. 2007; Kapur and Kinzer 2008; Mu et al. 2012; Strijbos et al. 2006). However, there is a critical idea that despite its assumed potential to reveal information on synchronous interactions in 3D settings, few studies have applied content analysis in these settings[1]. Therefore, the methodological aim of this study was to identify a method of content analysis to examine the interaction processes of students and teachers involved in a 3D game setting. In our analysis of the teachers' and students' interactions, Vosniadou et al. (2001) approach to teacher-student interactions (an analysis of classroom discourse) served as the foundation. However, as interactions were mediated by the scripted 3D game and this context influenced knowledge construction, we expanded on their approach. The analysis showed to be useful in terms of shedding light on the ongoing problem-solving discussions in the 3D environment under study. Additionally, quantifying the data based on the analyses enabled the comparison of the similarities and differences between the teachers' and students'—as well as different teachers'—utterances in their discussions. Therefore, this analysis served as a valuable tool to obtain firsthand knowledge about the nature of teachers' participation in the 3D game setting. Furthermore, analyzing the teachers' utterances together with the students' follow-up utterances in response to these allowed us to investigate the responses elicited by teachers' instructional activities (through their utterances) in this new TEL setting.

Similarities between teachers' and students' contributions

The findings illustrated that when teachers' and students' interactions are mediated by a scripted 3D game, teachers seem to apply different instructional activities than they would in traditional classroom settings (see e.g. Onrubia and Engel 2012; Webb 2009). In this particular 3D game setting, teachers and students used many similar types of discussion activities. Thus, this raises the following question: What are the benefits of having teachers involved in the environment, and what are the benefits of their actions in this context? The results of this DBR show two main advances for teachers' instructional activities in game settings. Firstly, our previous study indicated that productive vocational learning processes do not necessarily emerge without teachers' assistance. Thus, in the vocational context, teachers may have a unique role in empowering professional development, as in vocational education, students are most often young adults between 16 and 18 years of age who have little to no relevant work experience related to their future vocation. It may be hard to apply, for instance, their prior knowledge (Dochy et al. 1999) or internal resources (Arvaja 2007) to

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learning the essential skills needed at work. Secondly, the findings revealed that in 3D vocational learning settings, teachers incorporate new instructional practices to cultivate the knowledge and skills students will need in real-life work contexts. In general, teachers seemed to adopt work strategies that stimulated students to give contextual and technical instructions, answer and clarify, and propose disagreements and arguments.

Teachers' instructional activities and how students respond to them

The findings highlight teachers' different styles in empowering learning, not only with respect to their levels of contribution to the discussions, but also with respect to their types of contributions. The study illustrates that teachers were able to apply a "knowledge-providing" approach and a "joint problem-solving" approach "on the fly" to enhance vocational learning. Furthermore, the findings indicated that when teachers provided knowledge, the next student utterance was most likely to involve the provision of knowledge as well. The next student utterance was more likely to focus on shared problem solving when teachers either asked contextual questions or contributed to the shared problem solving process themselves. Although there are many factors at play, this may be an indication that teachers can guide the knowledge construction processes going on in the discussions in a certain direction, such as toward having students engage in shared problem solving. Thus, in the future this knowledge may be used to develop new ways for teachers to provide different learning opportunities for vocational students in 3D settings (e.g., to stimulate or encourage students to provide knowledge or engage in joint problem-solving activities). Additionally, this may help teachers to develop strategies that they can use in supporting the vocational learning processes in new TEL settings.

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Limitations and strengths of the study

In line with the DBR approach, this study was an attempt to investigate the role of teachers based on the authentic needs of students in a vocational education setting. Thus, one major limitation of our approach is that this kind of setting makes it impossible to control the influence of single parameters; therefore, the findings are only exploratory in nature (see also Herrmann and Kienle 2008) and it is impossible to generalize the findings. A second limitation is that our study did not examine students' learning process (as the main focus was on teachers' instructional activities). Third, only the short-term effect of teachers' and students' interactions was explored. Fourth, the teachers' internal resources (e.g. backgrounds, expertise or attitudes towards 3D games) were not investigated. Therefore, additional studies still need to be conducted to identify reasons for teachers' different styles in empowering learning in 3D learning settings. Finally, further qualitative studies are needed to shed light on the interaction processes between teachers and students who work together in a vocational education context. However, this study also has several strengths. First, particularly in the vocational learning context, further knowledge on new TEL environments and their relation to vocational learning practices is needed. Secondly, along with the development of learning environments, this study pays attention to the effective use of the potential offered by future 3D learning spaces with regard to the teachers' active role in empowering vocational learning and professional development, which has rarely been explored to date. Thirdly, the analysis made it possible to identify different types of teacher activities that empower vocational learning processes. Finally, one particular strength of this

DBR is that it has focused on investigating CSCL in the context of vocational education for several years (since 2004), which allowed us to gain a more in-depth perspective of the special features of vocational learning with the respect new 3D settings than a single experimental study would (cf. shortage of the research findings in the area of CSCL). Thus, next we will discuss the emerging need to apply TEL in vocational learning based on the findings of this study and our experiences in previous studies.

General discussion and directions for future research

Based on the findings of this DBR, new technologies can enhance vocational learning. Technology enables the design of new learning methods that bring new kinds of learning activities to vocational education (e.g., by illustrating the complex dynamics of business administration, see Minnaert et al. 2011). However, in recent discussions, it has been acknowledged that technological development in itself is not enough (Underwood and Dillon 2011), as the responsibility for students' learning cannot be transferred solely to technology. Stahl (2010) has highlighted that despite the researchers' optimistic ideas about CSCL, in reality, successful collaboration is rather singular and hard to identify, multiplex in the structure of its essential mechanisms and the elements influencing them, and exclusive in each of its contextual instances. While technology can be an asset to create virtual learning situations that could not be created in real life, teachers, instructional designers, and researchers should be aware that not the virtual environment in itself, but rather the participant's activity, is provoking collaboration or learning.

At the same time, new technologies may enable new ways to support teachers' instructional activities, as in traditional classrooms (cf. teachers' instructional discourse, e.g. Webb 2009); teachers are in charge of the learning scenario. In the new TEL environments, however, the technology takes more precedence of the learning scenario. The findings of this study illuminate clear a shift in the locus of instructional activity (cf. traditional classroom settings in vocational learning context), as teachers are able to mainly focus their attention on empowering vocational knowledge construction processes, and there is very little need for them to focus their effort on managing students activities. Thus, not only is the environment designed a priori, but the software, and users' interaction with the software also guides the lessons. This means that teachers are not always responsible for introducing, selecting, sequencing, and concluding activities (cf. orchestrating learning; managing activities of different students, groups and technological tools; Dillenbourg 2012). On the other hand, this does not mean that their role is redundant; rather we argue that this enables vocational teachers to focus on empowering learning processes instead of managing the flow of their classrooms. Thus, new technologies may enable teachers to better evaluate collaboration progress before intervening the students' learning processes.

Despite the potential of the idea that with the aid of new technologies, the role of teachers may be increasingly related to empowering collaborative learning situations in which joint problem solving may occur (Hämäläinen and Vähäsantanen 2011), there are critical aspects as well. According to Sawyer (2004) fostering students' collaborative problem-solving is related to the competencies of teachers. Therefore, current transformations in the work tools (e.g., integrating technologies to education) create challenges for teachers' professional development (Schlager and Fusco 2004) and their instructional activities that empower vocational learning (De Bruijn and Leeman 2011; Pillen et al. 2012). There is a critical standpoint that currently, teachers are not necessarily sufficiently equipped to help their students to develop future work-life skills in new TEL settings. In reality, it can be

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challenging for many teachers to adapt to these new practices in their teaching. Therefore, we need a better empirical understanding of vocational teachers' possibilities and encounters in new TEL settings related, for example, to identity tensions (Pillen et al. 2012), the teachers' attitudes towards TEL (Knezek and Christensen 1998; Kreijns et al. 2013), and professional agency (Vähäsantanen and Eteläpelto 2011) in their work. Thus, in terms of teachers' instructional activities in new TEL settings, it is not enough that new technologies are being developed to empower learning; there must also be a chance to support teachers´ instructional activities and professional development to better meet students' present and future work life needs.

To sum up, in vocational education teachers seem to play a special role in enhancing students' learning (e.g., helping them to develop transversal skills). Our findings indicate that, at their best, teachers are able to develop diverse and innovative ways to enhance students' vocational learning and professional development. Since new TEL environments may be more frequently integrated into vocational education and training in the future, it is encouraging to see that teachers are able to spontaneously develop new ways to support vocational learning in new TEL spaces. However, it is crucial to find more knowledge on what teachers can do to empower learning in new TEL settings (see Stein et al. 2008), such as mobile-supported work contexts (Motta et al. 2012). Currently, the emerging challenges of CSCL research involve the role of vocational teachers regarding technological and pedagogical development. Additionally, we need to investigate not only the benefits of new technologies, but also new ways of providing work-tools for teachers that produce knowledge of the learning processes. In practice, this could mean environments for vocational education that enable teachers to see when students need assistance in their collaborative knowledge construction processes.

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