**New TEL Environments for Vocational Education — Teachers' Instructional Perspective**

Raija Hämäläinen[1*] and Alberto Cattaneo[2]

[*]Corresponding

[1] University of Jyväskylä, Institute for Educational Research, P.O.Box 35, FI-40014 University of Jyväskylä, Tel +358 40 805 4250, Fax +358 14 260 3201, raija.h.hamalainen@jyu.fi

[2] Swiss Federal Institute for Vocational Education and Training, Istituto universitario federale per la formazione professionale IUFFP, Via Besso 84/86, 6900 Lugano, Phone +41 91 960 77 24, alberto.cattaneo@iuffp-svizzera.ch

**Abstract:** Modern vocational education is increasingly taking place in new technology-enhanced learning (TEL) settings. On the one hand, vocational education can benefit from the opportunities of technological development. On the other hand, such technologies may create new challenges for teachers. Therefore, there is a particular need to pay more attention to the dialogic pedagogical approaches in which teaching should be seen as a dialogical practice involving teacher–student interactions that create contextual opportunities for teachers to trigger students' learning in new TEL settings. This article reports on an exploratory study about the different ways in which teachers' instructional activities (via teacher-student interactions) are manifested in different emerging TEL contexts. Three case studies were selected for analysis in three different TEL settings. The results of this qualitative study indicate that 'teacher-led' approaches were applied in a technology-enhanced classroom context, 'teacher-student shared collaboration activities' were actively used in a virtual 3D-game setting and 'teacher-student(s)-supervisor(s) joint learning activities' were used to empower mobile-supported work-based learning. Based on the findings raised from these three empirical studies, future prospects for teachers' activities that facilitate vocational learning can be developed. Additionally, our findings may be helpful in developing professional tools for teachers to better enable learning in new TEL settings.

## 1 Introduction

The application of new technologies in vocational learning can be seen as one way to enhance vocational learning and respond to the emerging needs of working life. Previous research has indicated several optimistic notions of technology-enhanced learning (TEL) for vocational education and training (VET). For example, studies have shown the advance of technological tools in enabling vocational learning processes, e.g. by offering more illustrative 3D spaces to practice dangerous work situations (Hämäläinen, 2011) and by providing new tangible tools for carpenter learners to link the 2D representations of an object and its 3D shape (Cuendet & Dillenbourg, 2013; Cuendet, et al., 2014). Minnaert, Boekaerts, De Brabander & Opdenakker (2011) illuminated the effectiveness of an electronic questionnaire integrating process-oriented, intermediate graphical output features to practice the work skills required for commerce and business administration in a collaborative learning setting. Other studies (Boldrini & Cattaneo, 2013) have used electronic learning journals to foster processes of reflection upon apprentices' professional practices. Further, weblog and wiki tools have been helpful with respect to professional skill acquisition for dental assistants (x-ray management) and commercial employees (e.g. phone call management and customer care; see Gavota et al., 2010). In sum, the recent research findings have indicated that at its best, technology can upgrade traditional vocational learning approaches.

Related to the above advances of TEL environments for VET, there are also critical discussions that technology alone does very little to aid learning. It has been argued that although technology has rapidly advanced, the challenges of enhancing learning in TEL settings remain. Therefore, TEL crucially depends on the character of the actual learning activities in which learners engage with technology. As one potential solution for triggering learning in TEL settings, increasing attention has been given to individual (Schank & Abelson, 1977) and collaboration (Kobbe et. al., 2007) scripts as a particular kind of instructional approach to support learning. According to Kollar and colleagues (2006), scripts provide individuals with information about appropriate

actions within a situation and help them better understand the situations in which they are involved in TEL settings. This can result in enhanced problem solving (problem solving in TEL refers to learners' ability to use technology, to acquire and evaluate information, collaborate with others and perform tasks, OECD, 2012, p. 47)). In practice, scripts operate by structuring learners' activities and assigning learners' roles in order to enhance effective problem-solving processes in TEL settings, related to the thoughtful use of available resources and/or task division (for a detailed description of scripts, see a recent review by Fischer et al., 2013). On the other hand, the problem with the studies focusing on scripts has been that they have typically been conducted without the active role of the teacher. As a direct result, Dillenbourg and Jermann (2010) have argued that focusing only on specific scripts neglects the role of teachers in TEL settings. In line with that, it has been argued that, rather than the technologies themselves, it is the pedagogical and instructional approach used that makes the difference for TEL (Cattaneo & Aprea, 2014; Schmid et al., 2014; Hew & Cheung, 2013; Hämäläinen, 2011). Therefore, along with the development of technological environments and scripts, it is necessary to pay attention to the potential offered by an active role of the teachers.

In fact, according to Jones (2007), teachers' instructional activity is crucial in promoting effective learning in different TEL settings. Warwick, Hennessy and Mercer (2011) have also argued that the new technologies applied in education influence teachers' instructional activities. Therefore, it is the teacher, not the tool itself, which has the active role for arranging beneficial learning activities (see Warwick, Hennessy & Mercer, 2011). In vocational education in particular, teachers may have a particular role in triggering students' learning, as in this context learners are most often young (typically between 16 to 18 years of age) and have little to no relevant work experience upon which they can build their knowledge (Hämäläinen & De Wever, 2013). At the same time, in vocational education, more and more often teachers are increasingly working together with learners in new TEL contexts (e.g. in technology-enhanced classrooms and virtual settings). Related to this development, Vähäsantanen and Eteläpelto (2009) concluded that the amount of 'traditional teaching' conducted by teachers in vocational schools is diminishing; teachers' instructional activities are increasingly related to coaching students' learning. Also Hämäläinen and Vähäsantanen (2011) indicated in their review study that teachers' role seems to be moving away from being a resource of knowledge to being a fellow participant in facilitating interaction processes related to the learning task. As a direct result, in a future, increasing emphasis needs to be placed on the importance of teachers as pedagogical experts and on their influence in triggering students' learning processes via feedback and feed-forward in the emerging technological settings that mediate teacher–student interactions (Brown, 2014).

In this direction, Schaap, Baartman and de Bruijn (2012) have introduced the criticism that there is a paucity of research-based knowledge on how vocational education teachers/educators can trigger learning in various new TEL environments that mediate teacher–student interactions. In emerging TEL contexts, teachers' instructional discourse (e.g. Webb, 2009) needs to be adapted to accommodate the new needs of various TEL settings. Namely, recent research findings have indicated that when teachers' and students' interactions are mediated by new technological environments, teachers need to apply different instructional activities to trigger vocational learning than they do in traditional classroom settings (Hämäläinen & De Wever, 2013). In conclusion, we could say that in new TEL settings, teachers may need to consider two aspects of emerging technologies— their contextual features and their influence on the teacher–student interaction process. Related to this, in his recent study, Mercer (2013) argued that there is a particular need to pay more attention to the dialogic pedagogical approaches in which teaching should be seen as a dialogical practice involving teacher–student interactions that create contextual opportunities for teachers to trigger students' learning. Other studies have also indicated that the 'dialogic' educational approaches (see e.g. Alexander, 2008) are one promising way to trigger learning processes in new TEL settings (Wegerif, 2007), as such dialogic teaching approaches stimulate the development of skills and learning gains (Mercer, Dawes, Wegerif & Sams, 2004; Rojas-Drummond, Littleton, Hernández & Zúniga, 2010). In practice, it is important to understand successful teacher–student interaction processes to make use of technological environments in triggering learning (Boyle & Ravenscroft, 2012).

**2 Aims**

In summary, while there are optimistic notions of new technologies for supporting learning in the VET context, there is also a critical notion that much of the research has focused on students' learning in new TEL settings, leaving the teacher's instructional activity and, more specifically, how the emerging technological settings mediate teacher–student interactions less studied. This exploratory study aims to investigate the changing conditions in the teaching profession and reflect upon how the emerging technological settings mediate the instructional activity, giving special attention to how a teacher–student interaction is manifested in three different emerging TEL contexts. The underlying research questions are:

- What kinds of teachers' instructional activities are manifested in three different emerging TEL contexts? How do teacher–student interactions differ among the three?

- What kinds of roles of teachers and technology can be subsumed from these three TEL contexts? How do they differ with respect to a) the role of technology, b) teachers' role in controlling the instructional flow and c) their communicative approach?

## 3 Material and methods

The empirical part of this study was conducted in authentic (i.e. real curricular classes with students in VET) vocational school settings. It continues the long-term research projects (in Finland and Switzerland) focusing on finding instructional approaches to support vocational learning in new TEL settings. The present study additionally focuses on illustrating how the emerging technological settings mediate the instructional activity, giving special attention to how teacher–student interactions are manifested in different TEL settings (participants' names are pseudonyms).

Three different TEL settings were chosen to illustrate the eventual modifications technology produces on the teacher's role and more particularly in teacher–student interactions for two reasons. First, they occupy diverse positions of teacher–student interactions: two cases with new TEL settings — a 3D game setting and a mobile-supported setting — to support and facilitate learning across sites (namely between workplace and school contexts), which is increasingly indicated in vocational training (Griffiths & Guile, 2003; Ludvigsen, Lund, Rasmussen, & Säljö, 2011) and where there has still been a paucity of empirical studies; and a more 'traditional' technology-enhanced classroom setting. This provides an opportunity to examine how the emerging technological settings mediate the instructional activity, particularly the teacher–student interactions. Second, the technological support for vocational learning is quite different in each case, so that at the same time technology creates new and different ways to trigger learning in all three examples. Taken together, these three settings will illustrate a) how teachers' instructional activities (via teacher-student interactions) are manifested in three different emerging TEL contexts and b) what kinds of roles of teachers and technology emerge in these three TEL contexts.

### 3.1 Data collection

Our exploratory multiple case study (Yin, 2003) is based on data collected between 2010 and 2012. In each case, the goal of the data collection was to capture the required information to determine how teachers trigger vocational learning in each TEL context. In the data collection phase, we recorded all of the interactions between teachers and students. At least one camera was always used (and eventually additional audio recorders, for example, when activities were in groups) to record what happening during the lesson. One or two researchers were also always present as ethnographic observers during the activities. Detailed information on each setting is given in Table 1, and a brief narrative description for each of them is given below.

Table 1

*Case Overview*

| | Case 1:<br><br>Technology-enhanced classroom setting | Case 2:<br><br>3D-game setting | Case 3:<br><br>Mobile-supported setting |
|---|---|---|---|
| **Frame of reference** | 12-month research project on technology-enhanced classrooms | 24-month research project on teaching with a 3D-game environment | 48-month research project on the learning potential of light portable ICT devices |
| **Location** | Finland | Finland | Switzerland |
| **The grounding study, N = 115** | n = 51, 47 learners + 4 teachers | n = 20, 16 learners + 4 teachers | n = 44, 43 learners + 1 teacher |
| **# of participants in the selected case** | n = 10 learners + 1 teacher | 4 learners + 1 teacher | n = 25 learners + 1 teacher |
| **Domain** | Information and Communications Technology | General studies for the component of complementary skills | Professional knowledge for chefs |
| **Position in the curriculum** | First year | First year | Second year |
| **Aim of the learning task** | Declarative and procedural knowledge acquisition (Installation and operation of different Linux distributions) | Problem-solving and collaborative skills development | Declarative and procedural knowledge acquisition (Cooking methods) |
| **Duration** | 10 hours of face-to-face interaction and an adequate number of homework activities | 2-hour working period | 8 periods, four hours each. |
| **Pedagogical approach** | Inquiry-based learning (Bell, Urhahne, Schanze & Ploetzner, 2010) | Collaborative problem-solving (Brown & Campione, 1994)) | TEL Experiential learning, namely the Erfahrraum model (Schwendimann, et al., 2014) |
| **Type of technology** | 'Oma tila', a Personal Learning Environment (Attwell, 2007) including a blog and a questionnaire tools | Scripted 3D-game environment (see, e.g. Kobbe et al., 2007), based on RealXtend Technology | Mobile phones connected to a Personal Learning Environment (see, e.g. Pachler, Pimmer & Seipold, 2011) made by a recipe book and a learning journal |
| **Purpose of the technology** | To increase vocational learners' own control over their professional development and vocational learning (Chatti, 2010) | To provide new ways to practice work-life situations. To connect workplace and school-based learning | To better articulate the relationship between learning locations, as well as to allow learners to share experiences and learn from reflecting on their real professional practices |
| **Data collection performed by…** | One video camera, two audio recorders; two researchers worked as ethnographic observers | One video camera and four recording systems; additionally, data collection included recordings of the groups' discussions straight from the VoIP speech system using the software 'Audacity'; two researchers as ethnographic observers | One or two video-cameras; one or two researchers as ethnographic observers |

*Case 1. A scripted technology-enhanced classroom.* In this first case, the learning task was implemented in an Information and Communications Technology course called 'Alternative Operation System for a Workstation', in a Finnish vocational school. Students worked individually at their own workstation (see Figure 1), and the task was implemented in a personal learning space called 'Oma tila' (including students' own blog tool and a questionnaire tool). Six groups of students and their teachers enrolled in a scripted learning task consisting of

five phases in which the blog tool was actively used for reporting and reflecting: (a) choosing a Linux distribution according to each learner's own interests and skills; (b) installing the selected Linux distribution on the computer and comparing different students' experiences on the installation process with the installation of Open Suse Linux ('Was it easier/more difficult?', 'What were the differences?'); (c) becoming familiar with the use of their Linux distribution in the workstation environment; (d) becoming familiar with other students' installations; (e) making a questionnaire (for other students) on the issues concerning installation and writing a summary of the questionnaire responses. The task was carried out over the course of five days (altogether, 10 hours of face-to-face interaction). The aim of the learning task was to become familiar with the issues concerning installation and the actual operation of different Linux distributions.


Figure 1. The technological environment and technology-enhanced classroom context.

*Case 2. A scripted 3D-game setting.* In this second setting, the game environment was used in a Finnish vocational school as a part of general studies in vocational education for the component of complementary skills. The game environment was grounded on the notion that in vocational education, the meaning of inter-professional collaboration in groups, teams and communities of employees has become increasingly important for professional development, as in most vocational fields different experts need to solve problems together (e.g. at a construction site plumbers, electricians and air conditioning mechanics need to work together). During the gameplay (see Figure 2), each player works individually on a computer and has a first-person view of the 3D environment. In practice, the players are interconnected via a server, which runs the virtual world where inter-professional problem solving takes place and the players' communication is supported by the Voice over Internet Protocol (VoIP) speech system. VoIP is a methodology for the delivery of voice communications over Internet Protocol networks). Players — in groups of five people, including one teacher and four students — have to solve three scripted tasks: 'Gate', aiming to activate coordination between players; 'Restaurant', aiming to trigger distributed expertise and mutual dependency between players who are working in the inter-professional game roles of the receptionist, the workman, the waiter, the waitress and the cook; and 'Stage', five players that are working as 'roadies' with the goal of solving a practical problem involving how to organize the instruments for the band members. The empirical study included a two-hour working period.

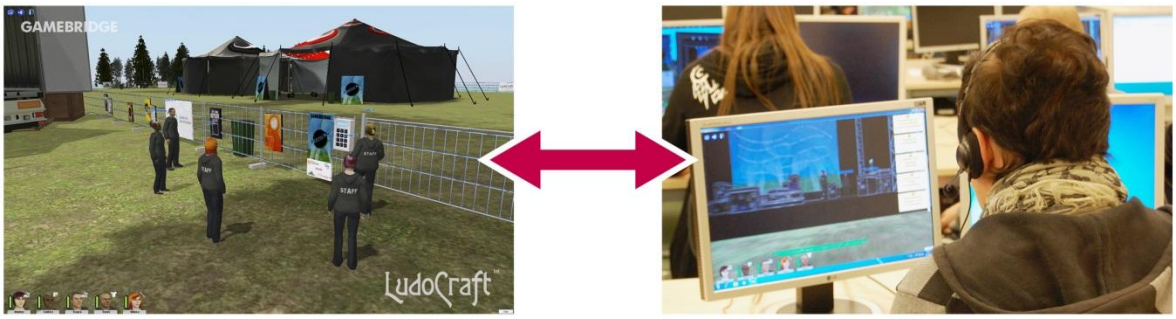


Figure 2. The 3D-game environment and virtual classroom context.

*Case 3. A non-scripted mobile and online tools setting.* Smartphones have been used in this third setting with a class of 19 apprentice chefs for the professional knowledge acquisition of different cooking methods in a Swiss vocational school. In the vocational field, different workplaces can employ learners to learn about how to handle different situations within the same professional domain; for example, cooks have to deal with different tools, different divisions of labour and different organizational workflows, depending on whether they are working in a big company canteen, in a hospital or in a tavern. The same cooking method can be executed differently in such contexts, but the expert professional has to be able to put it into effect independently from the context itself. The possibility to capture, via smartphones, real situations coming from different workplace contexts and share them at school is therefore enriching for learning. More specifically, apprentices were given a smartphone to be used in the workplace to take photos and a web-based environment where they could develop their personal recipe books and related learning journals, enriching them with the photos taken at work (Figure 3, left side). The teacher could access the platform to complete a preliminary selection of the materials produced to ensure that some meaningful aspects of professional knowledge would have arisen. On this basis, he tested two main learning scenarios: (a) beaming the pre-selected photos in the class and coaching a class discussion around them; (b) using learners' photos in a computer lab where learners could improve their own learning journals on the basis of the discussion. The whole experience covered 8 periods of about four hours each.


Figure 3. The mobile device and application, the online environment and the classroom setting.

### 3.2 Data analysis

Our previous studies ground the analysis of the present one. These previous studies have indicated that we need a better research-based understanding of the teacher's instructional activity and more particularly teacher–student interactions in the emerging technological settings (e.g. how a teacher–student interaction is manifested in classrooms, virtual settings and mobile-supported work contexts).

Concretely, we applied the ethnographic logic of inquiry (see Castanheira, Green, & Yaeger, 2009; Lipponen, & Kumpulainen, 2011) that proceeds as a series of cycles during which questions are posed and data are represented. In each case, one researcher worked as an ethnographic observer through cases 1, 2 and 3. Thus, the aim was to build a general understanding of teachers' instructional activities taking place in technology-enhanced vocational learning contexts. The interpretation of the teachers' instructional activities used in this study is in line with Vosniadou, Ioannides, Dimitrakopoulou and Papademetriou (2001), who argued that learning is greatly facilitated by interactions with peers and, in particular, teachers acting in the zone of proximal development (Vygotsky, 1978). With the emerging new technologies, the crucial question is how the emerging technological settings mediate the instructional activity when teachers acting in the zone of proximal development (via teacher–student interactions). Based on the ethnographically-grounded investigation, a qualitative analysis based on teacher–student interactions was conducted. In practice, we conducted an overview of all of the videos and made a list of events in which we identified teacher–student interactions being manifested. To provide a more specific understanding, we observed the videos several times to learn more about how teachers exercise instructional activities (see Lipponen & Kumpulainen, 2011). In each case, we started with a general question in mind: What is the role of technology and its reference to the professional situation, what is the teacher's role with respect to the learning situation flow management, how do teachers exercise new forms of instructional activities in triggering vocational learning within the emerging technological settings that mediate teacher–student interactions, and how does this emerge through situated discourse practices during teacher–student interactions in TEL environments? Next, we identified the patterns of teachers' instructional activities (Miles & Huberman, 1984). In this phase, we assumed that different types of instructional activities were manifested in different learning settings. Therefore, following the notion of Lipponen and Kumpulainen (2011), we selected episodes from each of the three TEL settings in which we identified evidence of these different instructional activities for a detailed micro-level investigation. In particular, three main categories have been used for this selection, based on the fact that the episodes could enhance our understanding of the following: (a) the role of technology and its reference to the professional situation; (b) the teacher's role with respect to the learning situation flow management; (c) the communicative approach in teacher–student interactions (for the detailed description of the theoretical background see Table 2).

Table 2

*Theoretical groundings for the categories of analysis*

| | |
|---|---|
| The role of technology | In the VET context, the role of technology can primarily be to bridge the gap between learning locations (Schwendimann et al., 2015), i.e. to create a strong relationship between the professional situations experienced at the workplace and the learning activities performed at school. To analyse the role technology played in this direction, we adopted the situation-based model by Boldrini, Ghisla and Bausch (Boldrini, Ghisla & Bausch, 2014), which identifies the relationship between the learning activity at school and its reference to the professional situation. According to this model, this reference can be direct or indirect. In the former case, you can profit from direct evidence, referred to as an authentic situation, in different forms and through different supports (oral or written narration, video, pictures,…); in the latter case, the reference to a concrete practice takes the form of a modelled situation, which is evocated or realized resorting to simulations, laboratories, role-playing, analysis of typical cases, etc. |
| Teachers' role in controlling the classroom flow | We identified how actively teachers were in charge of managing a sequence of activities for individuals and groups to enable effective learning activities. This was also traceable by making reference to the existence of a (pre-defined) script and to its level of enactment (Dillenbourg & Jermann, 2010), i.e. to the particular learning activities that teachers' pre-planning is expected to produce (cf. Ideal script, Kobbe et al., 2007; Onrubia & Engel, 2012). In |

| | |
|---|---|
| | particular, we looked at the interplay between the teacher and the technological solution to identify whether the locus of control of the instructional script was more 'internal' to the teachers or 'external' and committed to the technology itself. |
| The communicative approach in teacher–student interactions | We worked on the teacher-student communicative approach, keeping in mind the contribution by Mortimer and Scott (2003), who have distinguished between interactive authoritative and interactive dialogic approaches. In line with that, and according to the elaboration by Lehesvuori, Viiri and Rasku-Puttonen (2011), we identified the forms of authoritative teacher-talk and the dialogic teacher-talk manifested in various technological settings. |

Accordingly to these categories, one indicative example has been selected 1) to represent the dialogic teacher–student data, mainly focusing on the interplay that each emerging technological settings have on mediating teacher–student interactions, and 2) to concretely illustrate each of the three settings so that every teacher's voice is heard and represented.

## 4 Results

### 4.1 Teachers' instructional activities manifested in three TEL contexts

Next, we illustrate how teachers exercise new forms of instructional activities (via teacher–student interactions) in three different TEL settings. Each of the three empirical settings is presented as an exploratory case for study, since the technology itself brings about these differences. For each setting, we contextualize and cite excerpts (translated into English) embedded in our empirical data to illuminate our main findings. These specific excerpts were carefully chosen on the basis of the above-cited criteria as representative examples of teacher–student interactions and to provide a strong illustration of different technologies applied in VET settings. They allow three distinctly different ways of triggering vocational learning processes that teachers spontaneously applied in various TEL settings for vocational education to be described. The description of each setting is then followed by an analysis of the main findings.

#### 4.1.1 Teachers' instructional activities in a technology-enhanced classroom

In this first case, teachers' activities were mainly grounded on a pre-designed scripted lesson plan structured on five main phases, as explained previously (see Case 1 description). Thus, teachers were in charge of ensuring that learning activities proceeded according to five phases for each task. Despite the technologies used in this classroom setting (also depending on the type of curriculum), it was evident that teachers were in charge of pre-designing the tasks and real-time orchestration (referring to teachers' real-time instructional activities that arrange and organise learning activities to guide learners through learning processes maximizing the satisfaction of constraints and minimizing classroom entropy — see Dillenbourg, 2013) during each classroom activity. Concretely, teacher–student interactions were based on authoritative teacher-talk, which included mainly providing knowledge (e.g. by introducing the task(s), bringing forward content knowledge, opening up work-life knowledge), asking contextual questions, providing feedback and making conclusions. However, even if the teachers mainly led classroom activities with authoritative teacher-talk, the teacher–student distinction was not always clear-cut. Instead, there were occasions of the dialogic teacher-talk in which learner(s) had expertise that they shared and negotiated with the teachers. Finally, teacher–student interactions were influenced by the fact that learners' activities were mainly computer-based and technological tools mediated the teaching and learning activities, but also in these cases it was the teachers who had the leading role with respect to the learning

situation flow management. The following excerpt shows a typical situation in which the teacher is in charge of the classroom flow and gives (repeats) working instructions to keep students on track. Additionally, it illustrates that the teacher in charge of real-time orchestration in guiding learners through learning:

Teacher: Well now, lads, to start with, I will repeat what I just said, that there you'll find the menu for this time. This is the last week we will be working on these learning assignments 4. The installed Linux is there and hopefully up and running.

Lassi: Shall we update?

Teacher: No, don't start updating the system on any account.

Lassi: Leksa just switched off ...

Teacher: Huh?

Lassi: Seven is updating itself.

Teacher: Oh, Seven is updating itself?

Lassi: Yes, Leksa switched off the computer, so this will run twenty updates here.

Teacher: Yes, how long does it seem to take?

Lassi: Still six more to go.

Joel: It just took 20 minutes for me.

Teacher: Huh?

Joel: It just took 20 minutes on my computer.

Teacher: Yes, We can't but accept it. This is how it goes. Today we will complete those. And this kind of scheduling instruction ... The objective is that, well ... during this class you should complete those tasks 1–4 before we take a coffee break. So there would be one 45-minute period left for it, so it would be left to make the set of questions so that your partner can answer your questions. Now do you understand what we're going to do today and what you should accomplish? Is there anyone who doesn't know what to do? Everybody knows ... Good!

As we can see, the teacher started to follow a scripted lesson plan [to start with I will repeat… we will be working on…]; however, the teachers' instructional activity was influenced by an unexpected instance caused by several computers that were installing updates [Lassi: Seven is updating itself.]. The teacher reacted to that [Yes, how long does it seem to take?] with the intention to personally and directly manage the classroom situation, and related to that, the teacher smoothed students' ruffled feathers related to this computer update [Yes, We can't but accept it. This is how it goes.]. Finally, we can see that the teacher combined pre-design and classroom improvisation by concluding how the student should proceed and by ensuring that everybody understood the instructions. The unexpected moving away from the script is resolved (as we can see the teacher in charge of real-time orchestration during this unexpected event), and then the teacher can go on with the pre-designed lesson plan.

### 4.1.2 Teachers' instructional activities in a 3D-game setting

In this second setting, teachers' instructional activities were mediated by a technological tool — a scripted 3D game — that guided the learning processes (cf. classroom plan in a traditional learning setting). Related to that, there was hardly any need for teachers to focus their effort on managing the classroom flow. Therefore, in the 3D-game setting, teacher–student interactions emerged as shared problem solving. As illustrated in the following example, teachers and students engaged in shared problem solving, and teachers' role was to trigger vocational learning through the joint construction of knowledge in which all of the participants work together on a common product and goal.

In the following example, we illustrate one teacher–student interaction in the game phase 'Stage'. The players are working as roadies who have complimentary (and partly contradictory) roles that require problem solving as a team. The group has to identify each band member by combining received tips and organizing the band's

equipment in the right place on the stage (all players have complimentary information comprising a total of 25 tips). In more detail, there are eight boxes on the stage, and the players are able to change the owner of each pile of boxes. Five piles of boxes belong to the actual band members, and the rest belong to the warm-up band. One by one, the players are supposed to identify the band members according to the tips. Thus, the task challenges players to combine existing knowledge to successfully complete the task:

Susan: Wait a second, what did you say this Iroquois guy was?

Heta: Yes, who's got any text about that?

Susan: There's not really anything here ... The solo guitarist has blue eyes.

Teacher: The rhythm guitarist's hairdo requires some care.

Susan: It must be the rhythm.

Heta: It....

Teacher: The one with the long Rastas or those

Susan: No, the Iroquois...

Teacher: Yes, Iroquois.

Heta: Yeah, on the right-hand side

Teacher: Yes, now here at the edge on the right.

Susan: We've got a crowd of rhythm guitarists here ... hmm.

Arto: That's true, couldn't that, er, couldn't that be drum? Somehow one would expect the drums to be back there.

Example 2 illustrates a dialogic problem-solving dynamic among all participants (the learners — Krista, Heta, Susan and Arto — and the teacher). Specifically, the excerpt illustrates that problem solving is based on reciprocal interaction among participants, including the teacher. In the above example, dialogic roles are shown in communication, as Susan began with a contextual question that included her opinion that they should focus on [Wait a second...] a band member with the Iroquois. Next, Heta continued by asking if anyone had any new information about the Iroquois. This was followed by Susan explaining (in practice, who is taking the leading role in problem solving, instead of the teacher taking the leading role) that she did not, but she knew that the solo guitarist has blue eyes. Then, the teacher introduced (based on the information received from the environment) that the rhythm guitarist's hair needed attention. Susan concluded that the pile of boxes must belong to the rhythm guitarist. The teacher began to propose that the rhythm guitarist had long dreads, but Susan disagreed that the rhythm guitarist has the Iroquois (opposed to authoritative teacher-talk, Susan disagrees with the teacher's proposal [No, the Iroquois]). Then, the teacher agreed with Susan (opposite to traditional teacher-led activities). Next, Heta stated that the rhythm guitarist has to be placed in the right corner. The teacher continued the discussion by agreeing with Heta. The problem solving continued, again opposite to teacher-led activity, as next, Susan stated that they were proceeding in the wrong direction [We've got a crowd of rhythm guitarists here … hmm]. This was followed by Arto, who explained that he thought that the drummer should be placed in the back of the stage. As we can see in the above discussion, participants proposed contradictory arguments and modified each other's ideas with the goal of productively resolving the game task, with the teacher intervening in the interactions more with the intention of facilitating problem solving than of giving the learners the correct answers. Additionally, we can see that instead of the teacher leading the activity (cf. Example 1 in the classroom) the technological environment (gameplay) guided the learning processes. Finally, the example illuminates that instead of the teacher having the leading role by proposing the questions, it is Susan who takes the leading role in problem-solving activity.

### 4.1.3 Teachers' instructional activities in a mobile-supported setting

Observations on the third setting revealed that the teachers mainly had to ask learners — without any explicit pre-defined script, but just having in mind the learning objectives to be reached — to comment on their experiences (visible in the photos) to afford a rich dynamic of confrontation, sharing and reflection among peers. The result of was a joint teacher–student interaction (construction of knowledge), which resulted in a final shared (almost ever digitalized) object. In this dynamic, starting from photos already identified by the teacher or directly proposed by learners, several major points are addressed, some more theoretical (e.g. the albumin is a protein that is revealed when a certain temperature is exceeded), and others more operative (e.g. the different tools you can use to poach and their reciprocal characteristics, similarities and differences). The common denominator is the reference to one or more photos (i.e. concrete workplace experiences).

In the following example, the teacher was coaching a discussion on a specific cooking method for fish (poaching). The learners are in the computer lab, each of them looking at their own personal space on the web. The teacher used the beamer to display a few selected photos on the big screen to share them with the whole class. The lesson started with the teacher asking one learner to comment on his personal photos and then asked him (and implicitly to the others) to identify the main important elements in the specific cooking method. The main point of focus in this first phase is the importance of the cooking temperature. Another learner then asked to have his photo displayed and commented on, as it shows a cooking temperature that is different from the one identified so far (the point is the difference between the temperature measured internally for the food or externally). The conclusion points out the importance of the example (‘you see, from his example we have identified something important’). In addition, the teacher uses this apprentice’s self-experienced professional situation as an opportunity to share this learning occasion with the entire class (‘[to the class, beaming the photo] I draw your attention for a while to this colleague of yours. [turning to one researcher helping with the PC] May I have the photo enlarged a little bit? And in order. Because here we really go and *see* … [turning to the learner] What are you doing here?’). From the beginning, an interesting interaction takes place between the teacher — constantly asking for comments on and descriptions of the photos — and other learners spontaneously intervening by bringing in their own experiences. The verbs used by the teacher often make reference to sight (e.g. ‘You *see* that Marco …’, ‘Can you *show* it [the fish] to us on the other side?’). At the end of this sequence, the lesson continues as follows:

Teacher But did the fish get out of hand for anybody, or has everyone cooked it perfectly?

Arno Mine was white.

Teacher Yours was white ...?

Arno Yes, but he [the supervisor] didn't tell me it was due to the temperature.

Teacher But did you save the picture? Do we have it?

Arno You can see it a little bit among the veins.

*The teacher looks for the photo and shares it with the class.*

Teacher Here it is. When you learn in your culinary trade to identify your mistakes, you will not fail again.

Arno In the picture of the dish, you can see that there's some white in the cut.

Teacher We should have had it on the other side, but these are exactly the albumins coming out.

Arno He didn't tell me. I asked him how come and he said it was 'normal' and took it away.

Teacher You should have a look at the fat. Can't we see a photo of the fish cooking?

*They look for a photo on the web page showing this recipe.*

Teacher Maybe there, where there is no sauce [...] That one? [...] Is this raw or cooked?

Arno Raw.

Teacher Ah, about the fish cooking ... you can't see when you take it out without... turned on the other side?

Arno No ... [...] [*another photo*] Here it is, still poaching

Teacher You probably reached the temperature limit.

Arno Yes, but all the white came out, and he came over with some paper and cleaned it.

Teacher Ah beh! [*the learners laugh*]

Arno ... and he didn't say anything to me

Teacher Oh, he was right. That way *you* have to look at it and figure out why ...

Arno He said, 'It's normal'...

Teacher Did anybody else poach it another way?

Yuri Well, I poached a trout, but I don't think the trout releases albumins.

Teacher Of course, yes. Can you show it to us? [to the assistant] All the proteins release the albumins when they exceed the temperature.

Example 3 reveals the dialogic dynamic occurring in the class. From a certain point of view, the modality of interaction is similar to what happens in a traditional classroom setting when facilitating a discussion. At the same time, the teacher did not apply an authoritative style, conserving his influential role. He preferred to foster the learners' involvement and let them be the main characters of the lesson. What clearly differs from a traditional setting in this case is that most of the interaction is based on a digital object, and in particular on the photos taken by the learners in their own workplace. This means that the digital device acts as a vehicle to bring apprentices' professional experiences into school, which also requires some collaboration by the workplace supervisors. Photos constitute the trace to document what happened and at the same time the anchor for describing *and* the trigger for reflecting. The teacher orchestrated the discussion and regulated the turns of speech. From time to time, he sealed the learners' statements by summarizing what they discussed. But what stands out most in the teacher's behaviour is his relation with the digital object(s). Examining his interventions, we can easily notice the recurrence of verbs referring to sight ('Here you see well', 'Look at Mario['s photo]', 'Do you see the temperature here?', 'Can you make us see it when it came out [of the oven]?', 'You see [here] that Marco is using a traditional oven') and more specifically his constant searching for the existence of one or more photo(s) ('I have the photo', 'Can we have the photo in sequence?', 'Giovanni's photo can help you to identify the temperature'). This latter point is even more evident in the excerpt proposed above, where the teacher immediately asked for a photo documenting a learner's description and looked for it with increasing urgency ('But did you save the picture? Do we have it?'; 'We should have had it on the other side…'; 'You should have a look at the fat. Can't we see a photo of the fish cooking?'; '[looking for some photos in the recipe] Maybe there, where there is no sauce […] That one? […] Is this raw or cooked?'; 'Ah, about the fish cooking… you can't see when you take it out without… turned on the other side?'). The availability of such

digital objects led to a change in and informed the teaching practice and discourses, and consequently the structure of the instructional activity in class.

### 4.2 The roles of teachers and technology subsumed in three TEL contexts

All three examples described, although very different with respect to several dimensions and then not directly comparable, show how teachers' instructional perspective in new TEL environments for vocational education differs from each other in the instructional flow management, in the communicative approach and in the role of teachers. Additionally, the findings illuminate that the technology itself may bring about these differences, as teachers seem to introduce different kinds of teacher–student interactions when teachers' and students' interactions are mediated by the emerging technologies. Based on the findings of this study, Table 3 gathers the main elements influencing teachers' instructional activities and presents them in relation to the technology used in the corresponding setting. We can briefly summarize these results as follows.

Table 3

*Summary of the Teacher's and Technology Roles Observed by Looking at the Three TEL Settings*

| | **Tech-enhanced classroom** | **3D-game setting** | **Mobile-supported setting** |
|---|---|---|---|
| **Classroom flow led by…** | Lesson plan (scripted) | 3D-game software (scripted) | Online pictures (non-scripted) |
| **Locus of control** | Teacher | Game | Apprentices' workplace experience |
| **Teacher's talk** | Authoritative | Dialogic | Dialogic / supportive |
| **Problem-solving** | Teacher-led | Teacher–student shared | Guided by the teacher |
| **Instructional activity** | Teacher-led | Teacher–student shared collaboration activities | Teacher–student(s) – supervisor(s)' joint activities |
| **Reference to real situations** | Indirect (Simulated) | Indirect (Virtual) | Direct |

*Role of technology.* As previously stated, the role of technology was interpreted mainly looking at how much technology supports a direct reference to the link existing across learning locations. In this respect, in the technology-enhanced classroom setting, technology allowed an indirect reference to the concrete professional situation, realized through a simulation performed on the computer by each member of the class. The professional situation is then replicated in its main professional components, but the simulation of the real professional context is prevented by the laboratory structure of the activity performed at school, which makes the activity itself more protected and safer for learners. The personal, social and methodological, transversal components of professional competence are not considered. In the second setting, these components were the focus of the activity, but the reference to the concrete situation was even more indirect, being reproduced virtually through the 3D-game software. The situation was fully reproduced, but not necessarily linked to the apprentices' specific professional world. In the third setting, the reference to the situation is direct; even more, such reference is closely connected to the class members' real-life experiences in the workplace. And technology alone is what really makes this possible: Pictures taken at the workplace are the vehicle which allows the representation of the situation to be brought into the classroom as it is.

*Teachers' role in controlling the classroom flow.* Analysis of this first setting revealed that — as in traditional classroom settings (see, e.g. Onrubia and Engel, 2012; Webb, 2009), — the teacher is in charge of the classroom flow, according to and consistently with the pre-designed script. As was illustrated in example 1, in the technology-enhanced classroom pre-designed scripted lesson plan grounded teachers' instructional activities; the flow is completely driven by an ideal script, to which the actual script (Dillenbourg & Jermann, 2007) also refers when eventual unexpected events occur. In the 3D-game setting, there is no need to manage the classroom flow: the technological environment guided the learning processes and the role of the teacher was to trigger vocational learning and professional development instead of managing the classroom flow. In this respect, the main difference between this traditional classroom and the 3D-game setting was that in this latter case, the technological environment guided the learning processes, completely incorporating the instructional script. Finally, no real scripts are foreseen in the mobile setting, as the teacher profited from the apprentices' professional experiences reified in the pictures. Instead, in the mobile setting the teachers' main instructional role is to elicit self-regulation and reflection on professional competencies and identity starting from experiences brought to school by means of the pictures. At the same time, an upstream role the teacher plays in this third setting is to involve the workplace in the management and development of the school activities, by asking the in-company trainers — via the apprentices — to allow his apprentices to practice on tasks that will be relevant for the lesson proceedings. In line with that, the instructional role can be summarized in the general pedagogical approach enacted here that gives apprentices' professional experiences the main instructional role, through the teacher's orchestration. As a consequence, teachers' role in controlling the instructional flow changes when passing from one setting to the other: if in the first case it can be identified within the teacher, in a 3-D game setting the predominance has to be given to technology, and in particular to 3D software. In the third setting, the teachers' role in controlling the instructional flow is partly external, as in this case it is committed in some sense to apprentices and their professional experiences in the workplace.

*Communicative approach.* If in the first setting, teachers' instructional activities were rather traditional teacher-led activities mainly reflected in authoritative teacher-talk (for a detailed description of the dialogic teacher-talk, see Lehesvuori, Viiri & Rasku-Puttonen, 2011), in the game space authoritative teacher-talk did not occur, allowing space for dialogic teacher-talk, as the technology took precedence in the learning scenario. In the mobile setting, authoritative teacher-talk did not occur as frequently as in traditional settings; in contrast with the previous case, this did not happen because of the predominant role of technology, but because the learners took on a relevant role as commenters of their own real practices, thus allowing the teacher to only confirm and consolidate, or correct and deepen, what already emerged in the peer discussion. These findings also reflect themselves in the type of interaction the excerpts helped to highlight: looking at the second excerpt, for example, we can see that teacher–student interaction differs from example 1 (classroom setting). The players — teachers included — have complimentary roles, and dialogic problem solving (between the students and the teacher) strongly leans on building a shared understanding based on others' ideas and thoughts. In the mobile-supported setting, the teacher mainly served as an orchestrator, leaving the stage to learners during the lessons. From a teacher–student interaction point of view, the teacher in the mobile-supported setting intervenes in a supportive manner to manage the communication flow and to pose the right questions to elicit more information and details from the authors of the photos. Exploiting the availability of such traces, the teacher informally applied a sort of Socratic approach to teaching, asking learners to argue about the narration of their experiences. In a different way, but in this case as well, learners' knowledge increased as a result of the complementary roles played by several learners intervening in the discussion and interacting with each other. Moreover, this third setting is particularly relevant for vocational education, as the mobile learning solution broaden the conversation beyond the classroom context, to — at least implicitly — involve the in-company trainers in the interaction as well.

To sum up, new technologies enable new kinds of learning activities to be introduced in vocational education. However, at the same time this new learning setting has created new needs for teachers' instructional activities. Our findings suggest that the mobile-supported setting is similar to technology-enhanced classroom setting, as teachers orchestrate, in real-time, the dialogic flow, but at the same time the two settings are quite different regarding authoritative teacher-talk. Specifically, in 3D-game and mobile-settings we can see similarities concerning the complimentary roles played by participants (both students and teachers) in shared knowledge

construction and differences concerning the role of technologies, which in the mobile-supported setting do not guide the learning process, but instead are the vehicle for bringing learners' workplace experiences into the class and vice-versa.

## 5 Conclusion and discussion

This study illuminates fruitful possibilities that new technological environments provide for vocational learning. However, at the same time, technologies create new challenges for teacher–student interactions, as teachers have to develop new instructional activities within technology-rich environments. Our findings are in line with the notion of Van der Zande and colleagues (2012) that teaching is a complex profession, in the sense that teachers have to adapt to multiple ways of modifying their instructional activities (via teacher–student interactions) to fulfil the necessities of different learning contexts (also see Doyle, 1986). In this respect, we have shown that technology can play a crucial role in mediating teacher–student interactions within emerging vocational education settings. Our findings also indicate that different forms of teacher–student interactions may be useful in different technological settings. Specifically, this study illuminated that 'teacher-led' approaches were applied in a technology-enhanced classroom context, 'teacher–student shared collaboration activities' were actively used in a virtual 3D-game setting and 'teacher–student(s) –supervisor(s)' joint learning activities were used to trigger mobile-supported work-based learning. Thus, our findings are in line with the notion that new kinds of the 'dialogic' educational approaches (see, e.g. Alexander, 2008) are needed to trigger learning processes in new TEL settings (Wegerif, 2007; Rojas-Drummond, Littleton, Hernández & Zúniga, 2010).

The future of VET calls for novel instructional approaches to trigger learning processes. Recently, Akkerman and van Eijck (2013) claimed that school systems are strongly grounded on positioning students as objects to meet grade requirements and less like whole situated participants constructing their own knowledge and skills. At the same time, Sharples, Taylor and Vavoula (2007) have argued that in the future, 'a teacher has no ontologically privileged position, but is simply another participant in a continual conversation' (p. 21). Our findings illuminate that instead of sticking with traditional teacher-led instructional activities, emerging technologies create possibilities for new participatory modes of instructional activities (see teacher–student interactions in examples 2 and 3). This may, in turn, lead once again to a substantial change in teaching practices as more and more often emerging technological settings mediate teacher–student interactions. This was evident in the game-based and mobile-supported settings. In practice, teacher–student interactions were mediated and directly informed by the added values of the new technologies; in the game-based setting, the 3D environment permitted new ways to engage in shared problem solving to highlight the needs of work life, as teachers did not have to manage the classroom flow; in the mobile-supported setting, the teacher's action of looking for pictures, bringing the workplace into the classroom, suddenly became an instinctive reflex, given the high added value of visual information coming from different workplaces and procedures. Thus, the incorporation of technologies as tools mediating the teaching activity system seems to have important consequences not only on learners' outcomes, but also on the teacher's competence profile, as it is always the case when dealing with the integration of technologies into teaching, which require a specific set of competences (Cattaneo & Boldrini, 2009).

This study was an attempt to investigate teachers' instructional activities in new TEL settings based on the needs arising from vocational education. One major limitation of our approach is that our aim was to identify teachers' instructional activities as manifested in three different emerging TEL contexts; as different technologies are used to trigger different learning processes, the findings are only illustrative and exploratory in nature. As a direct result of that, it is impossible to generalize the findings. Additionally, a second limitation is that this kind of setting makes it impossible to control the influence of single parameters (cf. quasi-experimental studies); therefore, further studies are needed to investigate the learning outcomes of different technologies applied in vocational education contexts. Finally, when considering the findings of this study, one has to keep in mind that the case studies took place in two different countries (Finland and Switzerland). Despite these limitations, our study also has several strengths. First, currently technology is instilling new hope for improving vocational education; however, at the same time it is unclear how teachers can support vocational learning in these various new TEL settings. Therefore, the advance of this study is that along with the development of learning

environments, the findings shed light on teacher–student interactions in three different TEL contexts, which has rarely been investigated to date. The second strength of our study is that the researchers worked as ethnographic observers in each case during the data collection phase. This allowed us to gain a more in-depth understanding of the contextual nature of vocational learning with respect to new TEL environments than a single experimental study would permit. Third, this approach made it possible to identify the differences in teacher–student interactions with regard to the mediated role of technical environments. Thus, the findings illuminate new knowledge on how teachers can trigger vocational learning in different TEL settings. In particular, we showed how technological solutions can offer new possibilities to work on the articulation of different learning locations. In line with that, we argue that understanding teacher–student interactions in various TEL settings is crucial, as there is a growing need to apply new technological solutions that add value to vocational learning processes. Therefore, the present findings may help teachers to develop new teaching practices in new TEL environments in vocational education. Furthermore, a better understanding of the teacher–student interactions may be helpful for designing technological environments that provide professional tools for teachers (in addition to students).

In conclusion, this article illustrated three different ways teacher–student interactions that can trigger students' vocational learning in emerging TEL settings. Thus, on the one hand, vocational education can benefit from the opportunities of technological development. On the other hand, such technologies may create new challenges for teachers. We argue that related to integrating new technologies into vocational education, it is likely that future teachers will more and more often face different, possibly conflicting, contexts and perspectives in which they will have to be able to adapt their instructional activities according to their learners' needs, the necessities of various technologies and contextual work-life requirements. Therefore, we propose three main recommendations. First, new technologies are needed that provide support for teachers' instructional activities in new TEL settings (e.g. in the future, learning analytic techniques may be integrated within learning environments to provide teachers with real-time information about learning processes). Second, empirical studies need to focus on teacher–student interaction in emerging technological environments to better help teachers to trigger vocational learning in new TEL settings. And third, in the current state, the task of developing instructional activities for new TEL settings is often left to the teachers' own internal resources. Thus, teacher education and in-service training needs to focus on triggering the relationship between teachers' instructional activities and new TEL settings.

**Acknowledgements**

This research was supported by the Academy of Finland (Project 258659) and by the State Secretariat for Education, Research and Innovation (SERI) within the activities planned by the Leading House "Technologies for Vocational Training" (Dual-T project, BB.2009.0175). We would thank Elisa Motta, Kimmo Oksanen and Kati Laine, for their precious contribution in conducting the studies.

**References**

Akkerman, S. F., & van Eijck, M. (2013). Re-theorizing the student dialogically across and between boundaries of multiple communities. *British Educational Research Journal. 39*(1), 60–72. DOI:10.1080/01411926.2011.613454

Alexander, R. (2008). *Towards dialogic teaching: Rethinking classroom talk* (4th ed.). York: Dialogos.

Attwell, G. (2007). Personal learning environments – the future of eLearning? eLearning papers, 2(1). Retrieved from http://www.elearningeuropa.info/files/media/media11561.pdf

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education, 3*(1), 349-377.

Boldrini, E., & Cattaneo, A. (2013). Written identification of errors to learn professional procedures in VET. *Journal of Vocational Education & Training, 65*(4), 525–542.

Boldrini, E., Ghisla, G., & Bausch, L. (2014). Didattica per situazioni. In G. P. Quaglino (Ed.), *Formazione. I metodi* (pp. 337-360). Milano: Raffaello Cortina.

Boyle, T. & Ravenscroft, A. (2012). Context and deep learning design. *Computers and Education, 59*(4), 1224–1233.

Brown, G. (2014). Reconsidering assessment for learning: Insights from human factors and social conditions. Retrieved from http://earli-sig1-conference.org/gavin-brown.php

Brown, A., & Campione, J. (1994). Guided discovery in a community of learners. In K. McGilly, *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 227–270). Cambridge, MA: MIT Press.

Castanheira, M. L., Green, J., & Yaeger, E. (2009). Investigating inclusive practices: An interactional ethnographic approach. In K. Kumpulainen, C. Hmelo-Silver, & M. César (Eds.*), Investigating classroom interaction: Methodologies in action* (pp. 145–178). Rotterdam: Sense Publishers.

Cattaneo, A., & Aprea, C. (2014). Using technologies to integrate vocational learning in multiple contexts. In V. C. X. Wang (Ed.), *Handbook of research on education and technology in a changing society* (pp.675–690). Hershey, PA: IGI-Global.

Cattaneo, A., & Boldrini, E. (2009). Eleven Competences for the Teacher Using ICTs: a Quali-quantitative Research Pattern. In U. Bernath, A. Szűcs, A. Tait & M. Vidal (Eds.), *Distance and E-learning in transition – Learning innovation, technology and social challenges* (pp. 261–290). London-Hoboken (NJ): ISTE – Wiley.

Chatti, M. A. (2010). *Personalization in technology enhanced learning: A social software perspective*. Shaker Verlag, Dissertation, RWTH Aachen University.

Cuendet, S. & Dillenbourg, P. (2013). The benefits and limitations of distributing a tangible interface in a classroom. In N. Rummel, M. Kapur, M. Nathan, S. Puntambekar (Eds.), *To see the world and a grain of sand: Learning across levels of space, time and scale*. CSCL2013 conference proceedings. Volume I (pp. 137–144). International Society of the Learning Sciences.

Cuendet, S., Dehler Zufferey, J., Arn, C., Bumbacher, E., & Dillenbourg, P. (2014). A study of carpenter apprentices' spatial skills. *Empirical Research in Vocational Education and Training, 6*(3). doi: 10.1186/s40461-014-0003-3

Dillenbourg, P. (2013). Design for classroom orchestration. *Computers & Education, 69*, 485-492.

Dillenbourg, P., & Jermann, P. (2010). Technology for classroom orchestration. In M. S. Khine & I. M. Saleh (Eds.), *New science of learning: Cognition, computers and collaboration in education* (pp. 525–552). Dordrecht: Springer.

Dillenbourg, P., & Jermann, P. (2007). Designing integrative scripts. In F. Fischer, H. Mandl, J. Haake, & I. Kollar (Eds.), *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives* (pp. 275–301). New York: Springer.

Doyle, W. (1986). Classroom organization and management. In M.C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 392–431). New York: MacMillan.

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist, 48*(1), 56- 66.

Gavota, M., Cattaneo, A., Arn, C., Boldrini, E., Motta, E., Schneider, D. K., & Bétrancourt, M. (2010). Computer-supported peer commenting: a promising instructional method to promote skill development in vocational education. *Journal of Vocational Education & Training, 62*(4), 495–511.

Griffiths, T., & Guile, D. (2003). A connective model of learning: The implications for work process knowledge. *European Educational Research Journal, 2*(1), 56–73.

Hämäläinen, R. (2011). Using a game environment to foster collaborative learning: A design-based study. *Technology, Pedagogy and Education, 20*(1), 61–78.

Hämäläinen, R. & De Wever, B. (2013). Vocational education approach: New TEL settings—new prospects for teachers' instructional activities? *International Journal of Computer-Supported Collaborative Learning. 8*(3), (271–291).

Hämäläinen, R., & Vähäsantanen, K. (2011). Theoretical and pedagogical perspectives on orchestrating creativity and collaborative learning. *Educational Research Review, 6*(3), 169–184.

Hew, K. F., & Cheung, W. S. (2013). Use of Web 2.0 technologies in K-12 and higher education: The search for evidence-based practice. *Educational Research Review,* (9), 47-64.

Jones, D. (2007). Speaking, listening, planning and assessing: the teacher's role in developing metacognitive awareness. *Early Child Development and Care, 177*(6/7), 569–579.

Kobbe L., Weinberger A., Dillenbourg P., Harrer A., Hämäläinen R., Häkkinen P., et al. (2007). Specifying computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning, 2*(2/3), 211–224.

Kollar, I., Fischer, F., & Hesse, F. (2006). Computer-supported cooperation scripts—A conceptual analysis. *Educational Psychology Review, 18*(2), 159–185.

Lehesvuori, S., Viiri, J. & Rasku-Puttonen, H. (2011). Introducing dialogic teaching to science student teachers. *Journal of Science Teacher Education, 22*(8), 705–727.

Lipponen, L. & Kumpulainen, K. (2011). Acting as accountable authors: Creating interactional spaces for agency work in teacher education. *Teaching and Teacher Education, 27*(5), 812–819.

Ludvigsen, S., Lund, A., Rasmussen, I., & Säljö, R. (Eds.). (2011). *Learning Across Sites. New tools, infrastructures and practices*. New York: Routledge.

Mercer, N. (2013). The social brain, language, and goal-directed collective thinking: A social conception of cognition and its implications for understanding how we think, teach, and learn. *Educational Psychologist, 48*(3), 148–168.

Mercer, N., Dawes, L., Wegerif, R., & Sams, C. (2004). Reasoning as a scientist: Ways of helping children to use language to learn science. *British Educational Research Journal, 30*(3), 367–385.

Miles, M. B. & Huberman, A. M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational Researcher, 13*, 20–30.

Minnaert, A. M., Boekaerts, M., De Brabander, C., & Opdenakker, M. C. (2011). Students' experiences of autonomy, competence, social relatedness, and interest within a CSCL environment in vocational education: The case of commerce and business administration. *Vocations and Learning, 4*(3), 175–190.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning Making in Science Classrooms.* Milton Keynes: Open University Press.

OECD (2012). *Literacy, Numeracy and Problem Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills*. Paris: OECD Publishing. doi:10.1787/9789264128859-en

Pachler, N., Pimmer, C., & Seipold, J. (Eds.). (2011). *Work-Based Mobile Learning. Concepts and Cases*. Bern: Peter Lang.

Onrubia, J., & Engel, A. (2012). The role of teacher assistance on the effects of a macro-script in collaborative writing tasks. *International Journal of Computer-Supported Collaborative Learning, 7*(1), 161–186.

Rojas-Drummond, S., Littleton, K., Hernández, F., & Zúniga, M. (2010). Dialogical interactions among peers in collaborative writing contexts. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 128–148). Abingdon: Routledge.

Schaap, H., Baartman, L., & de Bruijn, E. (2012). Students' learning processes during school-based learning and workplace learning in vocational education: A review. *Vocations and Learning, 5*(2), 99–117.

Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., . . . Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers & Education, 72*, 271-291.

Schwendimann, B., Cattaneo, A., Dehler Zufferey, J., Bétrancourt, M., Gurtner, J.-L., & Dillenbourg, P. (2014). The 'Erfahrraum': A model for exploiting educational technologies in dual vocational systems. *Manuscript submitted for publication*.

Schank, R.C., & Abelson, R.P. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Erlbaum.

Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The SAGE Handbook of e-learning research* (pp. 221–247). London: Sage.

Van der Zande P., Akkerman, S., Brekelmans, M., Waarlo, A. & Vermunt, J. (2012): Expertise for teaching biology situated in the context of genetic testing. *International Journal of Science Education, 34*(11), 1741–1767.

Vosniadou, S. I., Ioannides, C., Dimitrakopoulou, A., & Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science. *Learning and Instruction, 11*(4), 281–419.

Vygotsky, L. (1978). *Mind and society.* Cambridge, MA: Harvard University Press.

Vähäsantanen, K. & Eteläpelto, A. (2009). Vocational teachers in the face of a major educational reform: Individual ways of negotiating professional identities. *Journal of Education and Work, 22*(1), 15–33.

Webb, N. (2009). The teacher's role in promoting collaborative dialogue in the classroom. *British Journal of Educational Psychology, 79*(1), 1–28.

Wegerif, R. (2007). *Dialogic, education and technology: Expanding the space of learning*. New York: Springer.

Warwick, P., Hennessy, S. & Mercer, N. (2011) Promoting teacher and school development through co-enquiry: developing interactive whiteboard use in a 'dialogic classroom'. *Teachers and Teaching: Theory and Practice, 17*(3), 303–324.

Yin, R. K. (2003*). Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.