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Chapter 25
Digital Video Tools in the Classroom: How to Support Meaningful Collaboration and Critical Advanced Thinking of Students?

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Introduction

Whether in the arts, at home, or in the workplace—digital video and web-based video systems have brought about a large variety of filmic expression in many areas. For example, in entertainment we use DVD movies that are partitioned into chapters or scenes (including additional scenes that were not shown in the original movie), which enable the viewer to systematically access specific contents of interest. In the workplaces, digital video technology is used for professional video analyses (e.g., in the area of professional sports Cassidy, Stanley, & Bartlett, 2006; Eckrich, Widule, Shrader, & Maver, 1994, or teacher education, e.g., Moreno & Ortegano-Layne, 2008; Petrosino & Koehler, 2007), as well as computer-supported collaborative work (e.g., in medicine, Sutter, 2002). Additionally, in the realm of Web 2.0 and the Semantic Web, users can actively participate by creating and broadcasting their own digital videos (Alby, 2007) and by designing complex information structures based on video. The annotation feature of YouTube constitutes a very recent example for this development. It enables users to add audiovisual or text-based commentaries, or to add hotspots to videos and then publish the results. In sum, in our everyday life we find many examples of video tools that include the selection of single scenes or objects from existing video information, and even the direct integration of video scenes with e-communication tools, so that the "constructive" use of video (in a constructionist sense, e.g., Papert, 1993) has become widely available.

As a result, the ways in which people "watch" video today are in the process of being reshaped (Cha, Kwak, Rodriguez, Ahn, & Moon, 2007). Concurrently new specific *skills* grow more important for people, so that they can use the new (audio)visual media to participate in societal communication processes, and

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to express themselves. Otherwise people will be limited in their opportunities to solve complex problems in the future. Current research in education has repeatedly emphasized that contemporary literacy concepts cannot be restricted to individual skills of reading and writing static texts, tables, graphs, but must now be extended toward complex visual media (e.g., Stahl, Zahn, Schwan, & Finke, 2006). These skills can be summarized as visual literacies (Messaris, 1994, 1998) for visual communication (Messaris, 1998), on the one hand, and new media literacies for participatory cultures and for community involvement (Jenkins, Clinton, Weigel, & Robison, 2006), on the other. The *visual literacies* model defined by Messaris (1994) refers to four skills levels, ranging from simple understanding of audio-visual content to sophisticated critical film analysis. Analysis is accomplished by using general film analysis methodology to de-compose and to evaluate the source, thereby developing a critical stance and aesthetic appreciation of visual communication. Visual literacies include productive communicative skills, too (Baacke, 1999a, 1999b). According to Jenkins et al.'s (2006) notions of *new media literacies*, emphasize active participation and include the abilities to interact meaningfully with media content and advanced cognitive tools ("appropriation" and "distributed cognition"), skills to interact and collaborate with others, and skills "to pool knowledge and compare notes with others toward a common goal" ("collective intelligence", p. 4) among other abilities.

However, such advanced skills of understanding and working creatively with (audiovisual) media need to be developed. They provide new challenges for school-based education, and for both students and teachers alike. Schools—especially in the sectors of history, politics, ethics, language, and media education—are challenged to provide opportunities for students to participate and to develop such visual and communication skills. This, in turn, requires radically changing the role of digital video and computers in classroom learning.

Digital Video in Education

Video has long been acknowledged in school-based education as a didactical means to pursue a variety of learning goals in many domains. However, empirical findings on its effectiveness for knowledge acquisition is somewhat inconsistent (e.g., Park & Hopkins, 1992; Salomon, 1983, 1984; Wetzel, Radtke, & Stern, 1994) with clear positive effects only for interactive video (McNeil & Nelson, 1991). Also, empirical findings on the use of video in the classroom show a limited variety and limited goal orientation among the teachers (Hobbs, 2006).

The pedagogy associated with educational media is in a way prefigured in the technical properties or the "affordances" (Norman, 1988) of the technologies in use. Audiovisual media, which are in the focus of this chapter, underwent drastic changes in their educational potential and in their technological "evolution": When films had to be mounted in projectors and played for a large public, education could not be achieved by having learners interrogate film-as-data, much less design, construct, or edit films. The educational value was limited to simply having students watch a film and derive information from what they saw. Alternative pedagogies for using audio-visual recordings emerged with interactive video technology (see Wetzel et al., 1994) or interactive DVDs—and more recently with constructive video technologies. These new developments add to the cognitive functions of film (Salomon, 1994) and enable new forms of active video-based learning. In interactive video, the learner is interacting with videos that others have captured, structured, and sequenced (e.g., as in an instructional video designed to learn challenging nautical knots: Schwan & Riempp, 2004). Interactive video activities are supported by various technologies, including digital video players (such as Adobe Flash Player, Apple Quicktime™, RealPlayer™, Windows MediaPlayer™), DVD-menus, embedded hotspots and dynamic hyperlinks). Research has shown that people learn from interactive videos when video-related actions (such as the use of video player functions or dynamic hyperlinks) accompany effective usage strategies. For example, in the Schwan and Riempp (2004) study, the participants learned to tie nautical knots from video clips by using the stop or slow motion functions to adapt the speed and flow of video information to their individual cognitive needs while they were working out the knot-tying procedure. Likewise, in a study of Zahn et al. (2004), participants interacted with dynamic hyperlinks plus stop, rewind, and fast forward functions in a hypervideo and used them strategically to structure and monitor their information input according to their cognitive capacities while processing the information on "lakes as ecological systems." In both studies, the learning outcome was shown to be closely related to individual usage patterns. As Schwan and Riempp summarize, the video-related usage strategies of learners can be thought of as "epistemic actions" in the sense that they support cognitive activities during the learning process and are of central importance for learning. Similar arguments are made by Spiro, Collins, and Ramchandran (2007) in their comprehensive reflections on video usage based on cognitive flexibility theory. The authors focus on the learning of complex problems in ill-structured domains and they sketch out how (nonlinear) digital video can be used to avoid oversimplifications and to support the understanding of complexity and multidimensionality, for example, in the domain of history. Taken together, these findings indicate that effective learning with digital videos actually may depend on new media skills (here: "the ability to interact meaningfully with tools that expand mental capacities," Jenkins et al., 2006, p. 4).

For constructive video, learners are not only interacting with video, they are creating "their own" video materials by either capturing video themselves and/or selecting from pre-captured video assets in order to edit and re-sequence them for purposes of critical reflection or communicating to an audience. By creating a video and sharing it with others, learners engage in the processes of collaborative problem-solving (de-composition, selection, evaluation of information in teams). The conjecture is that people can learn from constructive video because they "design" them with audience needs in mind thereby being supported by a given video tool. Examples include tools for de-composing and annotating video, (e.g., Smith & Reiser, 2005); creating video hyperlinks, (e.g., Zahn & Finke, 2003); or "diving" into video in order to create new points of view onto a source video and to share them within a knowledge community (Pea et al., 2004; Pea, Lindgren, & Rosen, 2006). Each of these tools provides specific affordances designed to support cognitive and socio-cognitive activities of people who use them to create new video content. Having students edit videos as an authentic "visual design problem" with the direct involvement of video tools puts students in the active role of designers *and* helps to foster the deep understanding of the topic. This active process also helps them to develop what Carver, Lehrer, Connel, and Erickson (1992) called organizational, representational, and presentational skills.

However, until today, creating scripts and storyboards, shooting and film-editing (not to mention video annotation or hypervideo construction) have not yet been considered key competencies in our educational systems, even though writing and editing texts are skills which are supposed to be promoted by instructional means. In short, with the exception of some basic experiences with home videos, YouTube, or similar platforms, skills for creating and designing video footage are lacking.

In the research to be reported here, the potential educational value of constructive video is investigated empirically by experimental studies in the laboratory and in the field. In particular, the cognitive and technical conditions necessary for effective video-supported collaboration and acquisition of (visual) literacy skills in student groups are studied. The overarching questions we are trying to answer are: How can digital video technologies be implemented in educational learning processes? How can they be implemented broadly and without an overall amount of effort that would render a widespread application very unlikely? This means, finally, that the curricular and classroom context must be taken into account when trying to practically pave the way for realizing this way of learning as a part of "normal" classroom activities.

In the remainder of this chapter, we present research that tackles these questions. First, we present two exemplary types of digital video tools with specific affordances that might be used to guide students in collaboration, design, and learning. Then, we will describe the concept of collaborative visual design as a theoretical framework that informed the development of a constructivist task for secondary school education. Finally, we will present our initial research on students' performance in a collaborative visual design task in a classroom setting and offer our conclusions from the results.

Tools and Tasks for Learning with Digital Video—an Integrated Approach

Video Tools to Guide Collaboration

Specific video tools were developed for educational purposes but have so far been minimally appropriated yet in K-12 education (Pea et al., 2006; Zahn et al., 2005). Two of these tools will be presented in the following two sections: The tools are designed to support group knowledge processes. They can enable collaborative analysis and collaborative design of visual communication, like editing,

re-sequencing, and annotating video to create new multimedia products. What needs to be considered, however, is that each of these tools affords specific cognitive and socio-cognitive activities. Our understanding of such affordances is related to the concept of "representational guidance" in collaborative problem solving (Suthers, 1999, 2001). It describes the implicit impact on social interactions that tools for students' productions of representational artifacts may have. Suthers and Hundhausen (2003) found, for example, that the salience of information in external representations can have important effects on students' interactions during collaborative problem solving (representational bias). These effects are based on both experimental data and a classroom study. Thus, we need to take into account that the form of external representations and the corresponding tools used in collaborative design scenarios can shape the interactions between learners and should therefore be included in the related research.

Tools for Collaborative Observation and Analysis

The DIVER/WebDIVER^{TM} system was developed by the Stanford Center for Innovations in Learning (SCIL) and is based on the notion of a user "diving" into videos. "Diving" refers to creating new points of view on a source video by using a virtual camera that can zoom and pan through space and time within an overview window of the source video. The virtual camera can take a snapshot of a still image clip, or dynamically record a video "path" through the video to create a dive^{TM} (which we also call a WebDIVER^{TM} worksheet, see Fig. 25.1 below). These can be

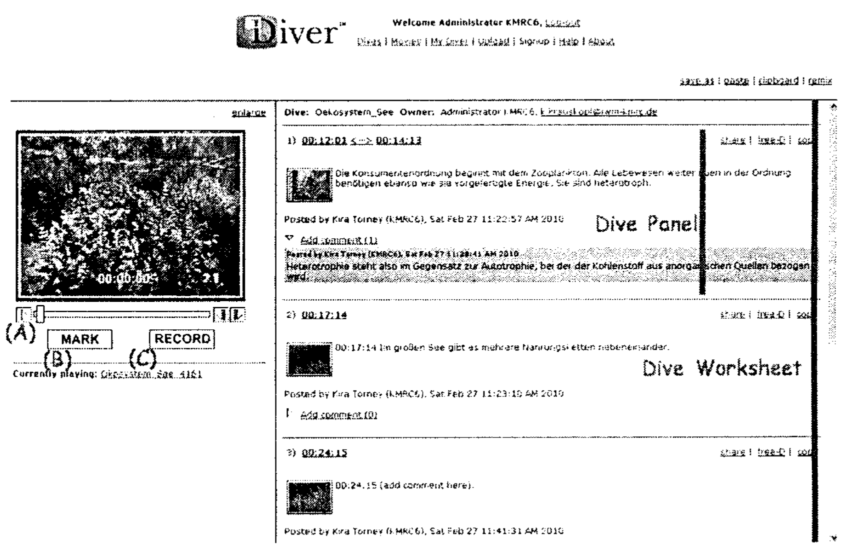

Fig. 25.1 WebDIVER^{TM} worksheet. **(a)** Button for playing and pausing the source video, **(b)** mark-button for capturing still images, **(c)** record-/stop-button for capturing sequences

commented on by writing short text passages or codes (Pea et al., 2004). A dive is made up of a collection of re-orderable "panels," each of which contains a small key video frame that represents a clip, plus and a text field and room for comments to be added to this dive. Diving into video performs an important action for establishing common ground that is characterized as "guided noticing" (Pea et al., 2006). The use of the virtual camera for the framing of a focus within a complex and dynamic visual field directs the viewer's attention to notice with particular attention what is being framed. Thus the viewer is guided to that noticing act from a particular point of view. While one can guide another to notice a video referent with a certain interpretation by pointing and speaking about it, this is a *transient* act. As a new tool for supporting guided noticing interactions, DIVER™ makes pointing to video moments and making interpretive annotations a *persistent* act that is then replayable as an artifact Pea, Lindgren & Rosen (2006). In this way, DIVER™ can be used as a tool to promote the development of "professional vision" in learning within disciplinary domains (Goodwin, 1994).

Originally, DIVER's primary focus was on supporting research activities in the learning sciences (such as interaction analysis: Jordan & Henderson, 1995), and in teacher education, where video analyses play a major role for understanding one's own behavior and reflecting on it in relation to the behavior of others. There are two different ways users work with video using the DIVER™ approach. In the first, after creating a dive using the desktop DIVER™ application, the user can upload it onto WebDIVER™, a website for interactive browsing, searching, and displaying of video clips and collaborative commentary on dives. In an alternative version of the WebDIVER™ system, one can dive on streaming video files that are made accessible through a web server over the Internet. Using WebDIVER™ in either of these ways, a dive can be shared over the Internet. Thus it can become the focus of knowledge-building exchanges, which can be argumentative, tutorial, assessment, or general communicative exchanges. With DIVER/WebDIVER™ it becomes obvious that digital video technology may not only amplify existing kinds of activities and communication, but that it might augment our spectrum of activities and initiate entirely new forms of learning (Pea, 1985; Beichner, 1994). For related prior work see also Goldman-Segal (1998) and Stevens, Cherry, and Fournier (2002). In our research we aim to provide empirical data specific to these theoretically implemented affordances to advocate their use in education by empirical data.

Tools for Collaborative Hypervideo Structuring

Other tools for video-based collaboration are based on the idea of hypervideo, i.e., the selection of video segments from a source video and creation of spatio-temporal hyperlinks (see Fig. 25.2) to video by multiple users. For example, in the hypervideo system originally developed at the Computer Graphics Center (ZGDV) in Darmstadt, Germany, and presented by Zahn and Finke (2003), (1) information is mainly presented by video, (2) knowledge can be collaboratively expanded by means of both dynamic links and written e-communication, and (3) the construction process of joint knowledge representation is reflected in a resulting hypervideo.

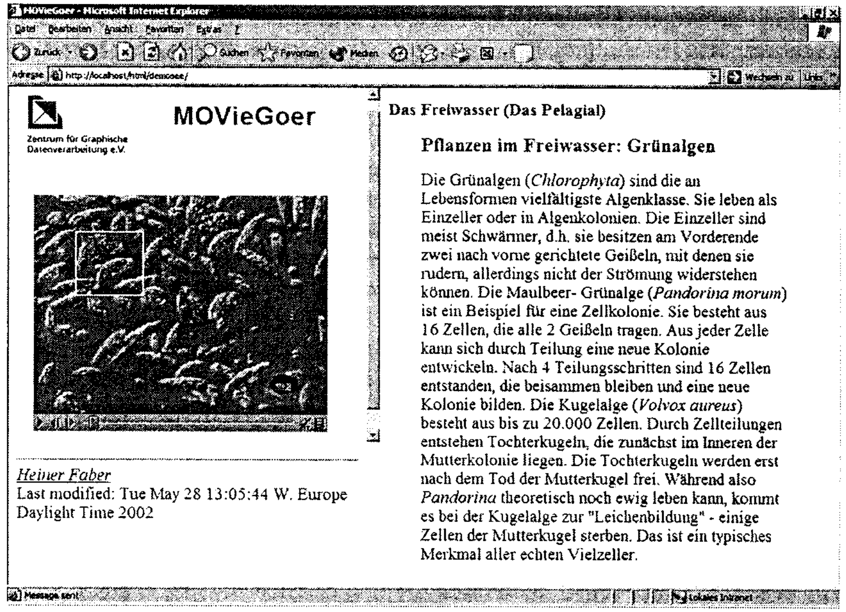

Fig. 25.2 Graphical user interface of a hypervideo system (see also Zahn & Finke, 2003). A dynamic sensitive region, "hotspot" within the video (white frame on the *left*) is connected via multiple links to other materials (e.g., a text document, on the *right*)

Hypervideo is thus denoted as a "dynamic information space" of a collaborating group (*DIS*, Zahn & Finke, 2003; Chambel, Zahn, & Finke, 2005).The system was first developed for unspecified learning or work situations. The basic idea was that structuring hypervideos by dynamic links can serve to promote both learning to integrate different information elements and developing nonlinear knowledge structures by collaboratively designing information and discussion links. Users of this hypervideo system can create their own dynamic sensitive regions ("hotspots") within video materials and add multiple links to these sensitive regions. Links can consist of data files uploaded from a local computer, as well as URLs. The links (or associated information elements, respectively) can then be discussed by means of an integrated e-communication tool. Thus, both randomly accessing videos and adding one's own new information and knowledge becomes possible. The web-based graphical user interface (see Fig. 25.2) allows the adaptation due to different GUI layouts and consists basically of a video player that visually displays the spatio-temporal hyperlinks within the video frame and offers functionalities in order to create new video annotations. Newly created video annotations are immediately transferred from the client to the server in order to be instantly shareable by the community. An example of a similar digital tool is the web-based application Asterpix (http://video.asterpix.com/). Users can, after creating a free account (a professional version is available for purchase that offers more features, like automatic object tracking for hotspots), select a video from the web either by search or by pasting the exact URL. After editing basic descriptive information of the video, it opens in the Asterpix hypervideo browser and hotspots can be added and edited. Hotspots can contain a text commentary, links to other web-videos or websites, and tags that help to identify an object referred to by the hotspot. This web application is of special interest, because, in contrast to YouTube, where only personally uploaded videos can be annotated, Asterpix enables viewers of digital videos on the Internet to share their thoughts and knowledge by re-"designing" the source video instead of being either limited to a written commentary or forced to upload a new video. As an example of a Web 2.0 application that represents the new paradigm of participation mentioned above.

On a generic level, the video systems described above can be seen as cognitive/collaborative tools that enable "pointing to video" (DIVER/Web DIVER™) and "linking video information" (hypervideo, Asterpix), to enhance the probability that in collaborative problem-solving processes, external representations help to focus joint attention and relate associated knowledge items so that negotiations of meaning between participants in a conversation will build upon a common ground. This form of communication with video is important for tapping powerful potentials (and some challenges) of video-enhanced learning in the classroom. The *potentials* can be seen in a more active and situated use of videos in many subject areas. Active and situative learning (Greeno, 2006), in turn, is the basis for sustainable knowledge and skills acquisition.

We take the approach of integrating these exemplary *tools* (and their affordances) as described above with a perspective of *design as problem solving* (e.g., Dillon, 2002). Therefore, a design problem involving constructive video was developed that allows for predictions of positive effects on learning outcomes (here: new media literacies and visual skills including an advanced understanding of video sources in the domain of history). As a heuristic for building the design task and for our research, we relied on the cognitive framework described in the next section.

Collaborative Visual Design—a Cognitive Framework

From a cognitive perspective, a design task is defined as a specific type of rhetorical problem (Stahl, Finke, & Zahn, 2006). *Visual* design consists of creating and structuring *visual* content for an anticipated audience according to the aesthetic standards of *visual* (or audiovisual) media. Our definition of visual design as problem solving is firmly based on three major lines of research from cognitive psychology: First, we note earlier findings by Goel & Pirolli, (1992), who demonstrated that design is a process of problem solving of an ill-defined and complex problem to be structured by the designer. Seitamaa-Hakkarainen (2000) provided further evidence for "dual space search" processes in such design. Second, we note influential cognitive approaches to text production (e.g., Flower & Hayes, 1980, 1986; Hayes, 1996), which explain writing for an audience as a complex problem-solving

process, where intensive interactions between a content problem space and a rhetorical problem space lead to knowledge transformation (Bereiter & Scardamalia, 1987). Finally, we note the constructionist approach of *learning through design* (e.g., Kafai & Resnick, 1996), which has been applied in pedagogy and approved by many case studies ranging from K-12 education to university and adult education levels. Particularly, multimedia design problems using the services of emerging computer technologies for the support of active learning and media skills acquisition have become popular. Examples include contextualized multimedia design in elementary biology (e.g., Beichner, 1994), software design in mathematics (e.g., Harel, 1990; Kafai, 1996), hypermedia design in history and the humanities (e.g., Carver et al., 1992; Bereiter, 2002; Stahl & Bromme, 2004), and designing instruction in simulations in physics (Vreman-te Olde, 2006). These examples all involve generative activities of (a) integrating various media and (b) structuring information for others. In this context, Erickson, Lehrer, and colleagues (Erickson & Lehrer, 1998; Lehrer, Erickson, & Connel, 1994) emphasized the importance of sub-processes in design problem solving, such as planning, transformation, evaluation, and revision in hypertext design for history learning (see Fig. 25.3).

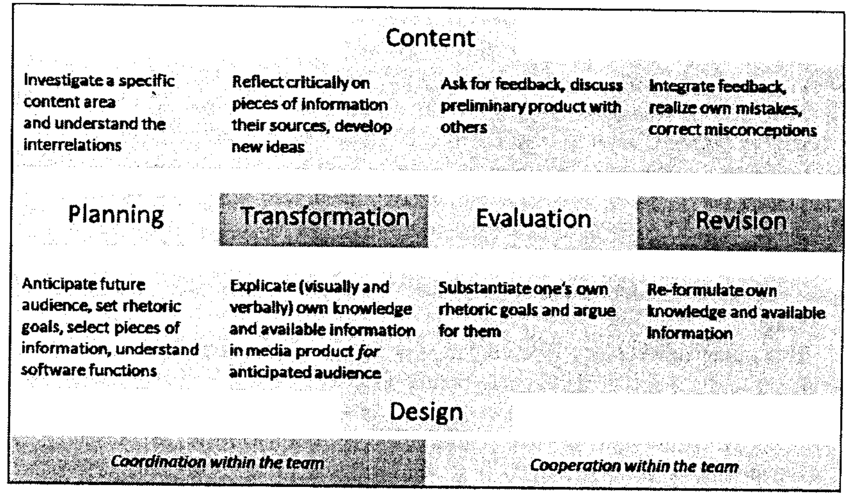

Fig. 25.3 Visual design as problem solving: cognitive and socio-cognitive processes during learning by designing, accentuating aspects of content, design, and teamwork (see also Zahn, 2009)

These cognitive perspectives are adopted in our works on learning by hypervideo authoring and creating digital video (Stahl et al., 2005; Zahn et al., 2005). We assume that students who design digital (hyper)videos, simultaneously have to take into account both visual content and style of their design product. Thereby they have to establish a joint dual problem space (for *joint problem spaces*, see Roschelle & Teasley, 1995) being distributed over the cognitive systems

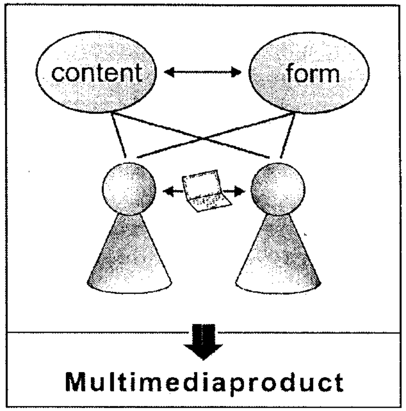

Fig. 25.4 Collaborative design activities as joint dual problem space involving content and form

of *at least two people* (see Fig. 25.4). The participants (students in our case) have to cooperate, when they decide *what* to say/show and *how* to say/show it, when they plan, transform, evaluate, and revise their video product. Thereby they have to negotiate shared design goals and their understanding of content (see Fig. 25.3). This adds not only to the educational value but also to the complexity of problem solving (see Barron, 2003; see also Lowry, Curtis, & Lowry (2004) who assume that in order to write a text in collaboration with others, students have to share and negotiate their content knowledge, as well as task schemas, genre knowledge, task goals, and task relevant strategies). In sum, we perceive collaborative visual design as complex problem solving that eventually can lead to deep understanding of content and new literacy skills acquisition in students.

This framework serves for conducting systematic research concerning the real (as opposed to the theoretical) learning potentials of collaborative visual design tasks. Scientific reports confirming the effectiveness of visual design that would go beyond the level of assumptions or case studies are very rare. However, this research has shown that in *realistic* scenarios (e.g., university seminars), student performance depends on situational factors including instructional support of the problem solving process (e.g., Stahl, Zahn, Schwan, & Finke, 2005). Hence, from a pedagogical perspective, the additional question arises *how* to instructionally support the complex process of collaborative visual design in class. Similar questions have inspired educational research approaches, such as for example, Kolodner's (e.g., 2003) influential works on Learning By Design^{TM} in science classes. The present endeavor reflects our scientific interest in providing new experimental work based on the theoretical considerations described above, to shed light on the application of visual design in an instructional framework.

Instructional Framing of Collaborative Visual Design: Approaches, Results, Problems

The cognitive models of writing and design on which we partly base our theoretical framework consider both individual and environmental factors as determinants for text production (e.g., Hayes, 1996). Individual factors incorporate motivational and affective states of the person who is writing, her or his working memory, long-term memory, and prior knowledge (e.g., task schemas, topic knowledge, genre knowledge, audience knowledge). Environmental factors incorporate the physical environment (e.g., the media or tools in use) and social factors (e.g., the collaborators in the writing process). Thus, visual design tasks, too, will be contingent upon interactions of cognitive and environmental factors present in a concrete classroom situation. *Cognitive factors* in our specific case include task schemas about video production, topic knowledge, and rhetorical concepts about digital video and filmic styles. *Environmental factors* in our case include peer–peer interactions and teacher–student interactions, as well as interactions with the digital video tools in use (affordances).

Empirical research concerning these possible influencing factors (to our knowledge) is virtually nonexistent. However, for our context, we can rely on a specific result reported by Stahl and Bromme (2004) who developed a set of instructional units for secondary students designing hypertexts and to help students in dealing one by one with the specific demands that the features of hypertext present for knowledge transformation. They argue that due to the novelty of the medium hypertext, student designers cannot be assumed to have firmly established media-related rhetorical concepts. Thus they developed a course program to tackle this specific problem by instructional means and compared two metaphors epitomizing rhetorical concepts about hypertext (space vs. book metaphor) in a case study. Results revealed a superiority of the space metaphor for learning by hypertext design.

For our purposes, we primarily look at media-related concepts in relation to "representational guidance" in collaborative problem solving (Suthers, 1999, 2001, see section about video tools). Our specific empirical investigations tap the following questions:

- How would students approach collaborative visual design tasks in a real, "noisy" classroom setting?
- How do students use the affordances of video tools for collaborative visual design?
- Where, precisely, do students need instructional support?

To find answers to these open questions, we developed a prototypical task for German secondary education (history and/or German language art lessons), i.e., designing a web page for a virtual history museum, and we conducted a field experiment.

Pursuing Instructional Goals and Developing a Student-Centered Learning Task

Relating to our framework described above, our task involves collaborative visual design based on a video resource showing a historical newsreel on the 1948 Berlin blockade (Fig. 25.5) andusing digital video tools (see tools section above). Students are asked to act as a team of online editors who design a web page for a popular German virtual history museum. The explicated overall design goal is to comment on the video showing the historical newsreel, for publication in the virtual history museum for future visitors. This product is based on the collaborative analysis of the source video by integrating additional information applying one of the digital video tools. Learners are explicitly made aware of the audience they are designing for (i.e., museum visitors) and the purpose the product should serve for this audience: Namely, the future visitors of the virtual museum should be able to develop a good understanding of both the content and the filmic codes/style of the historical newsreel.

Fig. 25.5 Landing of a Douglas C-54 of the US Air Force at the airport Berlin Tempelhof in July 1948. The supply of West Berlin with goods by the air forces of the Western Allies during the Berlin Blockade (June 1948—May 1949) by the Soviet Union represents one of the largest humanitarian operations in history. It is an important topic in Germany's postwar history as studied in secondary education. Henry Ries/DHM, © New York Times

Following our theoretical considerations the task includes an individual inquiry phase for planning, where learners first watch a digital video showing the historical Berlin-Blockade newsreel from 1948, then visit the virtual history museum LEMO, and finally familiarize themselves with the specific period of German history. Participants have to acquaint themselves with the contemporary use of newsreels as well as basic information on general filmic codes and style. Then, students explore the functions of the digital video tool fitting for the respective experimental condition with a thematically unrelated, instructional video clip. In the subsequent transformation phase students pair up together and collaboratively design elements for the web-museum using one computer. When working with the digital video tool, students are always free to evaluate and revise their evolving product.

Our major concern was a design task realizable within the constraints of an average lesson. One thing we did to accomplish this was to relate the content of the task to educational goals relevant to the teachers and students. We chose the described topic (historical content and visual/media competence) to satisfy curricular demands. Another equally important aspect was to adapt to the structural time prerequisites. Our prototypical research task was adapted to the standard German time-frame devoted to a subject in one day (two subsequent units of 45 min each). With regard to technical resources, we acted on the anticipation of how schools (at least in southwest the South-West of Germany) will be equipped in a few years from now, due to certain governmental programs. Thus, we are able to investigate several generic aspects of the learning processes that we assume to take place during learning with collaborative visual design tasks in the near future. Among these are the elaboration of content and visual information, the transfer of visual literacy skills to the analysis of other video sources, and the collaborative negotiation of meaning during the design activities.

The task was created to be applicable to German language arts and history learning. The former is the domain traditionally concerned with enhancing the levels of students' literacy and their skills for cooperative learning (e.g., Blell & Lüdtge, 2004).[1] The latter represents a domain where working with constructive video is considered highly preferable while also providing a challenge for students and teachers (Krammer, 2006; Smith & Blankinship, 2000). In addition to the new literacies described above, in history learning, factual knowledge is closely intertwined with specific thinking skills, like de-composing, evaluating, analyzing, and critically reflecting on historical sources—together with (re-)constructing knowledge. These are necessary skills for a full understanding of historical topics (e.g., Wineburg, 2001); however, they are difficult to teach in most traditional history lessons at schools. In line with these educational goals (which correspond to Jenkins et al.'s, 2006, notions of social and cultural skills for community involvement) our experimental collaborative task for history learning involves the following components: Critical analysis, judgment, collaborative problem solving, and appropriation. Precisely, the students could learn to use modern digital video tools for critical

[1] Reference models relating to the levels of proficiency in language learning and (media) literacy which are relevant for our work include the "Common European Framework of Reference for Languages" (Goethe-Institut/Inter Nationes, 2001), or the PISA concepts of "literacy" and "reading competence" (OECD, 2001, 2003). Further on, the general educational standards for the German Gymnasium include the ability to apply the basic terms of film analysis and to compare film composition with other formal strategies, for example, in literature (Core ideas for skills acquisition in German secondary education, *Gymnasium*, for grades 9 and 10, Ministry of Culture, Youth, and Sports of Baden-Württemberg, 2004).

analysis and discussion of archive video material, they could learn using general film analysis methodology to de-compose and to evaluate the video source, thereby developing a critical stance and understanding of the diversity of ideas during their collaboration. Furthermore, they could learn to design a web page, to present their own ideas on the Berlin-Blockade and work creatively with them.

Our task was first tested in a pilot laboratory experiment (Zahn, Pea, Hesse & Rosen, in press) with a sample of psychology students. We investigated both the general effectiveness of the task and the specific effects of how students use the digital video tool DIVER/WebDIVER™, in contrast to a control condition using "simpler" technology (video-player and text-editor). We examined the possible implicit impact of the different technologies on design products, dyads' conversations, and individual learning and skills acquisition. According to our underlying assumptions, the video tools were considered to be prototypical examples of either providing specific support in terms of technical affordances for the dyads' activities and socio-cognitive efforts (WebDIVER™) or not providing such support (video player and text editor). The results revealed generally high appraisal of the task and significant positive effects of the WebDIVER™M video tool concerning design, knowledge, and visual skills acquisition. The affordances of WebDIVER™ thus enhanced the quality of participants' design activities. Moreover, the influence of the video tools extended to the learners' socio-cognitive processes and focused their interactions on the task.

Integration into "Noisy" Classroom Settings—Initial Results from a Field Study

What follows are results from a field experiment (see Zahn, Krauskopf, Hesse & Pea, submitted) with 234 students in four German secondary schools. The same task was applied with 10th grade students (70% female, age M = 15.9 years, SD = 0.8). A 2 × 2 factorial experimental design was applied to test impacts of digital video technology, on the one hand, and shared media-related goals, on the other. More precisely, concerning the first factor, we again compared DIVER/WebDIVER™ with a Player & Text condition, as in our lab experiment. Concerning the second factor of the impact of shared media goals, we compared two different task goals provided with the instructions for "creating Dives" vs. "creating annotated movies". The media goals were based on the findings of Stahl (2005) that metaphors guide text-based construction of hyper-structures. As dependent variables we considered students' collaborative design activities, design products, dyads' conversations, motivation and knowledge and visual skills acquisition.

The procedure was divided into four steps (see Fig. 25.6), of which steps 2 and 3 should support collaborative problem solving: In step 1, students completed a questionnaire assessing 'participants topic- related prior knowledge, general interest in history, prior computer experiences, and knowledge about media production. In step 2, a phase of individual inquiry followed, where the students watched a

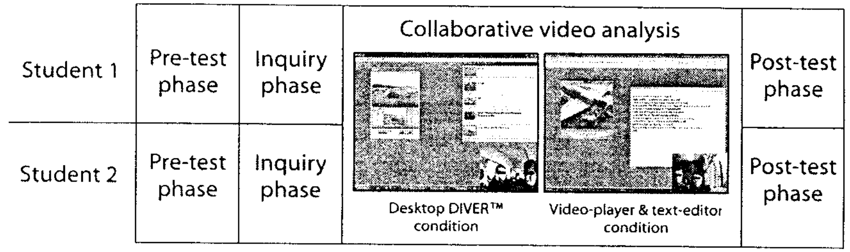

Fig. 25.6 General procedure of prototypical task and experimental design

digitized historical newsreel on the Berlin-Blockade from 1948 and consulted additional material on the respective historical context and filmic codes and style. In step 3, the design task was introduced and students were randomly joined in dyads to work with the computer in a face-to-face setting. After briefly practicing the respective digital processes, they were asked to analyze and comment on the historical newsreel, so that their product could be published in a virtual history museum. Working time for the video-based design task was restricted to half an hour. When students were finished, they proceeded to step 4, in which a post-experimental questionnaire tapped their appraisal of the design task and the group collaboration, and a multiple choice tested what knowledge about the topic had been acquired.

While the limited amount of time in the experiment needs to be discussed with regard to the space it leaves for processes of knowledge building to unfold, our field data (Zahn, Krauskopf, Pea & Hesse, submitted) show that participants' knowledge significantly increased during the design task ($F(1, 106) = 42.2$; $p < 0.01$, partial $\eta^2 = 0.29$). These cognitive outcomes were not differentially affected by the different conditions. In all conditions the design task proved to be interesting for the students and applicable in regular classroom situations. Replicating findings from the prior lab study, the affordances of DIVER significantly increased the quality of design products and influenced design processes positively by focusing the learners' interactions on task-relevant, conversations. Students working with DIVER considered design-related issues significantly more often than dyads working with the combination of Player & Text and displayed a tendency towards fewer help requests. Additionally, working with DIVER influenced the collaborative interactions within dyads indicating more autonomous design activities when working with DIVER. The digital tools did not further students' general problem solving behavior, which in all conditions was rather action-oriented and lacked thoughtful planning and evaluation (less than 3% of the time on the task was devoted to planning and less than 1% on evaluation).

In order to provide further qualitative evidence of process, we also conducted additional analyses focusing on how the dyads used and integrated technology affordances during their design-related interactions. The aim was to replicate corresponding findings from the pilot study that identified processes of "guided noticing" (Pea et al., 2006; Zahn, Pea, Hesse & Rosen, in press). There, interaction patterns were observable in dyads working with DIVER/WebDIVER™ mirroring how dyads' elaborations on the source video are guided by the tool affordance when they create interpretive annotations. As expected, exemplary episodes for these patterns (*design cycles*, Zahn et al., in press) were also found in the field data. Overall, such exemplary episodes illustrate the kinds of processes possibly lying behind the quantitative indicators reported above and give an impression of how learners' socio-cognitive processes are impacted and complement quantitative findings.

Conclusions

At the beginning of the chapter, we were posing the following questions:
How can digital video technologies be implemented in educational learning processes to foster new media literacy skills? How can they be implemented broadly and without an overall amount of effort that renders a widespread application very unlikely?

We sought answers to these questions by introducing an integrated approach to computer-supported learning with constructing digital video in history and German language art lessons. We presented an a cognitive approach where digital video tools are used in the context of collaborative visual design tasks to foster advanced literacy skills and the construction of shared interpretations in students. We demonstrated in a field experiment that the approach can be successfully realized. Predictions of positive effects on learning with digital video in class derived from our cognitive framework (collaborative visual design) were empirically supported.

More precisely, in the empirical studies we asked: How would students approach collaborative visual design tasks in a real "noisy" classroom setting?

How do students use the affordances of video tools for collaborative visual design?

Where, precisely, do students need instructional support?

Concerning the first question, we find in the field study that substantial knowledge and (visual) literacy skills acquisition takes place during a collaborative visual design task, even when students spend only a short period of time with the video material. Students well understood and appreciated the task as being interesting. These results are a strong support for the interpretation that students approach visual design tasks in the style of our exemplar as a valuable and practicable way of learning.

Concerning the second question, our results indicate that digital video technologies can act as powerful cognitive tools supporting the learning processes during collaborative visual design tasks. We found effects of different tools that afford different learning activities, which also extend their impact to the socio-cognitive level. Furthermore, the findings suggest that when explicit instructional guidance is limited, technological affordances implicitly guide students' task-related and socio-cognitive actions. Our data also indicate that subtle attempts to support the design process by providing metaphors to help learners structure their design problem space are easily overshadowed by the strong effects of tool affordances.

Concerning the third question, we found that tools do not support the overall design process (e.g., the amount of time devoted to planning, acting, evaluating, and revising), thus leaving the need of and room for explicit instructional modulation by an educator—especially the support of planning, evaluation and revision of design products by students.

Concerning the practical implications of our findings, we infer that constructive video tools can be directly integrated into regular educational practice and respective curricula support learning processes and new media/visual skills acquisition. However, the effects of implicit guidance by technological affordances need to be considered as an important factor in computer-supported learning by teachers with regard to the educational goals and applied teaching strategies. Studying them also means providing information for effective integration in the classroom, namely, the instructional integration of such tasks by the teacher who can make use of a tool's affordances for the learning goals. According to Oser & Baeriswyl, 2001), an educator's profession is to orchestrate teaching and learning processes. In line with this, learning activities and socio-cognitive processes afforded by the educational technologies in use can be seen as supportive to both these instructional aspects. As a result, in future studies we will seek to investigate the when and how of explicit instructional support of teachers and thus address their role as facilitating catalyst for (a) optimizing learners' problem solving within the joint problem space of a complex visual design tasks, as well as for (b) successful integration of these tasks into classroom instruction.

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References

Alby, T. (2007). *Web 2.0: Konzepte, Anwendungen, Technologien.* Muenchen: Hanser Fachbuchverlag.

Baacke, D. (1999a). Medienkompetenz als zentrales Operationsfeld von Projekten. In D. Baacke, S. Kornblum, J. Lauffer, L. Mikos, & G. A. Thiele (Eds.), *Handbuch Medien: Medienkompetenz – Modelle und Projekte* (pp. 31–35). Bonn: Bundeszentrale für politische Bildung.

Baacke, D. (1999b). Projekte als Formen der Medienarbeit. In D. Baacke, S. Kornblum, J. Lauffer, L. Mikos, & G. A. Thiele (Eds.), *Handbuch Medien: Medienkompetenz – Modelle und Projekte* (pp. 86–93). Bonn: Bundeszentrale für politische Bildung.

Barron, B. (2003). When Smart Groups Fail. *Journal of the Learning Sciences, 12*, 307–359.

Beichner, R. J. (1994). Multimedia editing to promote science learning. *Journal of Computers in Mathematics and Science Teaching, 13*, 147–162.

Bereiter, C., & Scardamalia, M. (1987). *The Psychology of written composition.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Bereiter, C. (2002). Emergent versus presentational hypertext. In R. Bromme & E. Stahl (Eds.), *Writing as design: Hypermedia and the shape of information space* (pp. 73–78). Amsterdam, Boston, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Pergamon/Elsevier Science.

Blell, G., & Lüdtke, C. (2004). Sehen, Hören, Verstehen und Handeln. Filme im Fremdsprachenunterricht [Seeing, hearing, understanding and acting – Films in foreign language education]. *Fsu, 6*(402–405), 445.

Carver, S. M., Lehrer, R., Connell, T., & Erickson, J. (1992). Learning by hypermedia design: Issues of assessment and implementation. *Educational Psychologist, 27*, 385–404.

Cassidy, T., Stanley, S., & Bartlett, R. (2006). Reflecting on Video Feedback as a Tool for Learning Skilled Movement. *International Journal of Sports Science & Coaching, The Sport Coach as Learner, 1*, 279–288.

Cha, M., Kwak, H., Rodriguez, P., Ahn, Y., & Moon, S. (2007). I Tube, you tube, everybody tubes: Analyzing the world's largest user generated content video system (pp. 1–14). San Diego CA, US.

Chambel, T., Zahn, C., & Finke, M. (2005). Hypervideo and cognition: Designing video-based hypermedia for individual learning and collaborative knowledge building. In E. M. Alkhalifa (Ed.), *Cognitively informed systems: Utilizing practical approaches to enrich information presentation and transfer* (pp. 26–49). Hershey, PA: Idea Group.

Dillon, A. (2002). Writing as design: Hypermedia and the shape of information space. Conceptual and empirical approaches. Advances in learning and instruction series. In R. Bromme & E. Stahl (Eds.), *Writing hypertext and learning* (pp. 63–72). Amsterdam: Pergamon.

Eckrich, J., Widule, C. J., Shrader, R. A., & Maver, J. (1994). The effects of video observational training on video and live observational proficiency. *Journal of Teaching in Physical Education, 13*, 216–227.

Erickson, J., & Lehrer, R. (1998). The Evolution of critical standards as students design hypermedia documents. *Journal of the Learning Sciences, 7*, 351–386.

Flower, L., & Hayes, J. R. (1980). The cognition of discovery: Defining a rhetorical problem. *College Composition and Communication, 31*, 21–32.

Goel, V., & Pirolli, P. (1992). The structure of design problem spaces. *Cognitive Science, 16*, 395–429.

Goethe-Institut/Inter Nationes/Council of Europe (2001). *Gemeinsamer Europäischer Referenzrahmen für Sprachen: Lernen, Lehren, Beurteilen. [A Common European Framework of Reference for Languages]*. Retrieved June 12, 2009, from http://www.goethe.de/z/50/commeuro/deindex.htm

Goldman, R. (1998). *Points of viewing children's thinking: A digital ethnographer's journey*. Mahwah, NJ: LEA.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*, 606–633.

Greeno, J. G. (2006). Learning in activity. In R. K. Sawyer (Ed.), *The Cambridge handbook of the leanring sciences* (pp. 79–95). Cambridge: Cambridge University Press.

Hayes, J. R., & Flower, L. S. (1986). Writing research and the writer. *American Psychologist, 41*, 1106–1113.

Hayes, J. R. (1996). A new framework for understanding cognition and affect in writing. In C. M. Levy & S. Ransdell (Eds.), The science of writing. *Theories, methods, individual differences, and applications* (pp. 1–27). Mahwah, NJ: Erlbaum.

Harel, I. (1990). Children as software designers: A constructionist approach for learning mathematics. *Journal of Mathematical Behavior, 9*, 3–93.

Hobbs, R. (2006). Non-optimal uses of video in the classroom. *Learning, Media and Technology, 31*(1), 35–55.

Jenkins, H., Clinton, K., Weigel, M., & Robison, A. J. (2006). *Confronting the Challenges of Participatory Culture: Media Education For the 21st Century*. Retrieved October 1, 2008 from http://www.newmedialiteracies.org/files/working/NMLWhitePaper.pdf.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences, 4*, 39.

Kafai, Y. B. (1996). Learning design by making games. Children's development of design strategies inthe creation of a complex computational artifact. In Y. B. Kafai & M. Resnick (Eds.), *Constructionism in practice* (pp. 71–96). Mahwah, NJ: Lawrence Erlbaum Associates.

Kafai, Y. B., & Resnick, M. (Eds.) (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world* (pp. XII, 339S). Mahwah, NJ: Lawrence Erlbaum Associates.

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., et al (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design™ into practice. *Journal of the Learning Sciences, 12*, 495–547.

Krammer, R. (2006). Filme im Geschichtsunterricht – Analysieren-Interpretieren-Dekonstruieren. *Historische Sozialkunde, 3*, 26–33.

Lehrer, R., Erickson, J., & Connell, T. (1994). Learning by designing hypermedia documents. *Computers in the Schools, 10*, 227–254.

Lowry, P. B., Curtis, A., & Lowry, M. R. (2004). Building a taxonomy and nomenclature of collaborative writing to improve interdisciplinary research and practice. *Journal of Business Communication, 41*, 66–99.

Mc Neil, B., & Nelson, K. (1991). Meta-analysis of interactive video instruction: A 10 year review of achievement effects. *Journal of Computer-Based Instruction, 18*(1), 1–6.

Messaris, P. (1998). Visual aspects of media literacy. *The Journal of Communication, 48*, 70–80.

Messaris, P. (1994). *Visual literacy – image, mind & reality*. Boulder, San Francisco, Oxford: Westview Press.

Ministerium für Kultur, Jugend und Sport Baden-Württemberg [Ministry of Culture, Youth, ans Sports of Baden-Württemberg] (2004). *Bildungsplan 2004. Allgemein bildendes Gymnasium [Education plan 2004. General university-track secondary Education]*. Stuttgart.

Moreno, R., & Ortegano-Layne, L. (2008). Do classroom exemplars promote the application of principles in teacher education? A comparison of videos, animations, and narratives. *Educational Technology Research and Development, 56*, 449–465.

Norman, D. A. (1988). *The psychology of everyday things*. New York. Basic Books.

OECD (2001). *Knowledge and Skills for Life: First Results from PISA 2000*. Retrieved June 12, 2009, from http://www.pisa.oecd.org/document/46/0,2340,en_32252351 _32236159_33688686_1_1_1_1,00.html

OECD (2003). *The PISA 2003 Assessment Framework: Mathematics, reading, science and problem solving knowledge and skills*. Retrieved June 12, 2009, from http://www.pisa.oecd.org/document/46/0,2340,en_32252351_32236159_33688686_1_1_1_1,00.html

Oser, F., & Baeriswyl, F. (2001). Choreographies of teaching: Bridging instruction to learning. In V. Richardson (ed.). *Handbook of research on teaching*. 4th edition, (pp. 1031–1065). Washington, D.C.: American Educational Research Association.

Papert, S. (1993). *The children's machine -rethinking school in the age of the computer*. New York: Basic Books.

Park, O., & Hopkins, R. (1992). Instructional conditions for using dynamic visual displays: A review. *Instructional Science, 21*, 427–449.

Pea, R. D., Lindgren, R. W., & Rosen, J. (2006). *Computer-Supported Collaborative Video Analysis*. Bloomington, US. Retrieved July 10, 2008, from http://hal.archives-ouvertes.fr/hal-00190631/fr/.

Pea, R. D., Mills, M. I., Rosen, J., Dauber, K., Effelsberg, W., & Hoffert, E. (2004). The DIVER™ project: Interactive digital video repurposing. *IEEE Multimedia, 11*, 54–61.

Pea, R. D. (1985). Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychologist, 20*, 167.

Petrosino, A. J., & Koehler, M. J. (2007). Teachers as designers: Pre an in-service teachers' authoring of anchor video as a means to professional development. In R. Goldman, R. Pea, B. Barron, & S. Derry (Eds.), *Video research in the learning sciences* (pp. 411–423). Mahwah, NJ: Lawrence Erlbaum Associates.

Roschelle, J. M., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69–97). Berlin: Springer.

Salomon, G. (1983). Television watching and mental effort: A social psychological view. In J. Bryant (Ed.), *Children's understanding of television: Research on attention and comprehension* (pp. 181–198). New York: Academic Press.

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort in learning as a function of perceptions and attributions. *Journal of Educational Psychology, 76*, 647–658.

Salomon, G. (1994). *Interaction of media, cognition and learning: An exploration of how symbolic forms cultivate mental skills and affect*. Mahwah, N.J. Lawrence Erlbaum Ass. Inc.

Schwan, S., & Riempp, R. (2004). The cognitive benefits of interactive videos: Learning to tie nautical knots. *Learning & Instruction, 14*, 293–305.

Seitamaa-Hakkarainen, P. (2000). *The weaving-design process as a dual-space search* (Research Report 6). Helsinki: University of Helsinki, Department of Home Economics and Craft Science.

Smith, B. K., & Blankenship, E. (2000). Justifying imagery: Multimedia support for learning through explanation. *IBM Systems, 39*, 749–767.

Smith, B. K., & Reiser, B. J. (2005). Explaining behavior through observational investigation and theory articulation. *The Journal of the Learning Sciences, 14*(3), 315–360.

Spiro, R. J., Collins, B. P., & Ramchandran, A. (2007). Reflections on a Post-Gutenberg epistemology for video use in ill-structured domains: Fostering complex learning and cognitive flexibility. In R. Goldman, R. Pea, B. Barron, & S. Derry (Eds.), *Video research in the learning sciences* (pp. 93–100). Mahwah: Lawrence Erlbaum Associates.

Stahl, E., Zahn, C., & Finke, M. (2006). Knowledge acquisition by hypervideo design: An instructional program for university courses. *Journal of Educational Multimedia and Hypermedia, 15*(3), 285–302.

Stahl, E., Zahn, C., Schwan, S., & Finke, M. (2006). Knowledge acquisition by designing Hypervideos: Different roles of writing during courses of "new" media production. In L. Van Waes, M. Leijten, & C. Neuwirth (Eds.), *Writing and Digital Media*, Studies in Writing (pp. 77–88). Oxford: Elsevier.

Stahl, E. (2005). Is a hypertext a book or a space? The impact of different introductory metaphors on hypertext construction. *Computer Education, 44*, 115–133.

Stahl, E., & Bromme, R. (2004). Learning by Writing Hypertext: A Research Based Design of University Courses in Writing Hypertext. In *Effective Learning and Teaching of Writing* (pp. 547–559). Retrieved July 10, 2009, from http://dx.doi.org/10.1007/978-1-4020-2739-0_37.

Stevens, R., Cherry, G., & Fournier, J. (2002). *Video Traces: Rich Media Annotations for Teaching and Learning*. In Proceedings of the CSCL 2002 Conference on Computer Supported Collaborative Learning. Boulder, CO.

Suthers, D. D. (2001). Towards a systematic study of representational guidance for collaborative learning discourse. *Journal of Universal Computer Science, 7*, 254–277.

Suthers, D. D., & Hundhausen, C. D. (2003). An experimental study of the effects of representational guidance on collaborative learning processes. *Journal of the Learning Sciences, 12*(2), 183–218.

Suthers, D. D. (1999). *Effects of alternate representations of evidential relations on collaborative learning discourse*. In Proceedings of the 1999 conference on Computer support for collaborative learning (pp. 611–620). Palo Alto, California: International Society of the Learning Sciences. Retrieved July 10, 2009, from http://portal.acm.org/citation.cfm?id=1150240.1150314.

Sutter, B. (2002). Instructional Artefacts. In G. Stahl (Ed.), *Computer support for collaborative learning: Foundations for a CSCL community – Proceedings of CSCL 2002 Boulder, Colorado, USA, January 7-11 2002* (pp. 72–81). Hillsdale, N.J: Lawrence Erlbaum Associates, Inc.

Vreman-de Olde, C. (2006). *Look – experiment – design. Learning by designing instruction*. Enschede: Gildeprint Drukkerijen.

Wetzel, C. D., Radtke, P. H., & Stern, H. W. (1994). *Instructional effectiveness of video media*. Hillsdael, NJ: Lawrence Erlbaum Associates.

Wineburg, S. (2001). *Historical thinking and other unnatural acts: Charting the future of teaching the past*. Philadelphia: Temple University Press.

Zahn, C. (2009). Gestaltendes Lernen:"Learning by design" im Schulunterricht?. *LOG IN Informatische Bildung in der Schule, 156*, 27–35.

Zahn, C., & Finke, M. (2003). Collaborative knowledge building based on hyperlinked video. In R. B. B. Wasson (Ed.), *CSCL 2003 – commuity events. Communication and interaction* (pp. 173–175). Bergen, NO: Intermedia.

Zahn, C., Barquero, B., & Schwan, S. (2004). Learning with hyperlinked videos–design criteria and efficient strategies for using audiovisual hypermedia. *Learning and Instruction, 14*, 275–291.

Zahn, C., Krauskopf, K., Hesse, F. W., & Pea, R. D. (2009). *Constructive video in the classroom – A field experiment on the role of computer technology and metaphors in complex problem solving performed by school students*. Manuscript submitted for publication.

Zahn, C., Pea, R., Hesse, F. W., & Rosen, J. (2009). *Knowledge building through collaborative construction of digital video: A comparative experimental study on the role of thechnology in complex problem solving*. Manuscript submitted for publication.

Zahn, C., Pea, R., Hesse, F. W. & Rosen, J. (in press). Comparing simple and advanced video tools as supports for complex collaborative design processes. *The Journal of the Learning Sciences*.

Zahn, C., Pea, R., Hesse, F. W., Mills, M., Finke, M. & Rosen, J. (2005). Advanced digital video technologies to support collaborative learning in school-based education and beyond. In: T. Koschmann, D. Suthers & T. W. Chan (Eds.) *Computer Supported Collaborative Learning 2005: The next 10 years*, (pp. 737–742). Mahwah, N. J. Lawrence Erlbaum Ass. Inc.