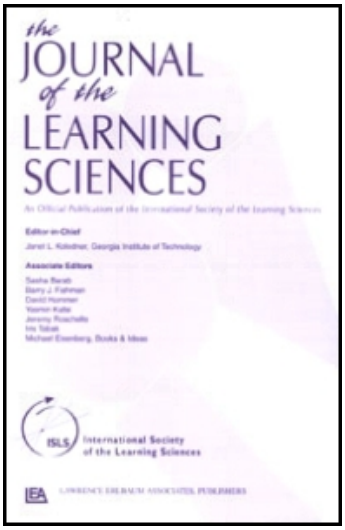

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Comparing Simple and Advanced Video Tools as Supports for Complex Collaborative Design Processes

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Working with digital video technologies, particularly advanced video tools with editing capabilities, offers new prospects for meaningful learning through design. However, it is also possible that the additional complexity of such tools does *not* advance learning. We compared in an experiment the design processes and learning outcomes of 24 collaborating participant pairs (dyads) using 2 contrasting types of video tools for history learning. The advanced video tool WebDIVER supported segmenting, editing, and annotating capabilities. In the contrasting condition, students used a simple video playback tool with a word processor to perform the same design task. Results indicated that the advanced video editing tool was more effective in relation to (a) fostering student understanding of the topic and acquisition of cognitive skills, (b)

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the quality of student design products, and (c) the efficiency of dyad interactions. The implication of our experimental findings for constructivist design-based learning is that mediating functions of video tools may be used as cognitive and social supports, for example when students learn by solving design tasks in school.

Video is an important resource for learning, although it is not without its challenges when more than passive watching is involved (Hobbs, 2006; Salomon, 1984; Wetzel, Radtke, & Stern, 1994). For example, there are significant challenges to using video for constructive "learning in activity" (e.g., Greeno, 2006) and for collaboration in meaningful learning situations. In this article we present research on digital video tools used for a particular type of educationally meaningful learning activity: collaborative design. Empirical research in the learning sciences has repeatedly demonstrated how collaborative design with computer tools and artifacts—as a constructive activity—can foster collaborative learning processes in student groups (*learning through design*, Kafai & Resnick, 1996; Learning by Design™, see Kolodner, Camp, et al., 2003; *design for collaborative learning*, Hennessey & Murphy, 1999). However, an issue that needs further investigation is the study of the *mediating functions* of computational tools in terms of how computer tools affect collaboration in design projects. Vygotsky (1930/1978) argued seminally that the central fact about human psychology is that our higher forms of mental functioning are mediated by cultural artifacts such as representational symbols. The systematic study of the mediating functions of computational tools may help encourage timely establishment of video-enhanced learning environments to support student learning and achievement in design tasks. The present article builds on "design" approaches to learning, with a particular focus on the "mediating functions" of technology during collaborative processes (Roschelle & Teasley, 1995; Suthers & Hundhausen, 2003). Our experimental study compares the mediating functions of simple and advanced video tools in a visual design task for history learning.

THEORETICAL BACKGROUND: THE NATURE OF DESIGN PROBLEMS

The design and construction of computational and media artifacts as a means of learning is a dominant theme of research in the learning sciences. For example, scholars associated with the MIT Media Lab and the "constructionist" pedagogy of Seymour Papert (1980, 1991) for applications of technology in learning and education—including Harel (1990), Harel and Papert (1991), Kafai (1996), Kafai and Ching (2001), and Kafai, Ching, and Marshall (2004)—have each provided studies of children as computer game designers using the Logo programming envi-

ronment, whereas other scholars have pursued constructionist learning with robotics and toys (e.g., Resnick, Martin, Sargent, & Silverman, 1996). Lehrer, Erickson, and Connell (1994; see also Carver, Lehrer, Connell, & Erickson, 1992) applied HyperAuthor for students designing complex hypertexts about American history topics. Pea (1991; Pea & Gomez, 1992), in his MediaWorks Project at the Institute for Research in Learning, created a multimedia-composing environment that after-school middle school learners used to develop multimedia presentations about environmental and urban issues in their local community. Goldman-Segall (1991, 1994, 1998) brought together traditions of video documentaries with Massachusetts Institute of Technology constructionist pedagogy in her Constellations and Orion projects, providing influential examples of what she calls "perspectivity" in how video is used for education. Participants in her studies construct and annotate their own pathways through collections of video clips of experiences in and out of classrooms and in interviews (Goldman, 2004, 2007).

In another strand of research, Kolodner and colleagues have studied *learning by design* for the science education of middle school students (e.g., Hmelo, Holton, & Kolodner, 2000; Kolodner, Camp, et al., 2003; Kolodner, Gray, & Fasse, 2003). In learning by design projects, student groups achieve real-world design challenges, such as designing a model of a subway system or a miniature vehicle, engaging in complex design cycles of science learning. These cycles include activities such as individual or small-group exploration, whole-class discussion, design, and knowledge representation (e.g., Kolodner, Gray, et al., 2003). Similarly, Nelson (1982; see also Nelson & Sundt, 1993) developed a design-based learning method for primary and secondary students that builds upon having students design and create physical objects for learning abstract concepts.

These different "design" approaches for learning have in common that they conceptualize design as a social practice in which learners are challenged not only to develop knowledge but also to articulate their knowledge. We consider design as "joint action that constructs shared information" (to put it in terms of a "situative" learning perspective, cf. Greeno, 2006, p. 86; see also Clark & Schaefer, 1989) and in which learning occurs because people actively generate artifacts and meanings.

What can be learned during such design projects? Well-known researchers of human computer interaction use the phrase *design rationale* to characterize what is engaged in design argumentation, as designers articulate and represent the reasons and the reasoning processes behind their design of artifacts (Moran & Carroll, 1996). When students design they are asked to reformulate their knowledge *for an audience* (Harel, 1990; Hayes, 1996; Kafai & Ching, 2001). For example, when designing a computer-based science game, learners transform their understanding of science concepts using the expressive constructs of a programming language and a gaming structure. When creating a model, learners apply science concepts and science laws to physical objects. When constructing hypermedia, learners translate their topic-

related ideas using a hyper structure for interactively dynamic sequences of texts and pictures. Thus, designing—like writing (see Bereiter & Scardamalia, 1987; Hayes, 1996)—is at its core a form of complex problem solving (Goel & Pirolli, 1992) in which the design of problem-solving activities shapes knowledge transformation processes and, ultimately, learning (Kafai, 1996; Kolodner, Camp, et al., 2003). Moreover, as a *collaborative* computational activity (Hennessey & Murphy, 1999; Maldonado, Lee, Klemmer, & Pea, 2007), design creates a demand for students to negotiate meaning in a design team. Learners need to achieve common ground about design goals and design content when they make their design decisions, taking into consideration the anticipated audience, the intended message, and the constraints of their available technologies. In this design process, they can express and defend (or change) their own understanding of a topic and concern themselves with how they represent that understanding (Kolodner, Gray, et al., 2003). They can also reflect on their own and their collaborators' knowledge or opinions in design discussions. They thus are expected to acquire knowledge, thinking skills, problem-solving skills, and communication skills during these design activities (Kolodner, Gray, et al., 2003). Examples of specific communication skills that can be acquired during *media* design projects include skills of critical analysis and media literacy (e.g., design skills, Carver et al., 1992; new media skills, Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006).

Yet learning through design cannot be taken for granted. Individual and collaborative achievements in design problems depend centrally on the organization of the activity system in which the project takes place (Kolodner, Gray, et al., 2003; Nelson & Sundt, 1993). For example, social and physical task environments interact with the individual cognitions of the participating individuals to shape design problem solving, as in writing (Hayes, 1996; Pea & Kurland, 1987). The tools used are likely to be influential factors shaping design processes. But to date, the systematic empirical study of this issue has been rare. The goal of this article is to direct researchers' attention to such system issues and deepen their understanding about how tools and external representations may shape collaborative learning through design. We thus investigated the *mediating functions* of video tools in collaborative design activities.

THE FUNCTIONS OF EXTERNAL REPRESENTATIONS AND TOOLS IN COLLABORATIVE LEARNING

The mediating functions of external representations as aids and catalysts for collaboration among learners have been addressed by research on collaborative science problem solving (e.g., Roschelle, 1992). This research has demonstrated that diagrams, texts, graphs, animations, and simulations can serve as social tools that facilitate exploration on the one hand and shape group communication on the other

(Pea, 1992; Roschelle & Teasley, 1995). Suthers and Hundhausen (2003) extended this perspective by assuming representation-specific influences of tools on collaborative processes—*representational guidance* (Suthers, 2001)—identifying three major types of mediating functions of external representations: (a) initiating negotiations of meaning, (b) facilitating deixis, and (c) providing a group memory. The *initiating* function is based on the expectation that single group members who want to add new ideas to a shared representation (thereby modifying it) may want to give a reason before they do so and thereby negotiate meaning with the aim of achieving common ground with other group members (Clark & Brennan, 1991). The *facilitating deixis* function is based on the assumption that existing components of shared representations facilitate discussion because they can provide visible referential anchors that ground subsequent negotiations of meaning. The *group memory* function assumes that prior ideas of the group that are externally represented are less likely to be ignored or forgotten—thus supporting discussions. Suthers and Hundhausen argued that different representational tools are distinctive in how they fulfill these functions because they differ in terms of their constraints and salience: constraints in *how* knowledge can be expressed and salience with *which* information can be emphasized.

Suthers and Hundhausen (2003) provided evidence for these three functions of mediating representations from their systematic experimental research. They demonstrated that in problem-solving tasks, graph users tend to represent fewer knowledge items, but more information links (evidential relations), compared to text and matrix users. Graph users also discussed more evidence (data) items than text and matrix users. And the representational work of graph users (as opposed to text and matrix users) influenced their later essay writing. In other words, different external representations had different effects on learners' interactions.

There is good reason to expect that the findings of Suthers and Hundhausen will apply not only to graphs, text, and matrices but to other complex representational tools. Here we focus on these issues with respect to tools for interacting with *videos*. Videos are complex dynamic visual representations combining different symbol systems and notations (Salomon, 1994; Wetzel et al., 1994). Moreover, emerging digital video tools provide various functions that can support knowledge construction (Chambel, Zahn, & Finke, 2006; Pea et al., 2004) and collaborative learning through design (E. Stahl, Finke, & Zahn, 2006; E. Stahl, Zahn, Schwan, & Finke, 2006; Zahn et al., 2005).

THE MEDIATING FUNCTIONS OF VIDEO TOOLS

What do we mean by *video tools*? Video tools are digital tools that facilitate cognitive and collaborative processes with features for augmenting the understanding of video information. They reorganize the structure of activity in which video is used.

Two classes of such video tools can be distinguished: video playback tools and video editing tools. *Video playback tools* allow learners to watch video information that *others* have captured, structured, and sequenced before. Their features range from video player functions to embedded dynamic hotspots that facilitate cognitive processes during watching (e.g., as in an instructional video designed for learning; see Schwan & Riempp, 2004; Zahn, Barquero, & Schwan, 2004). Spiro, Collins, and Ramchandran (2007) explained how videos with features for random access can support cognitive flexibility for the understanding of complexity and multidimensionality in ill-structured domains such as history. In collaborative learning situations, people can use video playback tools as sharable visual representations for discussion. A word processor can be incorporated into a task environment with a video player for learners to make annotations or commentaries for a group or an audience (Zahn & Finke, 2003).

In comparison, *video editing tools* allow for creating video information structures by selecting material from pre-captured video assets in order to highlight, segment, edit, and reorganize it for communication to an audience or for analysis, comparison, or annotation for purposes of critical reflection (Pea, 2006). Examples include *collaborative video editing tools* used to create and share new points of view (or perspectives) onto a source video (Orion, see Goldman-Segall, 1998; Goldman, 2007), to make observational investigations (Animal Landlord, see Smith & Reiser, 2005), to create hotspots and hyperlinks (HyperVideo, see Zahn & Finke, 2003; E. Stahl, Finke, et al., 2006), or to "dive" into video to select segments and to remix them for such purposes as collaboration and reflection (DIVER, see Pea et al., 2004; WebDIVER, see Pea, 2006; Pea, Lindgren, & Rosen, 2008). Each of these collaborative video technologies offers distinctive features designed to support the sociocognitive activities (i.e., socially distributed cognitive activities; cf. Salomon, 1993) of those who use them in collaborative situations to analyze, to refer to video information, and to provide video annotations.

There should be substantial differences in how the capabilities of these two classes of video tools contribute to the context of collaborative learning through design. In principle, both types of tools can be used in design problems. However, collaborative video editing tools—although they may be more complex and demanding—might better support meaningful learning than video playback tools with word processors.

Why do we make this conjecture? Applying the framework developed by Suthers and Hundhausen (2003) concerning the differing affordances of representational tools to the new case of video tools, we expect video tools to differ in their mediating functions within collaborative learning processes and outcomes. With *playback* tools, video is a sharable but basically unchangeable dynamic representation as a referent or anchor for discussion. With *editing* tools, video is open to direct modifications, such as highlighting, selecting segments, and reordering the sequence of video segments. We hypothesize, in the spirit of Suthers and Hundhausen, that these spe-

cific "remix" features should afford collaborative epistemic activities regarding the video content and form. For example, features for making video segments may initiate comparisons, interpretations, and negotiations of meaning among learners to achieve common ground (Clark & Brennan, 1991) before a video representation is altered (*initiating function*). Furthermore, highlighted segments or elements within video segments may support subsequent negotiations, comparisons, and interpretations (*facilitating deixis function*) because they enable acts of "guided noticing" (Pea, 2006). In an act of guided noticing using collaborative video editing tools, one student may invite another to jointly pay special attention to her interpretation of specific segments of the video, and she may do this by virtue of the tool having the affordance of zooming into specific video segments for juxtaposition, comparison, and commentary. And finally, the ideas of a group can be externally represented both visually and verbally in a new video-based representation so that these new ideas are then less likely to be ignored (*group memory function*). To test these conjectures, we conducted an experimental study.

GOALS AND RESEARCH QUESTIONS OF THE STUDY

In the present experiment, we sought to compare the mediating effects of collaborative video editing tools with video playback tools on learning. For this purpose, we compared two video technologies: a collaborative video editing tool with segmenting, editing, and annotating capabilities versus a video playback tool combined with generic word processing capabilities. We thus compared proxies of each system type with its associated capabilities. In our comparative study of uses of these two video technologies, we highlight the functional organization, or system characteristics, of certain human activities using tools. We argue that the tools not only change quantitative aspects of mental activity such as speed or accuracy but can also serve to "reorganize mental functioning," qualitatively changing human accomplishments and thinking processes. We aim to direct attention toward the systemic nature of thinking augmented by technologies (Pea, 1985) and to capture important aspects of what changes within sociocognitive activities of learning, in this case of video tools for collaborative design.

The present study addresses the following questions:

1. In what ways and to what extent does a collaborative video editing tool enhance learning in a design task compared to a video playback tool with a word processor?
2. Which specific features of a collaborative video editing tool support differences in collaborative processes that may explain differences in learning outcomes?

3. Which specific sociocognitive processes can explain the learning influences of uses of collaborative video editing tools?

For the purpose of our study, we developed a specific visual design problem in the domain of history: collaboratively designing a video-based Web presentation for a virtual museum. The goal was to analyze and comment on a video showing a historical newsreel from 1948, so that it could be published in the virtual history museum along with the comments. The topic of the newsreel was the Berlin Blockade in 1948. The students participating in our study were asked to analyze and comment on the newsreel so that future visitors of the virtual museum would have a good understanding of both the content and the style of the newsreel as an instrument of propaganda.

Instructional Goals of the Collaborative Design Task

History was chosen as a representative domain for our study because in history learning the use of video (e.g., historical sources from archives, historical newsreels) is considered highly preferable to the use of only static media, although it nonetheless provides challenges for students and teachers (Krammer, 2006; Smith & Blankinship, 2000). Video sources are an integral part of the history they show. For example, the video source in our experiment was a newsreel showing history topics (Berlin 1948) and it *was* a history topic (i.e., propaganda via newsreel). In terms of understanding such sources, historical content knowledge is closely intertwined with specific cognitive skills such as evaluating, analyzing, and reflecting critically on historical sources. Learning about history then means "*constructing history*" (Krammer, 2006; Wineburg, 2001), thereby developing skills of critical analysis and judgment. These are necessary skills for a full understanding of historical topics, but many people do not acquire them at school. Moreover, these skills are not unique to history learning. They are aligned with general communication and cultural skills for community involvement (*new media literacies*, H. Jenkins et al., 2006; *design skills*, Carver et al., 1992; and *advanced expertise* as described by Scardamalia, 2002). Our experimental collaborative task for history learning therefore involved two principal components: critical analysis and judgment, and appropriation. Critical analysis and judgment of video materials using a general film analysis methodology provided students during their collaboration with opportunities for developing a critical stance toward a supposedly authoritative video source and an understanding of the diversity of ideas. The constructive activity of designing a Web page for a real virtual history museum provided learners with opportunities for comparing and reorganizing knowledge as they produced their own ideas and worked creatively with them. During the collaborative design process, learners were assumed to appropriate the video content to their own purposes.

METHOD

Participants

A total of 48 German first- through third-semester psychology students (33 female, 15 male) participated in the study. Participants did not have any special expertise in the domain (German history/Berlin Blockade). Their mean age was 22.2 years ($SD = 4.8$). The participants were randomly assigned to dyads (15 same-sex, 9 mixed-sex dyads) for the experimental sessions.

Design

The study compared two independent groups with video tool as the between-subjects factor. The experiment was administered separately for each dyad. The dyads collaboratively accomplished a design task, having been randomly assigned to one of two conditions: collaborative video ($n = 12$) or video player & text ($n = 12$). In the first condition, dyads used the collaborative video editing tool WebDIVER. In the second condition, participants accomplished the design task using a video playback tool (Apple QuickTime) and a word processor (WordPad). Figures 1 and 2 illustrate the different video tools. For both conditions, students used a handheld tablet computer with an external keyboard and a mouse. The design task, instructions, and materials were kept constant across conditions.

Materials

The video used in the experiment was a digitized version of a historical newsreel originally produced by the Allied forces (United States/Great Britain) and shown to the German public during the Berlin Blockade in 1948. The video covered news information about the airlift established in 1948 by the Allied forces when Russia tried to cut Berlin off from the traffic of goods. It consisted of 95 single "shots" (i.e., single photographic elements; see also Katz, 1991) and lasted 5 min. The video used in the transfer task was a modern 65-s TV clip by the German Green Party (Buendnis 90/Die Gruenen) from the 2006 nationwide election in Germany.

The texts used in the experiment contained 350 to 1,500 words each. Content of text provided detailed information on three subtopics: "Berlin—from four powers' control to divided city" (accounts of the historical reality during those times), "Newsreels and propaganda" (content concerning media history on newsreels in post–World War II Germany), and "Short introduction to film analysis" (content about film theory and film production, filmic codes and styles that stimulate certain psychological responses in viewers).

WebDIVER (see Figure 1) is one of the software programs developed in the DIVER Project (http://diver.stanford.edu) at Stanford University. It is based on the metaphor of enabling a user to dive into videos to create points of view on precise

FIGURE 1 Collaborative video condition—WebDIVER.

spatiotemporal regions of one or more source videos. WebDIVER was first released to the research and education community in Autumn 2004, enabling any registered user to do video clip selection by panning and zooming with a virtual camera viewfinder in the browser, annotating clips, sequencing clips, and creating embeddable remixes of streaming video files without the video needing to reside on the user's computer. Users mark and record and annotate through a Web browser selections of space–time segments of videos stored in a remote database. Video files in various formats are uploaded by users and transcoded into a specific format (Adobe Flash, .flv) in which WebDIVER functionalities of selecting, annotating, and remixing of videoclips are accessible. In December 2005, YouTube.com was released and made video uploading and community features into a global phenomenon; it was the fourth most-trafficked Web site in the world as of November 14, 2009 (youtube.com, n.d.). Space–time selection of video segments and remixing as in WebDIVER is still unavailable as a commercial product offering.

With the functions offered by WebDIVER, users can select either a temporal segment or a spatiotemporal subregion of a video by mouse-controlling a rectangular selection frame (acting like a camera viewfinder) to pan and/or zoom into view only that subpart of the video that they wish to feature and then interpretively annotating their selection via a Web interface. Each dive movie clip and its associated annota-

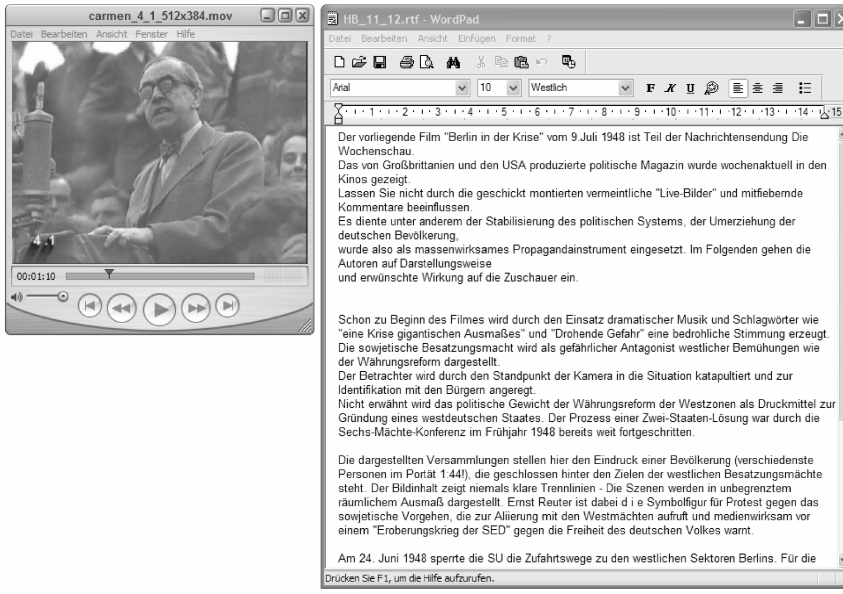

FIGURE 2 Video player & text condition—movie player and word processor.

tions is represented in a panel in the dive, and a remix of the video clips and annotations can be played to experience the dive. A named "dive" is represented in a Diver worksheet that contains a collection of one or more re-orderable "panels," each of which is marked by a key video frame that represents the user's video selection and a text field for an annotation or comment about that selection. Among the distinctive features of the WebDIVER system for the purposes of our study is that users can precisely highlight video selections of interest (i.e., spatiotemporal regions that are subparts of the full frames of a video file), annotate them, categorize or compare them, and reorder the video selections to be played in sequence (Pea, 2006). In distributed cognition terms (Hutchins, 1995; Pea, 1993; Salomon, 1993), the intention of the WebDIVER system is to augment the activity system encompassing the collaborating learners so as to make *communicative* activities comprising video-anchored conversations easier: selecting video moments as a joint focus of attention, annotating them, reengaging with the annotated video moments, and resequencing them into new communications. Users can collaborate with WebDIVER in guiding one another in noticing details and making joint comparisons of segmented video episodes (what Pea, 2006, called "guided noticing").

In the video player & text condition students used a basic video playback tool (Apple QuickTime) to analyze the source video and a word processor (Microsoft WordPad) for redescription, shared annotations, comments, or interpretations (see Figure 2). The video playback tool allowed participants to watch the source video

as often as they wished and to fast-forward, rewind, or stop and pause it at any position any time, but it did not afford making segments or editing the video. WordPad is superior to a normal text editor in allowing for basic formatting of text.

Measures of Learning and Performance

Prior knowledge and background. To assess prior knowledge in the domain of history, special computer expertise, or expertise in film and media production, we administered a pre-questionnaire (self-assessment) and a 12-item multiple choice pretest (knowledge test).

Content knowledge and cognitive skills acquisition. To assess the learning outcome (understanding of the history topic), we administered posttests measuring content knowledge and cognitive skills acquisition. First, as a measure of *content knowledge*, a multiple choice test was administered with eight questions, each with five alternatives and more than one possible correct alternative. Second, as a measure of cognitive skills (critical analysis and reflection on historical film sources), a knowledge transfer task was applied. It consisted of two questions relating to a political TV ad from the 2006 nationwide German government elections and was presented as digital video on the computer screen for interactive use by participants. The questions were answered in an individual free-writing text.

Joint design products. To assess collaborative design performance, we analyzed the panels created by the dyads in the collaborative video condition and the text files created by the dyads in the video player & text condition. From these products, the following data were obtained: (a) number of video selections, (b) precision of video selections (details/single images or sequences), and (c) changes in the order of video selections.

Dyadic interactions. To assess possible tool effects on collaborative processes, we captured dyadic interactions by video recordings from a Webcam (see Figure 3) and a screen recorder (Camtasia Studio by TechSmith). From these video data, a two-step content analysis of dyadic discourse was performed. During the first exploratory step, trained observers watched the video recordings and discussed them to find emerging content categories. The second step was conducted as a process of coding and counting. A coding scheme was developed based on the categories that emerged during Step 1. For the comparative content analyses during Step 2, the proportion of talking time in each category (related to the total amount of talking time) was measured using video analysis software (Videograph©) that allows users to mark video segments and to assign them to predefined categories.

FIGURE 3 Group interactions captured by screen video and Webcam.

Transcript analyses. For detailed process analyses, the video data from selected case examples were transcribed (conversation and action transcripts) in order to reflect possible tool effects on micro-processes such as achieving common ground in dyadic interaction. For the transcript analyses we integrated for our specific purposes the frameworks suggested by Roschelle (1992), Roschelle and Teasley (1995), Barron (2003), and G. Stahl (2006).

Procedure

The procedure consisted of four steps. In *Step 1*, participants were asked for their permission to capture their interactions on video and screen videos. They also answered the pre-questionnaires assessing background knowledge, interest in German history/World War II, general interest in politics, prior knowledge, prior computer experience, knowledge about media production, and visual abilities. In *Step 2*, an inquiry phase, participants watched a digital video showing the historical Berlin Blockade newsreel from 1948, visited LEMO (a popular German virtual history museum), and read prepared history/media history texts as well as a text about filmic codes and style. Step 2 was performed individually, but partici-

pants were informed about how the knowledge from the video, the virtual museum visit, and the texts would relate to their collaborative design task. In *Step 3*—the collaborative design process—the participants worked collaboratively at a computer in a face-to-face situation. The dyads briefly practiced using the video tools to establish familiarity. Then they were asked to act as a team of online editors to design a Web page for LEMO, which they had visited during Step 2. Work on the video-based design task was restricted to about half an hour. When the students were done, they could proceed with *Step 4*, in which self-assessment questionnaires and assessment tasks were completed by individual participants to assess their interest in and appreciation of the design task, their appraisal of the group collaboration, the prevalence of technical problems, and their content knowledge and skills acquisition. For cognitive skills assessment, the participants individually accomplished the transfer film analysis task (TV ad). They were then thanked and released and received an honorarium or course credit.

RESULTS

We first present results substantiating the comparability of our two conditions and then present results obtained from quantitative analyses of the design products and posttest results. Finally, we present the qualitative data from selected examples of interactions among the dyads.

Group Differences—Comparability of Conditions

Participants were not expected to possess any expertise in the domain of history, special computer expertise, or expertise in film and media production. The prequestionnaire scores showed that the participants' history knowledge was on a moderate level, with a mean of 8.4 ($SD = 1.5$) correct answers on a 12-item multiple choice test. The level of participants' prior computer experience was average, with a mean of 2.9 ($SD = 0.9$) on a scale ranging from 1 (*very little experience*) to 5 (*very much experience*). None of the participants had experience with film or media production. *T* tests revealed no significant differences between our two conditions concerning these variables (all ps $> .10$). The participants in the two conditions did not differ significantly by age, gender, educational background, or sociodemographic status, and the results of a mental rotation test revealed no differences in visual abilities (all ps $> .10$).

The dyads also did not differ significantly between the conditions in terms of within-group composition related to age, gender, or prior knowledge and interests. *T* tests on age differences, and differences in pretest scores within the dyads of the two conditions, as well as *t* tests on prior topic interest and a chi-square test on

mixed-sex and same-sex dyads (female and male) in the two conditions were not significant (all *p*s > .10).

Table 1 summarizes the participants' attitudes toward the visual design task, awareness of the overall design goal, control over digital video technology, and appraisal of their teamwork. Results indicated a generally high acceptance of the task, a moderate to high awareness of the overall design goal, high self-perceived control over technological tools, and a high appreciation of the teamwork. *T* tests did not yield significant differences on these measures (all *p*s > .10), indicating that the participants' overall positive attitudes toward the task and performance were similarly high in the two conditions.

In sum, the two conditions can be considered comparable in terms of the participants' backgrounds, prior knowledge, and interests and the compositions of the dyads.

Understanding the History Topic—Content Knowledge and Cognitive Skills

The posttest scores of all 48 participants were included in the analysis, but dyads were chosen as basic units of analysis (i.e., scores were averaged for each dyad), because *N* was smaller than 35, so we had to assume "nonindependent" scores (cf. Kenny, Kashy, & Cook, 2006). Also, analyzing the averaged scores of dyads seemed more defensible because the design products were group products.

Concerning content knowledge, the multiple choice tests on understanding the history topic revealed a total mean score of 34.5 ($SD = 1.6$) out of a possible 40. In the collaborative video condition, the average was significantly higher than in the video player & text condition, $t(22) = 2.23$, $p < .05$. The results presented in Table 2 suggest that the dyads in both conditions developed a good understanding of the historical content but that the dyads in the collaborative video condition learned

TABLE 1
Participants' Attitudes Toward the Task

	Collaborative Video		*Video Player & Text*		*Total*		*t Test*	
Category	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t(46)*	*p*
Appreciation of the task	3.7	1.1	4.1	0.8	3.9	1.0	–1.0	>.1
Goal awareness	3.3	0.9	3.5	0.8	3.4	0.9	0.7	>.1
Technology	4.4	0.6	4.2	0.9	4.3	0.8	–0.6	>.1
Appraisal of teamwork	4.2	1.0	4.1	0.9	4.2	0.9	0.1	>.1

Note. $N = 24$ for each condition. Self-assessments were made on 5-point semantic scales ranging from 1 (*low*; e.g., "the task was not interesting at all") to 5 (*high*; e.g., "the task was very interesting").

TABLE 2
Understanding of the History Topic: Content Knowledge and Cognitive Skills Acquisition

	Collaborative Video		*Video Player & Text*		*Total*		*t Test*		
Category	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t(22)*	*p*	*d*
Content knowledge[a]	35.2	1.6	33.8	1.4	34.5	1.6	2.23	<.05	0.9
Cognitive skills transfer[b]	3.2	1.1	2.2	1.0	2.3	1.1	2.41	<.05	1.0

Note. Based on dyads.
Maximum possible correct answers: [a]40, [b]8.

more during the design task than the dyads in the video player & text condition. The effect size was moderate (Cohen's $d = 0.9$).

Concerning the assessment of cognitive skills, written answers by participants to the knowledge transfer task questions were rated according to a coding scheme we had developed on the basis of a predefined default solution. The solution comprised the visible entities (e.g., objects, persons, animals) and the stylistic features used in the TV ad (e.g., mise-en-scène, camera, music, montage), as well as examples for correct interpretations of these elements (e.g., a close-up of a person's face aims at creating emotional involvement). Each correct item in terms of the visible entities and filmic style was scored. Additional scores were allocated for *any* reasonable interpretations, including those deviating from the default solution. No points were given for overgeneralized statements (e.g., "The TV ad aims at capturing votes"). The scores were then transformed into grades ranging from 0 to 8 (8 = *expert solution*). Participants' answers were rated independently by three (2 + 1) raters: The mean ratings of two well-trained raters (correlation $r = .8$, $p < .001$) were correlated with the rating of a third blind rater. Interrater correlation was significant and positive ($r = .9$, $p < .001$). The analysis of the transfer test results revealed a total average of 2.3 ($SD = 1.1$) for our sample (the highest average grade reached by a dyad was 5.5, and the highest grade reached by an individual was 7.5). The mean was significantly higher in the collaborative video condition than in the video player & text condition, $t(22) = 2.4$ $p < .05$ (see Table 2). The effect size was moderate to high (Cohen's $d = 1.0$).

In sum, our posttest results indicate that the dyads in the collaborative video condition learned more than the dyads in the video player & text condition when designing a Web page for a virtual history museum called LEMO. The findings suggest, too, that the dyads using collaborative video reached a higher level of skills transfer than the dyads in the video player & text condition. It still remains

open at this point, however, how the distinctive features of the video tools may have influenced collaborative learning.

Joint Design Products

For the total number of video selections, the mean was 47 (SD = 30.0). The dyads in the collaborative video condition selected significantly fewer pieces of video than the dyads in the video player & text condition, $t(22) = -3.7$, $p < .001$. The effect size was high (Cohen's $d = 1.5$). The results are shown in Table 3.

The detail-to-sequences ratio was calculated as a measure of precision. *Details* were defined as selections of one shot or less from the video (e.g., a selected person or object from a shot). *Sequences* were selections of video segments containing more than one shot. Hence, a ratio >1 indicates that more details than sequences were selected (thus high precision). A ratio <1 indicates that a larger number of sequences than details was selected (thus low precision). The total mean ratio was 1.4 (SD = 1.6). In the collaborative video condition, the ratio was significantly higher than in the video player & text condition, $t(22) = 2.24$, $p < .05$ (see Table 3), with a moderate to high effect size ($d = 0.9$) indicating that video selections were more precise in the collaborative video condition than in the video player & text condition. To analyze how selections were ordered, we compared the order of the video selections in the design products to the existing narrative order in the source video. The percentage of design products with at least one change in order was calculated. The total mean percentage of design products with changes in order was $M = 0.30$ ($SD = 0.47$). In the collaborative video condition, changes of order occurred. In the video player & text condition, there was a floor effect: No changes of order were found (see Table 3). A chi-square test was significant ($p < .05$). The effect size estimated on basis of the chi-square value was high ($d = 2.0$).

In sum, the results indicate that the dyads in the collaborative video condition displayed a tendency to make fewer but more precise video selections and a tendency to change the order of the video segments more often than the dyads in the

TABLE 3
Joint Design Products

	Collaborative Video		*Video Player & Text*		*Total*			
Category	*M*	*SD*	*M*	*SD*	*M*	*SD*	*p*	*d*
Number[a]	28	25.6	64	23.2	47	3.0	<.001[b]	–1.5
Precision[c]	2.1	1.6	0.8	1.3	1.4	1.6	<.05[b]	0.9
Reordering[d]	0.6	0.5	0.0[d]	0.0[d]	0.3	0.5	<.05[e]	2.0

[a]Number of items selected from source video. [b]*t* test. [c]Ratio of commented details and sequences. [d]Order of selections compared to order of source video. [e]Chi-square test.

video player & text condition. One possible interpretation for these results is that the dyads in the collaborative video condition proceeded more planfully in their accurate selections of video segments and used the tool functions to construct their own video information structures. The new structure thus tended to deviate from the existing narrative of the source videos, whereas the dyads in the video player & text condition kept closer to the original video.

Interactions Within Dyads

Twelve video recordings (six from each condition) of the dyads' interactions while collaborating on the design problem were analyzed. The subsample did not differ from the whole sample in terms of any of the variables (pre- or posttests). During Step 1 of the analyses the following categories were identified: 1 = content talk (1a = history related to Berlin 1948, 1b = media history), 2 = design talk, 3 = film-related talk, 4 = group coordination talk, 5 = technical issues talk, 6 = investigator-directed talk, 7 = task-irrelevant talk, 8 = incomprehensible talk. Categories 1–3 were considered directly relevant to the design task, whereas Categories 4–8 were considered indicators of possible problems (e.g., with group coordination, technology, understanding of the task, or motivation). Categories 1–3 were thus interpreted as behavioral indicators for the dyads' responsiveness to the design problem, Category 4 was interpreted as a behavioral indicator for the functioning of group work, Category 5 as an indicator for involvement with technology and tools, Category 6 as an indicator for help seeking, and Category 7 as an indicator for off-task behavior. Category 8 was not interpreted as a behavioral indicator but was treated as a control for the technological quality of the recordings (reliability). Selected examples for Categories 1–3 are presented in Table 4.

For the comparative analyses, quantitative data were obtained from the same sample of 12 video recordings by capturing the proportion of talking time that dyads dedicated to different themes. The proportion of talking time devoted to the task-relevant Categories 1–3 (content, design, film-related) equaled more than two thirds (70%) of the total talking time in both conditions. The results also showed in a complementary manner that less than 30% of the total talking time in either condition fell into Categories 4–8 (group coordination, technology, etc.). Off-task behavior was less than 3% and group coordination and technology talk was less than 10%, indicating that participants took their task seriously and did not forget about it during their video analysis. This interpretation of the group interaction data is confirmed by the results on self-assessed attitudes (task interest, appraisal of teamwork, and control over technology).

Differences between the two experimental conditions emerged only on a descriptive level (see Figure 4): The dyads in the collaborative video condition devoted a higher proportion of talking time to design issues than the dyads in the video player & text condition, whereas the opposite was true for film-related talk.

TABLE 4
Examples of Task-Relevant Interactions That Emerged From the Qualitative Video Analyses

1. Content talk, including all content-related utterances in the subcategories (a) history and (b) media history/newsreels

Example for 1a—History

L1: There was a currency reform and then, because of that currency reform, the Russians and the military and others left and disrupted everything.

L2: Mmhh.

L1: You know, there were these powers, four powers, who sat together …

L2: Mmmh.

L1: … and decided on the currency reform and the Russians had to react somehow, because they didn't want the reform, they wanted another one … that's why they left

Example for 1b—Media history

L1: This is a propaganda film of the USA … yes, see … (browses through the text sheets) … USA and Great Britain.

L2: … not objective …

L1: … Look, the title already indicates …: "Berlin in der Krise," that is already, that's the first thing … with dramatic music ….

L2: Yes, of course.

L1: The word "gigantic size," this word alone, imagine what it must be like, if you sit in the cinema in front of a huge cinema screen, you hear this music and this voice together with it. You will be attracted by it, think about it, these are other dimensions in comparison with the computer here … a "crisis of gigantic extent" …

L2: Yes.

L1: Pay attention to the formulation …!

L2: Stop, … this is it … "when the Russians barricade," but they don't say, that before there were also reparations …

2. Design talk, including all utterances related to audience design, selecting information for designing the Web page, structuring of the Web page, and phrasing and wording

L1: … supply crisis and air lift … Do they [the audience] have any prior knowledge at all, about what the film is about, the topic, the historical context of the film?

L2: No deep knowledge, but they know a little bit: world war, postwar period, division into sectors …

L1: … they have that …

L2: And that buzzword makes sense to everybody. "Airlift" should … this is nothing special.

L1: We don't have to explain that. But I don't think this … "supply crisis" is the right word …

L1: Should we take this film sequence and describe it?

L2: Do you plan to drag all this over ?

L1: Only that … with the music …

…

L1: I want this to start with

L2: We should still have a heading, … that it is about a newsreel … can we make this bold?

3. Film-related talk, including filmic themes (video and audio) and filmic style

L1: Here look, this language is boulevard press style … with everything …

L2: they don't say with which "retaliatory actions" …

L1: What have they done? Always this zooming in into faces … first, the mass of people, and then the single person, as if you're a part of the mass yourself … as if you stand there and you look to your left and to your right …

L2: Yes, I mean, single individuals are shown. This is a woman, a nurse. And what I didn't understand is this pan shot along that wall … where, in front of a wall?

Note. Excerpts are from a transcribed dyadic interaction between two learners. L1 = Learner 1; L2 = Learner 2.

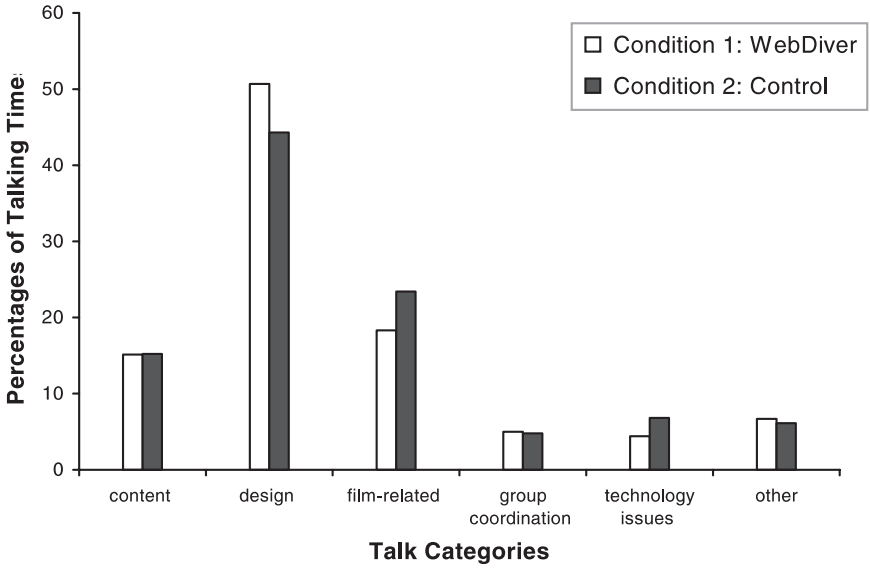

FIGURE 4 Comparison of relative talking time (percentage) in the two experimental conditions.

From these data, we draw the conclusion that the group interactions in both experimental conditions were task oriented and effective. The dyads talked about the same amount and in similar ways. Yet dyads in the collaborative video condition talked more about design issues, whereas dyads in the video player & text condition talked more about the original newsreel. These results cannot yet be interpreted per se (because they did not yield statistical significance), but they seem more plausible when we consider additional results from case analyses.

CASE ANALYSES

Although the reported effects are significant, they only provide *indirect* indicators for learning. We make conclusions from these results with caution, because evidence from quantitative analyses may not fully explain *how* the sociocognitive processes and conversation in the two conditions may have differed in quality. To examine this topic in detail, additional empirical data from case examples are provided along with qualitative transcript analyses. We provide four excerpts from transcripts of conversational interaction in which we examine how the dyads' task-related conversations might have been useful conversations for learning. The size of the selected episodes was limited for presentation in this ar-

ticle. Our specific focus here is on giving what Barron (2003) called a "detailed portrait" of how the dyads integrated uses of the features of video tools during their conversation to improve their collaborative design and learning activities (p. 315). The data and qualitative analyses provided here focus on the collaborating dyad as the unit of analysis. The episodes were drawn from several examples illustrating the two conditions of our study: one from the collaborative video condition (Case 1) and one from the video player & text condition (Case 2). These cases were selected to provide examples of the assumption we made earlier on the potential mediating functions of collaborative video editing tools for learning in design tasks: The collaborative video condition differs from the video player & text condition because it affords segmenting, editing, and annotating. If our assumption is correct that the distinctive features of a collaborative video editing tool used in collaborative learning through design make it easier to achieve conversational common ground, then traces of this effect should emerge in the discussions and conversational patterns of the dyads participating in our study.

The two cases presented here were selected because they are comparable in several critical dimensions but differ in other central aspects. In both cases, the dyads chose the same content when designing their presentations. Their interactions during design are characterized by the active participation of both members in the conversation, with rapid changes in conversational turn taking. In both cases, the language–action productions are coordinated and joint attention is maintained and expressed throughout the design process. Both participants take turns contributing to the collaborative design activity.

Nevertheless, the dyads' collaborations differ in ways that help reveal the mediating functions of video tools in collaborative learning. In Case 1, the dyad successfully uses collaborative video from the very beginning of the dyadic interaction. Their collaborative process is characterized by rapid agreement on a joint problem space (in this case, a focus on music and pictures of politicians as two major stylistic elements in the newsreel), by many equally distributed social exchanges, and by examples of matching language–action sequences that reflect mutual understanding and smooth cooperation. We find a number of short episodes of designing (design cycles) in which meaning is negotiated and knowledge is exchanged and noted while video segments are selected and comments are created. During these design cycles, the participants use WebDIVER as a supportive structure for establishing common ground before modifying the shared video representation, and they consistently refer to visual details or pictures as support for joint attention, interpretation, or comparison. This pattern is consistent with our conjectures about the mediating functions of video tools (derived from the initiating, facilitating deixis, and group memory functions defined by Suthers & Hundhausen, 2003) and was typical for dyads working with WebDIVER but not for those in the video player & text condition.

In Case 2 (video player & text condition), the dyad interacts on the basis of QuickTime plus WordPad. The session starts with an extensive planning discourse about design and structure—with repeated help seeking from the experimenter. During this discourse, the members decide to watch the newsreel and to criticize and comment on it for an audience of advanced school students (their design goal). As in Case 1, music and pictures of politicians as stylistic elements in the newsreel are mentioned as two major content areas. The dyad then plans to analyze the video collaboratively and to summarize the comments in a separate text. According to this plan, the collaborative process is characterized by an internal structure less defined and less productive than the structure in Case 1. We observe how both design strategies can be considered meaningful to our purposes at this point and fit well with the tools at hand.

Case 1: "Mark It!": Design Cycles Supported by Video Technology

The salient features of this dyad were coordinated coconstruction and use of the collaborative video editing tool, involving joint attention to details, decision making, elaboration of content, interpretation, and critical reflection during conversation. The episodes "zoom" into the design process and illustrate how the features of the collaborative video editing tool may be mirrored in a two-person interaction during design. *Episode 1-1* (Table 5) illustrates a design cycle starting from the guided noticing of a detail on the soundtrack and leading to comparison, the taking of a historical perspective, and critical reflection on content. *Episode 1-2* (Table 6) describes a design cycle in which the members *explicitly* include WebDIVER functions in their content-related conversation when creating a dive panel. *Episode 1-3* (Table 7) provides evidence of a design cycle starting from a visual detail and resulting in joint interpretation, comparison, and creation of a new dive panel with a new comment.

When repeating their video selection in Dive Panel 3, learner B hears a sound detail and draws joint attention to the sound of the aircraft on the audio track (line 1, Table 5). Based on this segment, he invites A to jointly attend to his interpretation—the hypothesis that sounds of aircraft before the airlift probably evoked quite negative feelings in the people in 1948 because they had experienced the bombings during World War II (line 1). A affirms this interpretation (line 2). B then takes leadership in developing the further hypothesis that the aircraft were reinterpreted as a positive symbol in the newsreel in the context of the airlift for the original audience in 1948 (line 3). In doing so, he takes a critical stance toward the video source. A affirms again (line 4). After having achieved this common ground, B proposes a design decision (i.e., to show in their own presentation how aircraft were reinterpreted and used as a *positive* symbol in the newsreel). A agrees (line

TABLE 5
Episode 1-1: From Sound Detail to Joint Interpretation: Basic Design Cycle With Guided Noticing

The dyad watches its third dive panel—a video selection of close-up shots of aircraft with one comment added so far.			
1	B	Oh, look! Good. Something else hit me. This noise, wrrrrh, that was something, the crowd had that a lot, didn't they? From the bombers	
2	A	Mhm	
3	B	So now airplanes are shown for a relatively long time and also experienced as positive, because up to this point, when planes came they brought death and …	
4	A	Yes, that's true. True	
5	B	and now they are presented as positive. Maybe we could add that as, add that to it too …	
6	A	Yes.	
7	B	That the symbol now has to be interpreted differently	
8	A	That's right.	
9	B	Okay. Wait a minute. "Airplanes are reinterpreted positively," or something like that.	*B types the comment*
10	A	Mhm	
11	B	Well?	
12	A	Mhm.	*B submits the comment*
13	A	Yes, that will do.	

Note. Excerpts from a transcribed dyadic interaction between two learners. A = Learner 1; B = Learner 2.

7), and B proposes a possible comment (line 8). A agrees; B writes the comment and asks A again for her opinion before submitting it.

This episode illustrates a short act of focused attention to a minute detail of a video scene that leads to the development of elaborate hypotheses concerning the sociocultural interpretation of that detail. By working on an existing dive panel and detecting a detail on the soundtrack, the dyad develops a critical stance and a historical perspective and establishes common ground before altering the representation. The new knowledge then results in the design activity of adding a comment to be shared with others as a "group memory." This tight design cycle exemplifies mediating functions of the video tool and shows how even in a very short period of time the dyad develops an entirely new historical perspective that is not at all evident from the source video.

The episode in Table 6 illustrates how the dyad explicitly refers to technology features during conversation. A and B are watching the newsreel to identify video selections that might be suitable for illustrating how aircraft are used in the newsreel as positive symbols for freedom and hope. B thinks aloud, commenting on what the speaker in the newsreel says (line 1, Table 6). A recognizes a picture she

TABLE 6
Episode 1-2: "Mark It!": Design Cycle With Explicit Reference to Features of Technology

The dyad previously hypothesized that aircraft are used as positive symbols in the newsreel. Now the participants watch the video again to find evidence for this hypothesis.			
1	B	Yes, such a huge number.	*Watches the newsreel video*
2	A	Yes, … that's what I meant	*Points to the screen*
3	B	Ah.	
4	A	Where they are all looking up.	
5	B	Ah. Yes, exactly, but …	*B rewinds the video, they watch the scene again*
6	A	There. There.	
7	B	Yes, take that out, yes.	
8	A	Especially the first one, where the woman …	
9	B	Yes, do it.	
10	A	Should we take the women? Or the men? Doesn't matter, I'll take the women, then I can still …	
11	B	Yes. Yes exactly. That's it.	
12	A	Yes, right? Mark it. OK. What do we call that? What …	*A marks the selection. A dive panel is created in WebDIVER*
13	B	Yes, do the title, "Pictures of Women, Who Are Looking Emotionally up at the Sky"	
14	A	*(laughing)* That was already a comment. Let's make a comment, anyway.	
15	B	Maybe something with population or something …	
16	A	Yes, right. That would be another point!	*B types the title "Population"*
17	A	Okay, and then …. Were they looking hopefully? For sure, don't you think?	
18	B	Yes. Comment. You have to click on "Add comment"	*A submits the title*
19	A	Yes, but it is …	
20	B	Oh I see, I don't know. Go ahead and click on it, yes …. Yes, that's it. That's all of it.	*They watch the selection*
21	A	Yes …. that they showed emotion.	
22	B	Mhm	

Note. Excerpts from a transcribed dyadic interaction between two learners. A = Learner 1; B = Learner 2.

apparently had in mind (line 2) and guides joint attention to it. B confirms (line 3), and A gives a reason for her choice (line 4). B hesitates (line 5). After considering an alternative, they agree on a preliminary design decision and selection of the picture (lines 6–11). They directly select it with the "mark" function of WebDIVER, creating a new dive panel (lines 12–14). The panel opens a window for a title and A asks B for a title (line 12). B proposes a possible interpretation of the picture in a

TABLE 7
Episode 1-3: From Visual Detail to Comparison: Complex Design Cycle With Guided Noticing

The dyad has created four dive panels. A and B are watching the newsreel again (from the start).			
1	A	That's also a kind of …… that's all so …… don't you think? The way that headline was ……. with the shadow behind it. That really gets to you ……. waah …. that's what I think. It's all so "dramatic"	
2	B	You're right, that, I didn't notice that 'til now.	*They play back to watch the scene again*
3	A	Yes, that ……. well yes, and then how the voice sets in right away.	
4	B	Yes, that, *that* I did notice. As if the world is coming to an end.	
5	A	Yes.	
6	B	Look. There. That is something. That is as if, those voices, that is what people knew from Hitler's speeches, too. *(imitates the voice)* So totally wound up just from the whole mood.	*A laughs when B imitates the voice*
7	A	Yes, I found that also in the later speech, but here it's extreme	
8	B	Mmhmm	
9	A	Should we somehow maybe.	
10	B	Pick that up, please, from the beginning with that title in it. Then we can ……	*A marks and records the scene*
11	A	The middle there also? (…)	
12	B	Put that there with the title. Exactly. As commentary.	
13	A	This way?	
14	B	And the music the way it starts also.	
15	A	mmhmm, and there	
16	B	mhm.	
17	A	Now?	
18	B	Mhmm. Yes. Exactly.	*A stops the recording (a new dive panel with title window appears in WebDIVER)*
19	A	Okay … then … title?	
20	B	You can write "Beginning" or something. Or?	
21	A	Yes. I will first write as a heading that …	*A types and submits the title "Beginning"*

(continued)

TABLE 7 (*Continued*)

			Short pause while they look at the screen
22	B	You mean film title, don't you?	
23	A	Yes.	*B starts typing a comment, "Concerning film title," then interrupts*
24	B	With this shadow and then with this, the writing that came after that. That was another one then ….	
25	A	Yes … yes!	
26	B	With that picture there, right? I think …… like earlier	
27	A	I think, like an old Hitchcock film	
28	B	Yes, exactly, I was just thinking that also. Like in *Psycho* or something.	
29	A	Yes! Exactly!	
30	B	And soon the murderer comes from behind, behind the shower curtain	
31	A	Yes, that is all, that isn't all so …. well, objective and reliable. Instead it is full right away, from the beginning you are somehow …. led ……	
32	B	Yes.	
33	A	I find it ……. so dramatic.	
…			*B types, finishing the comment … a dramatic mood is produced by a shadowed and blurred title similar to in Hitchcock movies. Music: sets in suddenly and loudly, accentuates what the speaker says. "Crisis of gigantic dimensions." Intonation like in a propaganda speech.*

Note. Excerpts from a transcribed dyadic interaction between two learners. A = Learner 1; B = Learner 2.

whole sentence (line 13). A objects, because this is a comment rather than a title, but then accepts the proposition by suggesting that they add a comment instead of a title (line 14). B reacts to her prior objection and proposes a short title (line 15), A agrees while reflecting on their product as it is so far (line 16), and B writes the title

in the window and submits it. Then A initiates an evaluation of their joint selection together with B (line 17). B affirms on two levels (line 18): He answers the question with "Yes" and he proposes a technology-related action in the same line ("You have to click on 'Add comment'") to make the preliminary selection a final decision. In lines 19 and 20, there is some uncertainty about technology functioning (i.e., whether the selection is complete). Then when they determine that it is, in the second part of line 20 and line 21, a socially distributed production again covers both technology and content. B states, "That's all of it" (referring to their selection with the title), and A continues, "Yes …. that they showed emotion," referring back to B's earlier proposition (line 13) concerning the positive emotions of the people looking up in the air.

This episode of "hybrid talk" (Kafai & Ching, 2001) again exemplifies the mediating role of the video tool in collaborative learning through design. At the beginning of the episode A draws joint attention to the picture she would like to select. This initiates negotiations of meaning. Then WebDIVER is used as a group memory in order to save a preliminary decision that should not be lost and that might be revised later on. The short dialogue on title and comment shows how technology features can influence attempts at information structuring and can guide conversation during design. It is particularly interesting how complex the interplay of interactions between the members of the dyad and technology becomes at the end of the cycle: Here the explicit mentioning of the specific video editing features (e.g., mark, add comment) initiate content-related conversation, and this episode thus reflects the use of tool functions as support for mutual understanding in a joint problem space of design and content.

The episode in Table 7 shows a complex design cycle. In this episode, A seems to think aloud (line 1, Table 7) when the dyad is immersed in watching the newsreel. In doing so, she discovers a visual detail (line 1 "that headline … with the shadow behind it") and takes up conversation by asking for B's opinion and sharing her discovery with him (line 1). B follows her guidance and now notices the detail, too, stating that he had not noticed this before (line 2). A then draws attention to the voice on the audio track (line 3). B follows, again confirming her perceptions (line 4), and takes leadership in interpreting these film techniques (lines 4–6). Thereby he makes an important cognitive step "out" of the video: He compares the particular intonation of the voices speaking in the newsreel to "what people knew from Hitler's speeches." Thus, B takes up a critical stance and a historical perspective (seeing the newsreel "through the eyes" (or ears) of its original audience in 1948). A joins in by naming a similar example coming later in the newsreel and comparing the two instances within the video (line 7). So she, too, takes up a critical stance and engages in reflective thinking. In other words, the dyad has established common ground based on a small visual detail (shadow) as their referential anchor, which initiated their negotiations. This negotiation process leads to an act of design: In the joint production (lines 9 and 10) A and B make a design decision

to express their new knowledge in a new dive panel. A proposes a concrete video selection (line 9) and B affirms by defining the selection more closely ("from the beginning"). After that, they engage in a sequence of language and action (lines 10–21) when they collaboratively select their video sequence and create their new dive panel titled "Beginning." B creates a comment within the dive panel, where the visual detail discovered before is to be described (lines 22–24). During this, B recapitulates their former perceptions based on the segment they have created upon A's agreement (lines 24–26), whereas A initiates another cognitive step out of the video by reflecting on issues of style and genre. She makes a new proposition based on the same segment in comparing the technique of that particular newsreel scene to Hitchcock's style (line 27), thereby taking a new critical stance. B affirms and specifies A's interpretation, remembering a specific scene in a Hitchcock movie (line 28, "like in *Psycho*"; and line 30, "and soon the murderer comes from behind"). A then summarizes their interpretations and brings the conversation back to the style of the newsreel (line 31). B follows (line 32), and they capture their prior conversation in a nutshell by writing and adding a comment (line 33).

The design cycle that becomes evident in this episode is framed by the moments of guided noticing in the beginning of the episode and the joint design act of creating a dive panel and a comment at the end. We can see embedded in this cycle how selected video details provide conversational anchors for further comparison and content elaboration. We find, too, how video selections serve as segments to establish common ground (Clark & Brennan, 1991) during interpretation, reflection, and design.

In this episode, two instances of learning occur. First, we find an instance of critical reflection with historical perspective determining the results in the creation of a new dive panel. Second, we find how genre comparisons are realized and expressed in the production of the comment. In the first sequence, the dyad focuses attention within the newsreel on a visual detail (shadow behind the title) and elaborates on it. A dive panel is created to select from the newsreel video (and thereby store) what the focus of the dyad's attention was and their conversation before—almost like "freezing" a joint focus of attention by means of recording and display technologies in order to have it available and to share it with a future audience.

The second learning sequence in this episode is initiated by the assigned task of adding a comment. The dyad focuses attention *within* their selection (in the dive panel) on a visual detail (shadow), and from this referential anchor a conversation unfolds that leads to critical reflection on the video source and, finally, a written summary.

In sum, the episode provides an example of segmenting and comparison and shows how—from a visual detail—new ideas are developed in taking a critical stance toward the newsreel. We see in the episode selected from Case 2 how the

dyad working on the same sequence in the other condition fails to develop such knowledge.

Case 2: "Let's Go On!": Conversation With Limited Results

The episode from Case 2 shows how the dyads in the video player & text condition used their environment to perform the collaborative design task. Episode 2-1 exemplifies how the dyad analyzed the same sequence that led to collaboration, meaning making, and a design cycle in Case 1 (see Episode 1-3 in Table 7).

In the episode from Case 2, C and D watch the newsreel and C asks D to stop the newsreel to talk about it (line 1, Table 8). D stops and starts recapitulating what she perceived in the scene they have just watched (the written and spoken film title "Berlin in Crisis," line 2). C continues the production by guiding shared attention to the music and by sharing her interpretation of the music as being dramatic (line 3). D confirms and guides joint attention back to her former perception (the word *crisis* in the film title, line 4). C sort of objects by putting into question whether they should interpret every single word (line 5). D ignores her objection by repeating part of the film title and asking C what the speaker has said in the newsreel (line 6). C responds by trying to remind herself and then suggests that they watch and listen again (line 7). D affirms by her action (replaying). When they repeat the scene, D discovers a picture in the video she finds interesting and suggests a preliminary selection to comment on (line 8). C affirms but goes on to exclude another picture in the scene (line 9). D suggests a possible comment (line 10), points to the respective picture in the newsreel, and goes ahead writing the comment down in the text editor. The scene continues playing. D repeats her previous suggestion (line 12)—without uptake. C answers by guiding attention to another point in the scene, suggesting a new comment (line 13). D takes up her suggestion, refining and completing it in a joint production (line 14), and writes down her own suggested comment, to which C agrees (line 15). D shares her further inferences (line 16), and C joins in, continuing the production by repeating what the speaker has just said in the newsreel (line 17). They seem to get immersed in the newsreel and in their interaction when D repeats her proposition, interprets it (line 18), and finally writes it down. C apparently enjoys the "immersive" situation and expresses her feelings by laughing and stating that it is fun (line 19). D is still involved in writing and worries about structuring their text (line 20). C guides shared attention to the audio, namely her perception of aggression in the speaker's voice (line 21). D kind of affirms, writes down what the speaker said, and follows the previous thoughts of C (line 22) when she compares the speaker's words to a newspaper headline. In lines 23–30, they try to find the right word for their comment (or punchline), but they cannot find it. D writes the comment down using "headline," and they decide to go on watching the newsreel.

TABLE 8
Episode 2-1: "Let's Go On!"—Conversation and Guided Noticing, But No Group Result

The dyad starts with the analytical phase of the collaborative process. In the text editor, the text "Title Berlin in Crisis" already appears. B and C watch the newsreel from the start.			
1	C	Stop! Let's stop, let's stop! We have …	*Stops the film at 0:22*
2	D	"The Berlin Crisis" is the title, right?	
3	C	Then the music, this dangerous, dramatic music	
4	D	Exactly, wait crisis …. is already …. crisis …. is already a very strong word. And then	*Types, adds a colon*
5	C	So somehow, … whether we analyze every word?	
6	D	In crisis, and then, what did he just say? Of certain dimensions?	
7	C	Yes, terrible or something. Yes. We can look at that again. Rewind again	*D clicks several times, starts the video from the beginning*
8	D	OK that's good	
9	C	Yes, now, we don't need that	
10	D	View of Berlin	*D points to the monitor and then begins to type "View of Berlin"* *They watch a scene of the film.* *Music and a speaker in the film are heard.*
11	C	Ah	
12	D	Crisis	
13	C	City, Berlin, people?	
14	D	View of the city of Berlin, everyday life, I would say	*Types "View of the city of Berlin, everyday life"*
15	C	Exactly, everyday life!	
16	D	Everyday life, everything is still fine, but the crisis is coming soon	
17	C	Crisis of gigantic dimensions	
18	D	of gigantic dimensions, gigantic, oh, these adjectives	*Types "Crisis of"*
19	C	That's fun, isn't it?	*(Laughs)*
20	D	I don't know why … dimensions. Even the speaker now, … everything, we have to sort it all out later, don't we? So I would say let's write everything down and then we'll sort it out later. Speaker: (reads the typing)	*Types "gigantic dimensions"*
21	C	And he is so aggressive	
22	D	He is …. yes, of course, pause, OK, Berlin, pause, is like a slogan. He says it like a newspaper headline, Berlin, pause, and then comes that "of gigantic dimensions" in other words newspaper headline	*Types "Speaker: Berlin—pause"*

(continued)

TABLE 8 (*Continued*)

23	C	It's called slogan?	
24	D	What's it called then? Not slogan, but a title	
25	C	Hm?	
26	D	What do you call it then? Like the ….	
27	C	Headline? Title line?	
28	D	Yes, like on the first page, exactly	
29	C	Headline	
30	D	Yes, I don't know um, like headline—punch title. I don't know. I can't think of the word. Punchline, like a headline, right? The first sentence isn't a real sentence. ….as if …. Let's go on	*C points ahead, types "Like newspaper headline"*
They watch a new film sequence.			

Note. Excerpts from a transcribed dyadic interaction between two learners. C = Learner 1; D = Learner 2.

The episode starts with an apparent attempt to initiate collaboration by C, who asks to stop the video. D answers by taking over leadership and drawing joint attention to the text (film title), while C follows at first but quickly guides attention to the music. D does not take up C's proposition but sticks to her own thoughts. C openly objects, but D kind of insists and C follows. However, they seem to have lost track of what was said in the newsreel, and they decide to watch and repeat the scene again. The mutual attempts of both members to take leadership in focusing joint attention are not successful. The dyad cannot agree upon a common referential anchor for reaching common ground. They cannot build upon common ground and have to start over again. No text product results from this discourse.

A second attempt starts with line 10 of Table 8, when D points to the screen. This time the dyad is more successful. They elaborate on how the newsreel visualizes everyday life in postwar Berlin, and, based on this referential anchor, they make inferences, interpret the use of language by the speaker ("these adjectives") and finally write down their comment to share it with their future audience. When they are done with this, however, another problem arises: They have to worry about the structure of their text product. They delay solving this new problem and concentrate on their text, taking it as an anchor to build upon. They elaborate on the "aggressiveness" of the speaker's voice, thus critically reflecting on the newsreel. This approach—successful at first—ends abruptly when the dyad struggles with finding the right word to express their interpretation. They finally give in and take a word that fits roughly but is not the word that they are searching for.

The episode shows that the dyad tries to collaborate—even tries to engage in a perception–action cycle—but is limited in reaching common ground. In their first

attempt, they have obvious difficulties finding a suitable referential anchor for further meaning making. They do not discover any concrete visual details and decide to proceed in a text-centered manner, which may add to their difficulties. In their second attempt, once they refer to a visual element, they can use it as their anchor and obviously enjoy it (at least C does). However, a new limitation becomes obvious that hinders further interpretation: They have problems putting their selection and interpretation into "substance" and explicitly miss a structure to integrate their knowledge immediately. As a result, some ideas emerging from the conversation get lost, for example the interpretation of what the speaker says and how he says it in an aggressive voice. This discovery is not summarized in the text. Instead, as can be seen in the excerpt, the text items of this dyad end up being mere repetitions of what is said in the newsreel. They thus remain at a surface level and hardly reveal any deeper interpretations.

In sum, the selected episodes from the design processes reveal direct effects of video tools on conversation that favor the collaborative video condition for facilitating the achievement conversational common ground, making the dyads' collaborative design with video more productive.

DISCUSSION

The empirical research presented in this article contributes to researchers' understanding of the mediating role of digital tools in collaborative learning through design with videos. In an initial learning lab experiment, we developed a video-based design task for history education. We compared a collaborative video editing tool to a basic video playback tool combined with a word processor in reorganizing the system of learner activities. We investigated the following questions:

1. In what ways and to what extent does a collaborative video editing tool enhance learning in a design task compared to a video playback tool with a word processor?
2. Which specific features of a collaborative video editing tool support differences in collaborative processes that may explain differences in learning outcomes?
3. Which specific sociocognitive processes can explain the learning influences of uses of collaborative video editing tools?

The study reveals meaningful results in answering these questions. Our overall results indicate that students learned more with a collaborative video editing tool than with a video player combined with a word processor, with effect sizes ranging from 0.9 to 2.0 for the different outcome variables. These results demonstrate that, within the parameters of our experimental design task, the segment-

ing, editing, and annotation capabilities of the collaborative video editing tool had positive effects on understanding of and reflection on the video content as well as on the improvement of cognitive skills (such as critical film analysis skills). The design products revealed that the dyads in the collaborative video condition worked with fewer video selections that were, however, more precise, and that they reordered their selections more often than the dyads in the video player & text condition. In other words, the dyads in the collaborative video condition designed their products with more independent structure than in the source video, whereas the students in video player & text condition adhered to the existing narrative structure of the source video. Case studies illustrate how the collaborative video editing tool made it easier for dyads to achieve conversational common ground, making their collaboration more productive. The dyad supported by the segmenting and editing capabilities of the collaborative video tool could use technology features to create segments, annotate them, and design their sequential interrelationships. The participants explicitly referred to technology features during content-related conversation and interacted in a more meaningful way when talking about the newsreel. The selected episodes from Case 1 exemplify the mediating functions of the collaborative video tool during design cycles with joint attention to visual details and successful interpretation (e.g., taking a historical perspective in response to isolated film elements) that results in a group product (comment, dive panel, or both). In contrast, the dyad working with the video playback tool tried to establish common ground but did not succeed: Either the conversation did not result in deep elaboration at all, or, if it did, the members missed a structure to keep the results of their elaboration during conversation. The case studies thus reveal two important features of the distinctive mediating functions of these video tools: (a) Segments enable comparisons, and (b) having segments makes it easier for dyads to create common ground in learning through design.

What can we conclude from the specific findings of our experiment for the broader field of the learning sciences? In terms of a science-oriented conclusion, we can state that our evidence supports the validity of theoretical assumptions about mediating tool functions for shared knowledge construction in collaborative processes (Roschelle, 1992; Stahl, 2006). We applied the specific assumptions suggested by Suthers and Hundhausen (2003) about mediating functions of representations for collaboration to our case of video tools used in complex design tasks: (a) initiating negotiations of meaning, (b) facilitating deixis, and (c) providing a group memory. We found that how learners used the affordances of an advanced video editing tools enhanced collaborative learning through design as predicted when compared to a simple video tool. This is a step toward improving scientific understanding of tool-supported knowledge construction. The results imply, too, that the mediating functions of video tools can be used as supports for constructionist and design-based learning.

Closely related to this scientific conclusion is a practice-oriented conclusion that we may derive from our evidence. Knowing that advanced video tools can support collaborative learning through design and cognitive skills development, we can encourage timely establishment of learning environments to support student learning and achievement in visual design tasks *in the classroom*. In light of Web 2.0 participatory cultures, schools—especially in the domains of history, politics, ethics, language, and media education—are challenged to provide opportunities for youth to participate and to work with modern digital media. As Jenkins et al. (2006) put it:

> Schools as institutions have been slow to react to the emergence of the new participatory culture; the greatest opportunity for change is currently found in afterschool programs and informal learning communities. Schools and afterschool programs must devote more attention to fostering what we call the new media literacies: a set of cultural competencies and social skills that young people need in the new media landscape. (p. 4)

Based on our evidence we can expect that working creatively with advanced video tools, for example in middle school history lessons, in language arts, or in media education, can help to develop such new media literacy skills in students. The design task we developed is an example of how to design productive ways for nontraditional learning with video tools in a real "noisy" classroom. Nevertheless, experts will need to know far more. Although the lessons researchers in the learning sciences have learned with older media might extrapolate to new media and offer valuable guidance, field studies are needed that address specific questions such as the following: *How can we productively use collaborative video editing tools for student teams? Which educational goals should be addressed, and how? What kinds of scaffolding support and informative assessments do teachers need to provide? What guidance can we offer educators for designing activities that leverage video tools for learning?* Further research to advance this line of inquiry would also be valuable for the study of *distributed* collaboration among youth and for domains of collaborative knowledge construction other than history and media studies. In this study, our learner groups were co-located, and conjectures about how the properties of video tools would influence learning processes and outcomes may be put to a more stringent test with distributed collaborative groups. Researchers are likely to find new design activity patterns when they investigate online groups or Web communities of students using collaborative video editing tools (e.g., on YouTube). Such results will be especially important, too, considering that new media and advanced video platforms are becoming widely available and spread as new important forms of social communication in youth culture (e.g., Jenkins, 2009). Research on the learning potentials of advanced video tools will

remain an exciting and challenging field in the learning sciences, and we hope to stimulate additional inquiry with our contributions from the present study.

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