Digital Media in the Classroom: A Study on How to Improve Guidance for Successful Collaboration and Learning in Student Teams

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Abstract: Digital video technologies provide a variety of functions to support collaborative knowledge construction. Yet, for novice learners, positive outcomes also depend on effective guidance of group interactions. In this paper, we present empirical evidence for the use of web-based video tools to support students' collaborative learning in a history class. In an experiment with 16-year old learners (*N*=148) working with a history topic, we compared two contrasting types of guidance for student collaboration in dyads (cognitive task-related guidance or social interaction-related guidance). We also compared two types of video tools. Both types of guidance and tools were aimed at supporting students' active, meaningful learning and critical reflection. Results indicate that social interaction-related guidance was more effective in terms of learning outcome (e.g., critical reflection skills) than cognitive task-related guidance. The different tools did not yield significant differences in learning. The practical implications of these results are discussed.

Introduction

Computational technology and digital media can greatly enhance the possibilities for creative knowledge construction in social learning situations. However, there are open questions related to guidance of group interactions in desirable directions, especially when novice learners face complex authentic learning tasks: For example, a major concern expressed from the instructional perspective is how instructive guidance should be designed in accordance with human cognitive functioning (e.g., Kirschner & Sweller, 2006). In addition, CSCL research has emphasized the necessity of considering the complex relations between tasks, tools, interaction processes and learning outcomes (e.g., Van Drie, Van Boxtel, Erkens, & Kanselaar, 2003). In our contribution, we tap into these issues by examining the example of digital video technologies used for collaborative knowledge construction in a classroom setting. Specifically, we investigate in an experiment *how* instructive guidance can be balanced for middle-school students in order to support skill-intensive socio-cognitive processes during a short collaborative design task for history learning with different digital video tools.

The potential of digital video technologies reaches far beyond the dynamic presentation and illustration of visual information. With digital video tools, learners may zoom into and out of digital video sequences, they may insert hyperlinks into videos in order to relate visual information to other instructional materials, and they may arrange video sequences for discussion and reflection. Such functions are expected to afford, for example, detailed observations (e.g., Smith & Reiser, 2005), multiple perspectives (e.g., Goldman, 2004) or the understanding of complex concepts in ill-structured domains (Spiro, Collins, & Ramchandran, 2007). The affordances of digital video technologies can be restructured for youthful learners in classrooms, so that students can either create their own representations (e.g., multimedia documents) or arrange video contents in order to understand and explain complex subject matter (Zahn, Pea, et al., 2005). This usage, in the sense of *learning through design* (e.g., Kafai & Resnick, 1996), goes far beyond teacher-centered approaches where videos on curriculum topics are only watched by individual learners or in whole-class models.

Over the last several years, we have investigated collaborative design with video tools. Evidence from our experimental studies has indicated that specific affordances of video tools (e.g., of WebDIVER^{TM}, Pea, et al. 2004), when employed in design tasks for history learning, can support learners' social interactions to become more productive than those performed with simple technological solutions, resulting in improved learning outcomes (e.g., Zahn, Pea, Hesse & Rosen, 2010). Yet, initial field studies with 16-year-old students (Zahn, Krauskopf, Hesse, & Pea, 2010) showed that the positive effects of video tools were sometimes limited to an "action-level", and students would have needed more guidance to optimize their collaborative design process. This finding is consistent with findings from Barron (2003) showing that student groups can have problems engaging in productive knowledge-building conversations during video-based mathematics problem solving. It is also consistent with related evidence showing that collaborating students need help in organizing, planning and conducting scientific inquiries (Edelson, Gordin, & Pea, 1999), in scientific argumentation (Kollar & Fischer, 2004) and in accomplishing scientific design projects (Kolodner, et al. 2003).

Two sources of problems can hinder productive socio-cognitive processes when students perform design tasks with digital video tools: The complexity of collaboration with *video tools* and the complexity of collaborative *design.* We have demonstrated in prior research how specific video tools can influence collaborative learning (e.g., Zahn, Pea, Hesse & Rosen, 2010). In the present study, we take into account their *differential* complexity (Zahn, Pea et al. 2005) when they are used as design tools for learning. *Design* tasks generally consist of creating and structuring content for an anticipated audience according to the aesthetic standards of the media at hand. They include the setting of design goals and complex processes of knowledge transformation, as was proposed earlier by related cognitive research (e.g., Bereiter & Scardamalia, 1987, Goel & Pirolli, 1992; Hayes, 1996). According to Détienne (2006) *collaborative* design includes the management of task interdependencies and of multiple perspectives. Correspondingly, design activities relate to the levels of the design problem/design solution and group cooperation. Moreover, when designers use complex and sometimes unfamiliar *digital tools* (video tools in our case), they coordinate their collaboration by establishing a social problem space that is distributed over the cognitive systems of at least two people *and* a digital artifact, creating new coordination problems familiar in distributed cognitive systems (Streek et al., 2011). Based on this shared context, they negotiate their choices of design goals and their understanding of content, task schemas, genre knowledge, and task relevant strategies (as in *collaborative writing*, e.g., Lowry, Curtis, and Lowry, 2004). The importance of the shared (multimodal) context for design was repeatedly emphasized (Détienne, 2006).

Consequently, although designing video or other artifacts with digital tools is highly desirable for students, because it is cognitively engaging, students may sometimes be cognitively overwhelmed by the complexity of having to find a design solution, manage the group and use an unfamiliar digital tool. They actually may need guidance throughout the process so that learning through design can take place. Based on previous research on the nature of design (e.g., Détienne, 2006), we might provide such guidance, tackling either *cognitive design task*-related issues or *social interaction*-related issues (similar to Fischer et al.'s (2002) distinction of *content-specific* and *content-unspecific* instructional support or Weinberger et al.'s (2005) *epistemic* vs. *social scripts*). It is still open whether guiding students' design activities or their social interactions would lend important support for successful task completion - or whether students might feel restricted by too much guidance and be impeded in their creativity and learning. Also, the mediating role of the digital video tools for collaboration under such conditions is quite unclear. Hence, in our study, we compared the two forms of guidance using two types of video tools, and we explored whether interactions would occur.

Experimental Study

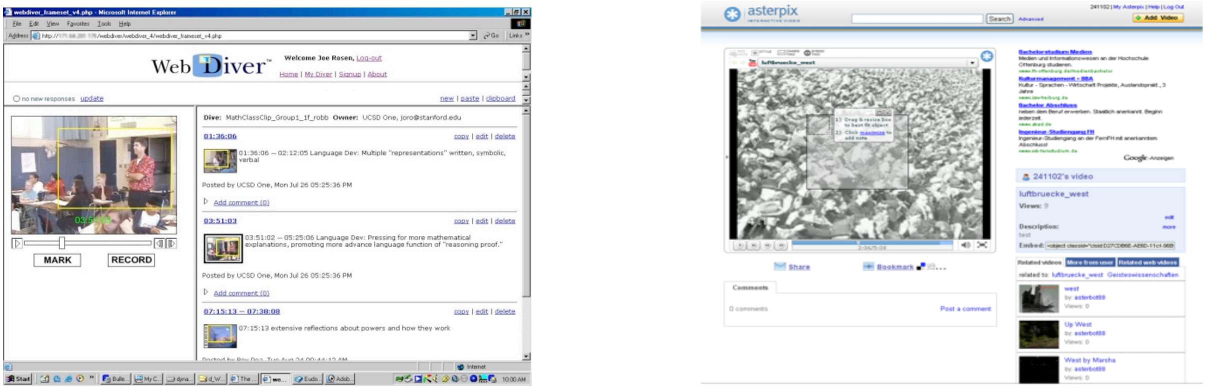
Method

Participants: 148 students (81 male, 65 female, 2 no answer) from four different German high schools located in Southwestern Germany participated in the study. Their mean age was M = 16.2 years (SD = 1.0). Prior to the study we obtained written consent from the students' parents and the school administration. The sample size varies minimally (see Tables 1 to 3), due to problems with data availability from stored design products and video taped interactions.

Study design: The study was conducted in a computer classroom set up at our institute. Classes accompanied by their respective teachers came to the institute on regular school days and as part of their regular history curriculum. Upon arrival they were randomly grouped into dyads and assigned to one of the four experimental conditions of a 2 x 2 study plan. The first factor *Guidance* (cognitive design-related vs. social interaction-related) determined which type of instructive guidance was provided to support the collaborative accomplishment of a visual design task: guidance either emphasizing the cognitive aspects of the design task (e.g., setting a design goal, planning a design concept, tailoring information *for an audience*), or guidance focusing on smooth collaboration (e.g., developing *common* ground about design goals, and design decisions, determining *communication* rules for discourse practice). The second factor *Video Tool* determined whether the students worked with WebDIVER^{TM} (Pea, et al., 2004) or Asterpix as their design tool: The tools differed on a generic level in either supporting collaborative analysis (WebDIVER tool for guided noticing) or collaborative linking of information (Hypervideo tool Asterpix). With WebDIVER, learners' cognitive/collaborative analysis is heightened by their ability to zoom into and out of digital video sequences, and arrange digital video sequences for discussion and reflection. With the Hypervideo tool Asterpix, the collaborative ability to insert new knowledge artifacts into an existing digital video is heightened by hyperlinks relating visual information to other materials. All other circumstances were kept constant across conditions.

Task: A visual design task based on a historical newsreel was employed. This task had been carefully developed for the purpose of studying computer supported history learning with digital video tools in a realistic classroom (e.g., Zahn, Krauskopf, Hesse & Pea, 2010). It follows central educational goals in the domain of history in German middle school education (Krammer, 2006). Furthermore, it is theoretically founded in cognitive and collaborative frameworks of advanced learning and knowledge building approaches (e.g., Scardamalia, 2002). During this task, students work on a newsreel about the Berlin blockade in 1948, so that it can be published, e.g., on a website of a virtual history museum. They are asked to analyze and comment on the newsreel so that future visitors of the virtual museum can develop a good understanding of both the content and the style of the newsreel as a propaganda instrument. To accomplish the task, the students can use a collaborative video tool (see Tools section). The constructive activity of designing content for a web page of a virtual history museum provides learners with a framework for comparison and re-organization of knowledge, as they produce their own ideas and work creatively with them. During the collaborative design process, it is assumed that learners appropriate the video content to their own thinking purposes and develop advanced thinking skills. The learning goal and a special challenge for the students is to understand that the newsreel is not only "showing" the history topic (Berlin 1948), but that the newsreel itself *is* a history topic (i.e., a newsreel as an historical means for propaganda). In other words, historical content knowledge is closely intertwined with developing advanced thinking skills (Scardamalia, 2002), like being able to analyze and critically reflect on video messages.

Materials and Tools: The video used in the visual design task is a digitized version of an historical newsreel originally produced by the Allied forces (US/Great Britain) and shown to the German public during the Berlin blockade in 1948. It covers news information about the airlift established in 1948 by the Allied forces when Russia tried to cut off Berlin from traffic of goods. It consists of 95 single pictures and lasts five minutes. The video used in the transfer task is a modern 65-second TV-Clip by the German Green Party (Buendnis 90/Die Gruenen) from the 2006 nationwide election in Germany. The texts used in the experiment contain 350-1500 words each. The content of the texts provides detailed information on three sub-topics: accounts of the historical context of Berlin in post-war Germany, information on media history and newsreels in post-World War II Germany, and a short introduction on film theory. Guidance was implemented in text-based form within the computer environment used for general task instruction. The texts differed between conditions in their descriptions of how one should best proceed to solve a visual design problem. The video tool used for computer-supported learning in the visual design task was either WebDIVER (see Figure 1a) or Asterpix (see Figure 1b). WebDIVER 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 for expressing points of view regarding precise spatio-temporal video areas of one or more source videos. Asterpix is a commercially available hypervideo tool. It is based on the idea of enabling users to select areas of interest and place graphical hyperlinks into a source video.



Dive: MathClassClip_Group1_1f_robb Owner: UCSD One, joro@stanford.edu

01:36:06

01:36:06 -- 02:12:05 Language Dev: Multiple "representations" written, symbolic, verbal

Posted by UCSD One, Mon Jul 26 05:25:36 PM

03:51:03

03:51:02 -- 05:25:06 Language Dev: Pressing for more mathematical explanations, promoting more advance language function of "reasoning proof."

Posted by UCSD One, Mon Jul 26 05:25:36 PM

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07:15:13 extensive reflections about powers and how they work

Figures 1 a and b. Graphical user interfaces of the collaborative (hyper-)video tools used in the study: (a) WebDIVER^{TM} (right), (b) Asterpix (left).

With the functions offered by WebDIVER, users can select either a temporal segment or a spatio-temporal sub-region 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 a video that they wish to feature, and then interpretively annotating their selection via a web interface. Each dive movie clip and its associated annotations is represented in a panel in the dive, and a remix of the video clips and annotations can be played to experience the dive. Asterpix was a Web 2.0 tool (http://www.asterpix.com/, no longer available) with functions based on the hypervideo idea: Users could isolate dynamic, sensitive regions within video materials, provide text commentaries to these regions and add links to other web resources. The links could further be discussed by means of an integrated e-communication tool. Thus, users could include their own annotations and knowledge in a video and share them with others in a group or community (cf. Zahn et al., 2005).

Procedure: A week before the students came to our lab, they filled in questionnaires that assessed their prior knowledge and other control variables. The *experimental* sessions consisted of the following steps: In Step

1 (preparation phase), the students individually read the overall instructions, including the different types of guidance (either guidance for effective design or guidance for effective social interactions during design). Then they read the history/media texts, and watched the video showing the historical Berlin-Blockade newsreel from 1948. They briefly practiced the use of the video tools to establish familiarity. In Steps 2, 3 and 4 (collaborative design and learning phase) the participants worked collaboratively in dyads at a computer. In Step 2 (planning), those students in dyads in the *social interaction*-related guidance condition were asked to write down the content they would like to cover in their design products and how they would like to coordinate their design work. Those students in dyads in the *cognitive design*-related guidance condition were asked which design goals they would aim for. In Step 3, the dyads were asked to design their product according to their initial ideas using either WebDIVER or Asterpix. In Step 4 (evaluation) the dyads were asked to evaluate the quality of their own products and teamwork. When students were done, they continued with Steps 5 and 6 (test phase), where self-assessment questionnaires and knowledge tests were completed individually. In Step 7, the participants individually accomplished a transfer task (TV-ad, see Materials section). They were then thanked and released and went back to their schools with their teachers. During the whole procedure, the teachers were present and tutors were also available for any questions or technology problems.

Measures: To assess prior background knowledge in the domain of history, computer expertise or expertise in film and media production, a pre-questionnaire (self-assessment) and a multiple choice knowledge test were administered. To assess the effectiveness of our text-based instruction as implementation of guidance (manipulation check), we asked the subjects to select a maximum of three alternatives from six statements about the task's characteristics (3 social characteristics, e.g., "one of the most important aspects of the learning unit was good communication" and 3 design characteristics, e.g., "one of the most important aspects of the learning unit was to design for a target audience"). To assess collaborative design performance, the design products created by the dyads with WebDIVER or Asterpix were analyzed. From these products, the following categories of data were obtained: "video selections/sensitive areas with comments", "style features commented", and "interpretations" in the comments. Additionally, dyadic interactions were captured with a webcam and a screen recorder (Camtasia Studio by TechSmith). The proportions of talking time in the categories "design planning", "design action", "design evaluation", "technical issues", "problems", and "off task" (related to total amount of talking time) were extracted from these video data using video analysis software (Videograph©). To assess treatment effects on learning outcomes, a post-test was administered, consisting of a multiple choice test measuring historical topic knowledge and a transfer task tapping advanced visual analytic skills. The multiple choice post-test consisted of 8 items. (Sample item: "At the beginning of 1946 Germany is... a) ...a unified nation, b) ...divided into four sectors, c)... divided into an Eastern and a Western part, d) ...divided into 16 Länder." The theoretical maximum of this test was 13 points, and it had a satisfactory internal consistency, Cronbach's $\alpha = .71$. The transfer task part of the post-test was assigned to reveal skills of critical analysis and reflection in response to a video message. It consisted of two questions relating to a political TV-ad from the 2006 nationwide German government elections. ("Please analyse the following video sequence by answering the questions 1) Which film techniques were used? 2) What might have been the intention of using them?"). The questions were open ended.

Results

We will first present results substantiating the comparability of our conditions, and then results obtained from quantitative analyses of the design products and post-tests. Due to assumed interdependence of students working in one dyad, we determined dyads as the unit of analysis and used data aggregated within dyads (cf. Kenny, Kashy & Cook, 2006). The level of significance for all analyses was set to .05.

Comparability of the conditions: 2 x 2 between subjects ANOVAs with the factors Guidance and Video Tool revealed no significant differences between the conditions concerning participants' age, prior experience with computers in general and video software in particular, their history grade, or their dispositional interest in history (all $p > .10$). The dyads also did not differ significantly between conditions concerning within-group composition related to age, gender, prior knowledge, history grade, or historical interest (all $p > .10$). In addition, student dyads did not differ in their appraisal of the task, the appraisal of their teamwork or the amount of invested mental effort during task work (all $p > .10$), indicating that the participants' overall positive attitudes towards task and performance were similarly high in the four conditions. In sum, the conditions can be considered comparable. However, historical knowledge showed a marginally significant interaction, $F(1, 68) = 3.86$, $p = .05$, partial $\eta^2 = .05$, showing that for students working with WebDIVER, those participating in the cognitive design-related guidance condition scored higher on the pretest ($M = 10.23$, $SD = 2.55$) than students in the social interaction-related condition ($M = 8.22$, $SD = 2.20$), $t(34) = 2.53$, $p = .02$. For students working with Asterpix, there were no significant differences. All ANOVAs reported here were also run as ANCOVAs controlling for interest in history and prior knowledge, and they are reported when they show different results.

Manipulation Check: The means and standard deviations of students' choices in the question tapping their understanding of the task are shown in Table 1. An ANOVA revealed no significant difference between conditions concerning their scores in "design task" characteristics, *F*s < 1, *ns*, but a significant difference for the "social task" characteristics for the factor Guidance, $F(1, 68) = 15.51$, $p < .001$, partial $\eta^2 = .19$. More "social task" items were chosen by students who had received social interaction-related guidance than by students who had received cognitive task-related design guidance. Our text-based implementation of guidance by task instructions can thus be considered effective for eliciting the students' awareness of the design problem in all conditions and the students' increased awareness of the *social* demands of the collaborative design task in the social interaction-related conditions.

Table 1: Means (*M*) and Standard Deviations (*SD*) for the manipulation check.

	Selective video editing tool (WebDIVER^{TM})				Integrative video editing tool (Asterpix)			
	CDG (*n* = 18)		SIG (*n* = 18)		CDG (*n* = 19)		SIG (*n* = 17)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Manipulation check – social	0.81	0.75	1.37	0.65	0.71	0.49	1.31	0.58
Manipulation check – design	1.44	0.65	1.30	0.49	1.40	0.63	1.40	0.62

Note. CDG = cognitive design related guidance, SIG = social interaction related guidance

Design Performance: The means and standard deviations of the scores of the dyads' design products concerning numbers of commented video selections, style features and interpretations are presented in Table 2. Interrater reliability for style features and interpretations were satisfactory, Cohen's $\kappa \geq .94$. ANOVAs revealed a significant main effect for the factor Guidance: The mean scores in all the mentioned indicators were significantly higher for the products of dyads in the condition with social interaction-related guidance, than for those from dyads in the condition with cognitive design-related guidance, in terms of *number of comments*, $F(1, 67) = 6.46$, $p = .01$, partial $\eta^2 = .09$, *number of style features*, $F(1, 67) = 4.78$, $p = .03$, partial $\eta^2 = .07$, and *number of interpretations*, $F(1, 67) = 4.63$, $p = .04$, partial $\eta^2 = .07$. Hence, design performance in the visual design task was higher in the social interaction-related guidance conditions than in the other conditions. No further main or interaction effects were found. Thus, the two forms of video tools were not used in different ways - at least in relation to the quantitative indicators of design performance we applied here.

Table 2: Means (*M*) and Standard Deviations (*SD*) for the quality indicators of students' design performance.

	Selective video editing tool (WebDIVER^{TM})				Integrative video editing tool (Asterpix)			
	CDG (n = 18)		SIG (n = 18)		CDG (n = 19)		SIG (n = 14)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Number of commented video selections	4.11	3.38	6.61	3.03	4.11	2.38	5.43	3.65
Number of style features	0.14	0.48	1.22	2.26	0.29	0.77	0.64	1.17
Number of interpretations	0.11	0.47	0.89	1.53	0.32	0.82	0.64	1.15

Note. CDG = cognitive design-related guidance, SIG = social interaction-related guidance

Historical Topic Knowledge: Analyses of the scores from the multiple choice post-test on knowledge about the history topic revealed a total mean score $M = 7.54$ ($SD = 2.46$) out of 13 possible points. We conducted a mixed 2 x 2 x 2 ANCOVA with the two between-subjects factors Guidance and Video Tool and the within-subjects factor Pre-Post-Test to test for differences in the gain in individual factual knowledge. After controlling for the differences in pre-test scores, the results still showed a significant increase in factual knowledge over time, $F(1, 67) = 34.80$, $p < .001$, partial $\eta^2 = .34$. However, there were no significant differences between the conditions, *F*s < 1, *ns*, and no significant interaction, *F*(1, 67) = 1.93, *p* = .17 indicating that the students in both conditions had developed an understanding of the historical content.

Critical Analysis and Reflection: The students' written answers to the transfer task questions were coded independently by 2 raters. For the coding procedure, coders considered a pre-defined default solution created by an expert in visual media production (first author of this paper). The solution comprised exemplary stylistic features used in the TV-ad (e.g., camera, music, montage), as well as examples for correct interpretations of such elements (e.g., close-up of a person's face aims at creating emotional involvement). Based on this example, raters counted the number of named style features and interpretations. Also, the elaborateness of the answers was rated on a 3-point Likert scale (1 = simple, 3 = elaborate). Interrater reliability was satisfactory for the number of style features, Cohen's κ = .91, and the elaborateness rating, Cronbach's α = .80. However, rater agreement for the number of interpretations of these style features was very low, Cohen's κ = .10. Closer analyses revealed that the raters differed greatly with regard to how strictly they applied the coding scheme. For further analyses we decided to only use the coding of the more conservative rater. The analysis of the transfer test results revealed a total average of *M* = 1.97 (*SD* = 0.74) for "number of style features", *M* = 0.37 (*SD* = 0.23) for "number of interpretations" and *M* = 1.19 (*SD* = 0.47), and for "elaborateness of the answer". ANOVAs revealed that the means (see Table 3) of all these indicators were significantly higher in the answers of students in the conditions with social interaction-related guidance, than in the conditions with cognitive design-related guidance: *number of style features*, *F*(1, 68) =7.96, *p* = .01, partial η^2 = .11, *number of interpretations*, *F*(1, 68) = 4.36, *p* = .04, partial η^2 = 06, *elaborateness of the answer*, *F*(1, 68) = 4.11, *p* = .047, partial η^2 = .06. Overall, effect sizes were of medium to large size. There were no effects of the video tool factor, *F*s < 1.1, *ns*, or any significant interactions, *F*s < 1, *ns*. Thus, although all students developed a comparable understanding of the topic, the learning outcomes in terms of advanced thinking skills (critical analysis and reflection) were higher when social interaction was supported in the student dyads.

Table 3: Means (*M*) and Standard Deviations (*SD*) for the tests tapping factual knowledge and indicators of the transfer task.

	Selective video editing tool (WebDIVER™)				Integrative video editing tool (Asterpix)			
	CDG[b] (*n* = 18)		SIG[c] (*n* = 18)		CDG (*n* = 19)		SIG (*n* = 17)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Transfer test – critical analysis and reflection								
Number of style features	1.77	0.63	2.37	0.51	1.72	0.78	2.06	0.87
Number of interpretations	0.34	0.23	0.43	0.26	0.30	0.21	.42	0.19
Elaborateness of the answer	1.09	0.35	1.31	0.40	1.08	0.44	1.31	0.63

Notes. [a]Theoretical maximum = 13. [b]CDG = cognitive design-related guidance, [c]SIG = social interaction-related guidance.

Dyadic Interactions: For analyses of dyadic interactions, we coded the proportions of time students were engaged in activities belonging to one of the categories "design planning", "design action", "design evaluation", "technological issues", "problems" and "off task" (related to total amount of talking time, *M* = 21.52 minutes, *SD* = 4.46). 20% of the videos were coded by a second rater and agreement was on average satisfactory, median of Cohen's κ = .64. However, 2 x 2 ANOVAs with the two between-factors Guidance and Video Tool yielded no significant differences between the conditions (see Figure 2). Further analyses on a more fine-grained level are ongoing and will be available at the time of the conference.

Discussion

Our results provide evidence from an experimental study that helps to answer the question of how to improve guidance for student teams solving a complex authentic design task for history learning with the support of web-based video tools. Results indicate that while using either of the advanced video tools we offered was generally effective, differences in the types of guidance we implemented (*cognitive task*-related vs. *social interaction*-related guidance) resulted in different learning outcomes. Firstly, the immediate design products of the dyads' task work were of better quality. Secondly, individual students scored significantly higher in a transfer test evaluating critical analysis and reflection skills. Concerning factual knowledge about the topic ("Berlin blockade"), no differences and no trade-off effects in performance in a multiple-choice posttest emerged. Moreover, during the students' dyadic interactions, similar amounts of time were devoted to the subtasks "design planning", "design action", "design evaluation", "technical issues", "problems" and "off task" behavior in all conditions. Thus, the differences in the transfer test were neither at costs of other learning outcome measures, nor could they be explained by a first (superficial) analysis of specific students' interaction time spent on task. This finding was not confined to a specific tool used in our study: Results show that given the conceptual differences of the video technologies (WebDIVER and Asterpix) described above, the benefits of supporting the social problem space persist. We thus conclude that the dyads with social interaction-related guidance learned *more* than the dyads with cognitive task-related guidance, and we conjecture that even given different affordances for the two video tools, social interaction-related guidance improved the quality of dyadic interactions on a deeper content level. And this leads us to the question of *how exactly* that quality was improved. In a next cycle of analyses we will investigate differences in the content of dyadic interactions and be able to present the first results by the time of the CSCL conference. These findings will add further answers to the question of *how* instructive guidance can be balanced for middle-school students in order to support skill-intensive socio-cognitive processes.

When interpreting the results reported here to draw conclusions for school practice, we need to consider the following issues: In this study we created a highly controlled, computer-supported experimental setting, thereby enabling us to draw causal conclusions. We exposed students to a short-time visual design task for a regular history lesson, which is different from large design projects performed over several weeks. So the results cannot be generalized to such projects. However, we compared our results from this experiment with the results from an earlier field study in a real, "noisy" classroom situation with a comparable sample of students and with the same short task and test items (Zahn, Krauskopf, et al. 2010). Results revealed general gains in factual knowledge (pre- to post-tests) similar to those obtained in the field. No indications of influences of the artificial experimental situation (positive or negative) were found. From the analyses, we may thus conclude that students of the age group investigated here seem to have sufficient working patterns for completing short design tasks (establishing a design problem space), but not necessarily for social interaction (establishing a social problem space). This might be the case because design tasks are often used in school-based education and students are familiar enough with them to perform the necessary activities. However, they seem to be less able to activate effective ways of team interaction from their everyday school experiences. In other words: Guidance repeatedly emphasizing the aspects of design problem solving thereby focusing on the design product may *not* improve the learning addressed here, but guidance improving collaborative activity (coordinating teamwork and communication) can. For design-based interventions such as this, the result may be somewhat unsurprising, but certainly worth highlighting. The strength of the social interaction-related guidance described here is such that it calls for further analysis across a broad range of collaborative learning environments. For teachers this issue would be important in practice if, indeed, their guidance of students' collaborative task work in real lessons were focused on social interaction processes. This perspective is consonant with related views across different domains and digital media (e.g., Barron, 2003) – and hopefully stimulates further CSCL research.

References

Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences 12* (3). 307-359.

Bereiter, C., & Scardamalia, M. (1987). The Psychology of Written Composition. Hillsdale, NJ: Lawrence Erlbaum Associates.

Détienne, F. (2006). Collaborative design: Managing task interdependencies and multiple perspectives. *Interacting with Computers*, *18*(1), pp 1-20.

Edelson, D.C., Gordin, D.N. & Pea, R.D. (1999). Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design. *The Journal of the Learning Sciences, 8* (3&4). 391-450.

Fischer, F., Bruhn, J., Gräsel, C. & Mandl, H. (2002). Fostering Collaborative Knowledge Construction with Visualization Tools. *Learning and Instruction 12.* 213-232.

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

Goldman, R. (2004). Video perspectivity meets wild and crazy teens: Design ethnography. *Cambridge Journal of Education, 2*(4), 147–169.

Hayes, J.R. (1996). A new model of cognition and affect in writing. In M. Levy & S. Ransdell (Eds.), The Science of Writing. (pp. 1-27). Hillsdale, NJ: Erlbaum.

Kirschner & Sweller (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist Discovery, Problem-Based, Experiential, and Inquiry-based Teaching. *Educational Psychologist, 4*(2). 75-86.

Kafai, Y. B., & Resnick, M. (Eds.). (1996). *Constructionism in Practice: Designing, Thinking, and Learning in a Digital World* (pp. XII, 339 S.). 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^{TM} Into Practice. *Journal of the Learning Sciences*, 12, 495-547.

Kollar, I., Fischer, F., & Slotta, J. D. (2007). Internal and external scripts in computer-supported collaborative inquiry learning. Learning & Instruction, 17(6), 708-721.

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.

Pea, R., Mills, M., Rosen, J., Dauber, K., Effelsberg, W., & Hoffert. E. (2004, Jan-March). The DIVER™ Project: Interactive Digital Video Repurposing. *IEEE Multimedia, 11*(1), 54-61.

Pea, R. D. (2006). Video-as-data and digital video manipulation techniques for transforming learning sciences research, education and other cultural practices. In J. Weiss, J. Nolan, J. Hunsinger, & P. Trifonas (Eds.), *International handbook of virtual learning environments* (pp. 1321–1393). Dordrecht, The Netherlands: Kluwer Academic.

Scardamalia, M. (2002). Collective Cognitive Responsibility for the Advancement of Knowledge. In B. Smith (Ed.), Liberal Education in a Knowledge Society (pp. 67-98). Chicago: Open Court.

Smith, B., & Reiser, B. J. (2005). Explaining behavior through observational investigation and theory articulation. *Journal of the Learning Sciences, 14*, 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. D. Pea, B. Barron, & S. Derry (Eds.), *Video research in the learning sciences* (pp. 93–100). Mahwah, NJ: Erlbaum.

Streeck, J., Goodwin, C., & LeBaron, C. (2011, in press) (Eds.). *Embodied interaction: Language and body in the material world*. Cambridge: Cambridge University Press.

Van Drie, J., Van Boxtel, C., Erkens, G., and Kanselaar, G. (2003). Supporting Historical Reasoning in CSCL. In B. Wasson, R. Baggetun, U. Hoppe, & S. Ludvigsen (Eds.), *Designing for Change in Networked Learning Environments. Proceedings of the International Conference on Computer Support for Collaborative Learning - CSCL 200*3, (pp. 93-102). Bergen, NO: InterMedia.

Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer-supported collaborative learning. *Instructional Science, 33*(1), 1-30.

Zahn, C., Pea, R., Hesse, F. W., Mills, M., Finke, M., & Rosen, J. (2005). Advanced Digital Video Technologies to Support Collaborative Learning in School 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, NJ: Lawrence Erlbaum.

Zahn, C., Pea, R., Hesse, F.W. & Rosen, J. (2010). Comparing Simple and Advanced Video Tools as Supports for Complex Collaborative Design Processes. *The Journal of the Learning Sciences. 19*(3). 403-440.

Zahn, C., Krauskopf, K., Hesse, F.W. & Pea, R. (2010). Digital Video Tools in the Classroom: How to Support Meaningful Collaboration and Critical Thinking of Students? In: M.S. Khine & Saleh, I.M. New Science of Learning: Computers and Collaboration in Education. New York: Springer.