Facilitating Web Design Skills through Online Design-Based Learning: The Case of Collaboration Scripts and Incomplete Concept Maps

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Abstract: Web design skills are an important component of media literacy. The aim of our study was to promote university students' web design skills through online design-based learning (DBL). Combined in a 2x2-factorial design, two types of scaffolding were implemented in an online DBL environment to support the students through their effort to design, build, modify, and publish web sites on processes and outcomes measures, namely collaboration scripts and incomplete concept maps. The results showed that both treatments had positive effects on domain-specific knowledge acquisition and on content-related discourse quality and collaboration skills in a subsequent discussion. There was synergism between the two scaffolds in that the combination of the collaboration script and incomplete concept maps produced the most positive results. To be effective, online DBL thus needs to be enhanced by appropriate scaffolds, and both collaboration scripts and incomplete concept maps are effective examples.

Web Design Skills as a Component of Media Literacy

Media literacy has become an important competence in our society (Piette & Giroux, 2001). It concerns the competence to both critically analyze media and to create messages in a wide variety of forms (e.g. print, audio, video, and multimedia; Hobbs, 1998). Designing web content is one important component of media literacy, which however receives little attention in college and university education as reflected by empirical evidence showing that web design skills of university students are not very high (e.g. Shannon, 2008; Wallace & Clariana, 2005). In deed, web design is a challenging and complex process that requires learners to build complex web sites involving hyperlinked documents, different navigation systems, and social information spaces as well as to account for the possible needs, purposes, and abilities of different users (Spyridakis, Wei, Barrick, Cuddihy & Maust, 2005). In this study, we investigate how the acquisition of university students' web design skills can be supported in CSCL environments.

Facilitating Web Design Skills through Online Design-Based Learning

One promising approach to support students' acquisition of web design skills is Design-based Learning (DBL). DBL has been described as a combination of problem-based learning and inquiry learning and has gained wide-spread attention in the Learning Sciences (e.g. Fortus, Dershimer, Krajcik, Marx & Mamlok-Naaman, 2004; Kolodner, 2002). In DBL, students engage in design tasks such as building and creating computer programs, models, projects, etc. Engaging in such design processes is supposed to support learning of content knowledge as well as the acquisition of social and communicative, inquiry-related skills (e.g., communication, collaboration and problem-solving skills; see Kolodner, 2002). The design task is defined as an ill-structured problem that encourages students to engage in design-based discussions, which involves asking questions, searching and giving answers, evaluating answers and engaging in discussions about the content. Educational research has developed quite a number of different DBL-approaches such as Learning by Design (LBD; Kolodner, 2002), Design-Based Science (DBS; Fortus et al., 2004), and Engineering Competitions (Sadler, Coyle & Schwartz, 2000). In LBD, students go through two cycles of activities. One cycle concerns the *design* of the artifact (e.g., designing and building a miniature car that goes from one end of the classroom to the other), while the other focuses on the *investigation* of the designed artifacts by means of controlled experiments. In both cycles, activities on different social levels (individual, small groups, and plenary) are realized to help students acquire science knowledge and skills and to benefit from each others' comments and suggestions. We investigated if DBL can successfully be transferred to online learning and be used to facilitate the acquisition of web design skills. However, given the complexity of DBL, we were interested in whether students can benefit from further instructional support measures such as incomplete concept maps and collaboration scripts.

Supporting Online Design-Based Learning through Collaboration Scripts and Incomplete Concept Maps

As described, DBL requires students to engage in complex design processes and challenging investigation processes. In addition, when students work in small groups, they need to engage in high-level collaboration processes that seldom happen spontaneously (Cohen, 1994). Therefore, additional support during online DBL seems to be promising. There are at least two categories of scaffolding that have a certain potential to improve online DBL: (a) social scaffolding, that refers to the guidance and structuring of social interactions (Kollar, Fischer & Hesse, 2006), and (b) content scaffolding, that refers to conceptual support concerning the content of the task (Cox & Brna, 1995). Our study focuses on (a) computer-supported collaboration scripts as a realization of social scaffolding and (b) incomplete concept maps as a realization of content-related scaffolding.

Computer-supported Collaboration Scripts

DBL typically requires students to engage in collaborative learning activities through their investigation. In LBD, students collaborate in small groups to reach an understanding of the design task at hand, control and conduct the design process and related empirical investigations, and effectively communicate with other learning partners (Kolodner, 2002). Many studies have demonstrated that students often do not collaborate well and experience difficulties when supposed to engage in high-level collaboration processes (e.g., Cohen, 1994). If realized online, these problems may even be amplified. As a solution, collaboration scripts are considered powerful instructional interventions. They facilitate high-level collaboration processes by specifying, sequencing and distributing learning activities and roles among learners in a small group (Kollar et al., 2006). For example, Kollar, Fischer and Slotta (2007) demonstrated that collaboration scripts are able to improve collaboration processes and individual learning outcomes through structuring the interactive processes between learning partners. Moreover, collaboration scripts may facilitate communicative-coordinative processes between students and guide them through complex learning processes (Haake & Schümmer, 2003; Hoppe, Gaßner, Mühlenbrock & Tewissen, 2000). With respect to knowledge acquisition, there is evidence that collaboration scripts can positively affect especially the acquisition of more domain-general knowledge, but if properly designed also may facilitate the acquisition of domain-specific knowledge (Weinberger, Stegmann & Fischer, 2010). Based on this, we expected that implementing a collaboration script in an online DBL environment would lead to more domain-specific knowledge concerning learning content and domain-general knowledge on collaboration than unstructured collaboration.

Incomplete Concept Maps

In online DBL, students have to acquire science concepts and realize their mutual relations, after that connect them with ideas about research and design, and finally organize their ideas for addressing the challenge (Vattam & Kolodner, 2006). To help achieve this, shared external representations that provide students with visual representations of the to-be-learned content have been demonstrated useful (e.g., Suthers, 2003). In online DBL, one type of shared external representations that may be useful are concept maps, which are visual representations that graphically depict relations between concepts (Baker, 2003; Cox & Brna, 1995). Studies on the use of concept maps and graphical organizers indicate positive effects on comprehension of content (e.g. Romance & Vitale, 2002), intensive discourse about content (Fischer, Bruhn, Gräsel, & Mandl, 2002), and content quality of discussions (Jacobson & Levin, 1995; Suthers, 2003). One strength of using concept maps lies in the graphic representation to visualize and manage domain-specific knowledge necessary for the design task (Tergan & Keller, 2005), which enables students to understand and remember complex information and abstract concept relationships (Armstrong, 2003) as well as to organize and communicate their ideas and thoughts (Cox & Brna, 1995; Jonassen, Beissner, & Yacci, 1993). Even more, concept maps that involve missing concepts and relationships can increase students' activities for seeking missing information, which in turn may positively affect learning outcomes (Baker, 2003). Thus, in this study we used incomplete concept maps and implemented them in an online DBL environment. We expected that incomplete concept maps would increase students' discussions about content and thus lead to higher levels of domain specific knowledge and collaboration skills than unsupported DBL.

Research Questions and Hypotheses

In this study we examined to what extent a collaboration script and incomplete concept maps as well as their combination affect (1) the *acquisition of domain-specific knowledge* and *domain-specific skills* related to the design and building of web sites and (2) the content-related *discourse quality* and *collaboration skills* shown in a subsequent collaborative transfer task. We expected positive effects of both treatments on both kinds of outcomes and hypothesized the combination of collaboration script and incomplete concept maps to lead to the highest results in the post tests.

Method

Participants

100 students from the Educational Technology Department of Tanta University (Egypt) participated in the study in winter term of 2009. 15 participants were male, and 85 participants were female (M_{Age} = 20.00, SD = .71). Their task was to design, build and publish tourist web sites about Egypt by aid of the software "FrontPage".

Design

An experimental 2x2-factorial design was established with the collaboration script (without vs. with) and incomplete concept maps (without vs. with) as independent variables (see table 1). The students were randomly assigned to dyads which were then randomly assigned to one of the four conditions.

Table 1: Design of the empirical study.

		Collaboration Script	
		Without	With
Incomplete Concept Map	Without	N= 20 (10 dyads)	N= 24 (12 dyads)
	With	N= 24 (12 dyads)	N= 32 (16 dyads)

Setting and Learning Environment

The students participated in an Arabic online DBL environment, the design of which was inspired by the LBD approach (Kolodner, 2002). In each condition, the online DBL environment was divided into three sections (see figure 1). The left part of the screen (1) included tutorial videos about how to use the learning environment. The middle section (2) involved the course instructions, a news forum, and links to the learning phases, which in accordance with the course schedule appeared in a sequential order. The right section (3) included a range of communication tools (chat rooms, Wiki pages, and emails) to be used by the students and the teacher.

Figure 1. Screenshot of the Online DBL.

Each dyad had a private chat room, in which either a collaboration script, an incomplete concept map, both or none of the two were integrated (see below). Moreover, each dyad had a private Wiki page to receive comments, questions, and answers from other groups during designated sessions in which each dyad was supposed to evaluate the web sites created by one other group. The role of the teacher was to provide the students with all details about the task and instructions for each learning phase as well as technical support for the students during the learning phases.

The learning scenario included five phases. (1) The first phase started with the teacher providing the design task to the students, namely to create tourist websites on Egypt. Then, the students started their investigation by looking at both good and poor tourist web site examples, based on specific constructive standards for designing web sites, which were extracted from the literature and presented in the online environment (e.g., Harbeck & Sherman, 1999; Powell, 2001). (2) The second phase was devoted to learn about "FrontPage" software and the constructive standards for designing web sites by providing nine online tutorial lessons. At the end of each lesson, there was a small group discussion during which the different treatments were implemented. (3) Through the third phase, each dyad developed and discussed a plan for their web site and sent it to other groups before the group session. (4) During the fourth phase, each dyad built and published their web sites individually, then discussed, compared, and decided which of the two to represent their group. (5) In the fifth phase, each dyad had the opportunity to modify, rebuild, and republish their web site. In each of these phases, the students worked individually, in small groups (dyads), and in plenary sessions. The treatment was provided during the small groups discussions.

Procedure

First, pre-tests served to determine prior domain-specific knowledge and domain-specific skills related to the design and building of web sites. Subsequently, the student dyads were introduced to the online DBL environment. Afterwards, they participated in the learning phases for an overall of 41 days. In each learning phase, the students started their work individually, then conducted small group (dyadic) discussions (depending on the experimental condition with or without collaboration scripts and incomplete concept maps), and at the end of each phase, plenary sessions were conducted. In the final phase the students took two post-tests: post-test 1 was realized as an unstructured chat session to measure content-related discourse quality and collaboration skills employed in a subsequent online discussion, and post-test 2 was a test on domain-specific knowledge and domain-specific skills related to the design and building of web sites.

Experimental Conditions

The experimental design of this study consisted of the following four conditions:

(1) In the *control condition,* groups did not receive scaffolds during their small group discussions and thus led unstructured discussions using regular chat facilities.

(2) Groups in the condition *with collaboration script only* received a collection of interaction-related prompts to structure their collaborative discussions. The collaboration script involved different activities and roles for each student during the small group' discussions (see figure 2): (a) first, student 1 was instructed to ask a design-related question, (b) which student 2 then was supposed to answer. Then (c) student 1 was asked to either accept the answer with or without comment(s) or to refuse the answer with or without justification(s). After that (d) student 2 could either accept his/her partner's answer with or without comment(s) or refuse his/her partner's answer with or without justification(s). Finally (e) the discussion between dyads about the questions repeated until both students agreed on the same answer. After that the students' roles were switched to start a new cycle of the collaboration script (student 2 asks a new question and student 1 gives answer, etc.).

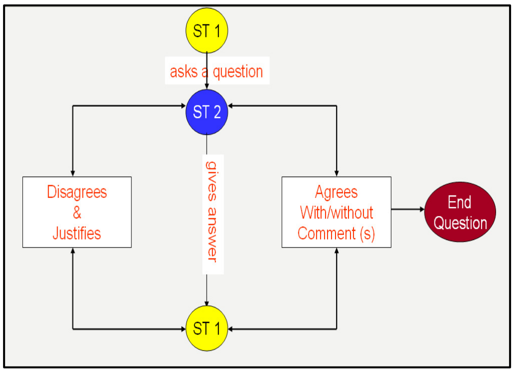

Figure 2. Visual Representation Shows Sequence of the Computer-supported Collaboration Script.

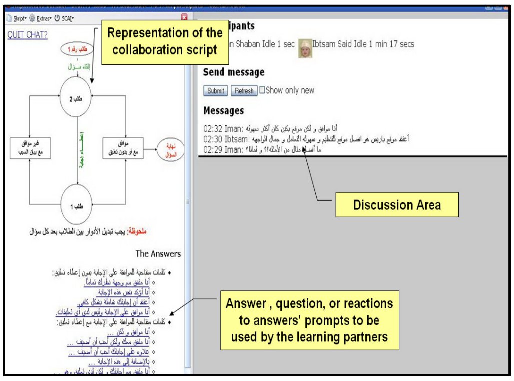

Figure 3. Chat Room Supported with the Computer-supported Collaboration Script.

In this condition, each chat room was equipped with the script (see figure 3). The right side of the chat room (discussion area) was where students could send and receive messages from their partner, while the collaboration script was located in the left side of the screen. The collaboration script section was divided into two parts: the *upper part* presented a visual representation of the script, while the *bottom part* involved specific prompts (based on the work by King, 1989) to assure a high level of discussion. There were prompts concerning questions (e.g. “Explain how…?” “What is the best…?” “Why…?”), answers (e.g. “I think the answer is…”, “From my perspective…”), and reactions to answers (e.g. “I support this answer”, “I agree but…”, “I disagree because…”). The prompts were changed automatically according to the student's role after sending his/her message to his/her partner. In addition, the student was not allowed to write his/her message in the discussion area before selecting a prompt that was associated with his/her role.

(3) In the condition with *incomplete concept maps* only, groups were provided with 12 incomplete concept maps, one for each chat session. Each concept map involved the key concepts, principles, and propositions related to the contents of the particular learning phase, which were listed and ranked in a hierarchical order. Each level of the concept maps had the same color, shape (e.g. circles, oval, or rectangle), and size. Lines and arrows were used to indicate relationships between the concepts. We also put verbs on each arrow to clarify the kind of relationship between the two concepts. Each concept map therefore represented a

group of related concepts. In each group, some boxes and arrows were not named to evoke students' discussions about this missing information (see figure 4) and to force them to discuss all sections of the map. Students explicitly had the task to fill in blank spots in the concept map. The missing concepts were varied between specific concepts that related more to the topic (e.g. bookmarks, hotspot area, DHTML effects) as well as intermediate (e.g. hyperlinks, Marque, jump menus), and general concepts (e.g. toolbars, multimedia, and interface) that focus on specific content. The missing verbs were limited to relationships between specific concepts (e.g. verb "create" to express the relationship from "image maps" concept to "hotspot area" concept) or between specific concepts with intermediate and/or general concepts (e.g. verb "write" to express the relationship from "Marque" as intermediate concept to "Marque text" as specific concept).

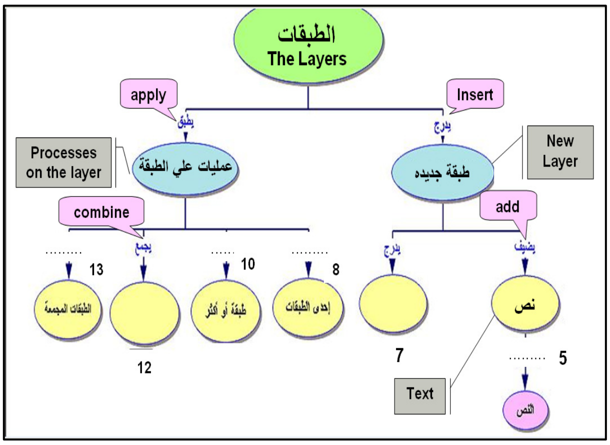

Figure 4. Screenshot of Incomplete Concept Map (Representations in Bubbles and Square Boxes Serve as Caption and were Not Presented in the Concept Map).

(4) In the *combined condition*, the students were supported with both the computer-supported collaboration script and incomplete concept maps during their small group discussions.

Dependent Variables and Instruments

Two tests were used to assess different learning outcomes: Post test 1 measured content-related discourse quality and collaboration skills in a subsequent collaborative transfer task; post test 2 assessed individuals' factual knowledge and skills on web design.

With respect to content-related discourse quality and collaboration skills, we analyzed the final discussion in each small group, which was realized without treatment. Trained coders first segmented each discourse into meaningful sentences and rated the segments (total agreement = 86 %). To assess *content-related discourse quality*, a coding scheme was developed to capture what web-design concepts were used during discussions (Cohen's κ = .71). The number of used concepts during the final chat discussion was used as indicator for content-related discourse quality. With respect to *collaboration skills*, a coding scheme was developed to identify the different kinds of questions (Cohen's κ = .97), answers (Cohen's κ = .76), and reactions to answers (Cohen's κ = .83) that were suggested by the collaboration script. After that, a principal component analysis (PCA) with all 16 variables was performed resulting in two factors which were used to describe two different dimensions of collaboration skills. The first factor included the categories "accepting answers with comment(s)" and "refusing answers with justification(s)", which we labeled as "elaborative dimension of collaboration skills". The second factor included only one variable, which was "evaluation questions". Thus, this factor was labeled "metacognitive dimension of collaboration skills".

Post test 2 measured both domain-specific factual knowledge and domain-specific skills of web design. The *factual knowledge test* consisted of 66 multiple choice questions directed towards the functionalities of FrontPage. The *application-oriented knowledge test* assessed students' Web-design skills when using FrontPage software. To that end, they were asked to perform the different functions of FrontPage and could reach between 0 (the action could not be performed) and 2 points (the action was performed correctly) for each function. Reliabilities were sufficient (α = .72 for factual knowledge test, α = .96 for application-oriented knowledge test).

Results

Collaboration Skills and Domain-Specific Discourse Quality

Table 2 presents the mean scores and standard deviations concerning collaboration skills and domain-specific discourse quality in the subsequent collaborative transfer task for the four experimental conditions.

An ANCOVA with the collaboration script and the incomplete concept maps as fixed factors and the *elaborative dimension of collaboration skills* exhibited in the final unstructured chat session as dependent variable as well as the total number of discourse segments as a covariate revealed significant and positive main effects for both treatments ($F(1.46) = 17.30$, $p < .001$, $Eta^2 = .28$ for collaboration script, and $F(1,46) = 7.43$, $p < .001$, $Eta^2 = .14$ for incomplete concept maps), and their interaction ($F(1,46) = 20.69$, $p < .001$, $Eta^2 = .32$). An analogous ANCOVA with the *metacognitive dimension of collaboration skills* exhibited in the final unstructured chat session as dependent variable revealed significant and positive main effects only for the collaboration script ($F(1.46) = 4.60$, $p < .001$, $Eta^2 = .09$). The interaction effect did not reach statistical significance ($F(1,46) = .14$, *n.s.*). An ANCOVA with the collaboration script and the incomplete concept maps as fixed factors and the *domain-specific discourse quality* as dependent variable as well as the total number of discourse segments as a covariate revealed significant and positive main effects for both treatments ($F(1,46) = 13.30$, $p < .001$, $Eta^2 = .23$ for collaboration script, and $F(1,46) = 45.11$, $p < .001$, $Eta^2 = .50$ for incomplete concept maps). The interaction effect did not reach statistical significance ($F(1,46) = .24$, *n.s.*). Due to significant effects on the Levene's test on homogeneity of variances, the effects were re-tested with non-parametrical tests (Kruskal-Wallis test and Mann-Whitney U-test), confirming the results of the ANCOVAs.

Table 2: Mean scores (standard deviations in brackets) concerning collaboration skills (elaborative and metacognitive dimension) and domain-specific discourse quality in the subsequent collaborative transfer task for the four experimental conditions.

	control group	collaboration script only	incomplete concept maps only	collaboration script and incomplete concept maps
	M *(SD)*	M *(SD)*	M *(SD)*	M *(SD)*
Collaboration skills (elaborative dimension)	- .75 *(.22)*	-.56 *(.42)*	-.47 *(.21)*	1.24 *(.79)*
Collaboration skills (metacognitive dimension)	- .75 *(.10)*	- .03 *(.88)*	- .45 *(.29)*	.83 *(1.16)*
Domain-specific discourse quality	6.40 *(2.22)*	16.75 *(9.44)*	9.08 *(.79)*	20.38 *(6.77)*

Acquisition of Domain-Specific Knowledge and Skills

For *domain-specific factual knowledge* about FrontPage software and standards for designing web sites (mean scores see Fig. 5), the results showed significant and positive effects for both the collaboration script and incomplete concept maps. An ANCOVA with the collaboration script and the incomplete concept maps as fixed factors, group membership as further independent factor nested within the experimental conditions (to account for interdependencies in the data of the two learners in a group), the post test scores in the factual knowledge test as dependent variable and the pre test scores as a covariate showed stronger effects for incomplete concept maps ($F(1,95) = 28.13$, $p < .001$, $Eta^2 = .37$) than for the collaboration script ($F(1,95) = 11.94$, $p < .001$, $Eta^2 = .20$). The interaction effect did not reach statistical significance ($F(1,95) = 2.30$; *n.s.*). Thus, the combination of collaboration script and incomplete concept maps led to the highest levels of knowledge acquisition.

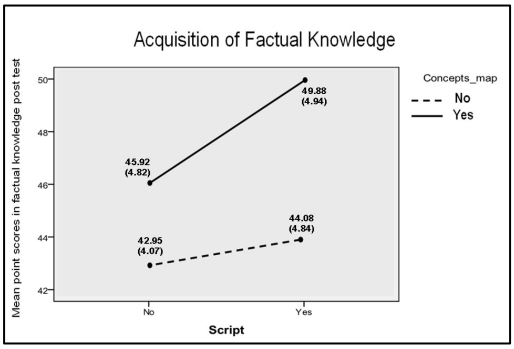

Figure 5. Mean Scores (Standard Deviations in Brackets) in the Test on Domain-Specific Factual Knowledge across the Four Experimental.

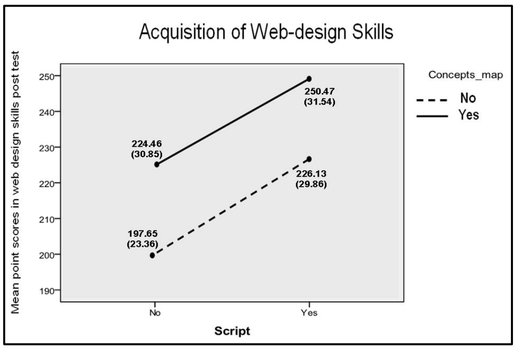

Figure 6. Mean Scores (Standard Deviations in Brackets) in the Test on Domain-Specific Web Design Skills across the Four Experimental.

A similar pattern was found with respect to the *acquisition of web design skills* (mean scores see Fig. 6). An ANCOVA with the collaboration script and the incomplete concept map as fixed factors, group membership as further independent factor nested within the experimental conditions, the post test scores in the Web-design skills test as dependent variable and the pre test scores as a covariate showed significant and positive main effects for both treatments ($F(1,95) = 21.90$, $p < .001$, $Eta^2 = .31$ for incomplete concept maps, and $F(1,95) = 27.61$, $p < .001$, $Eta^2 = .36$ for the collaboration script), but no significant interaction effect ($F(1,95) < 1$; *n.s.*). Thus again, additive effects for both treatments with respect to web design skills were found.

Discussion

Overall, our results support quite clearly our expectation that online DBL can be improved by adequate scaffolding. When considering the results in the unstructured control condition and comparing them to the other three conditions, it is confirmed that additional scaffolding can improve learners' knowledge and skill acquisition in online DBL. As our study indicates, implementing social and content scaffolds in an online DBL environment are powerful means to improve collaboration skills and content-related discourse quality in a subsequent collaborative transfer task as well as the acquisition of factual knowledge and skills on web design. Obviously, and in line with prior research (Kollar et al, 2007; Weinberger, Ertl, Fischer & Mandl, 2005), the collaboration script we used seemingly helped learners lead more sophisticated discussions, which in turn may have led to the acquisition of domain-specific factual knowledge and web-design skills. This is a very encouraging finding since many laboratory studies on collaboration scripts in CSCL contexts failed to find positive effects on more domain-specific outcomes. Perhaps, compared to early studies, the more extensive learning phase employed in this study employed may have promoted such positive effects. Yet, to test the underlying process assumptions, in-depth process analyses are necessary, which are currently under way.

In line with results of studies on the collaborative use of concept mapping techniques (e.g. Fischer et al., 2002), the incomplete concept map provided the students with effective conceptual support concerning the domain-specific content of the task. This may have facilitated the content-related, but in parts also the social-interactive level of the discussions between students (Jacobson & Levin, 1995) during their work in the online DBL environment (Tergan & Keller, 2005). Also, these higher levels of discussion and collaboration obviously may have been responsible for enabling students to acquire both factual knowledge on Web-design concepts and web-design skills. Yet again, process analyses are needed to confirm these process assumptions.

With respect to the question how collaboration scripts and incomplete concept maps work together in online DBL, we found a results pattern that can be described as a nice materialization of what Tabak (2004) called "synergistic scaffolding". On almost all dependent variables we found the combination of collaboration script and incomplete concept maps to evoke the most favorable results, going beyond what could be achieved by each of the two scaffolds alone. Thus, our results make a strong case for augmenting online DBL by scaffolding measures directed at both the interactional and the content-related level. A limitation of our study, however, may lie in the measurement of web-design knowledge and skills, since our operationalizations merely relied on rather context-free, one-dimensional measures. For example, measuring the acquisition of design knowledge according to different categories such as stages, values, roles, principles, patterns, techniques, and design psychology, as suggested by Hoadley and Cox (2009), might be a valuable alternative to our approach.

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