Facilitating Collaborative Diagnosing in Medicine With a Simulation: Effects of Adaptive and Static Information Sharing Scripts

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Abstract: In their daily practice, physicians often collaboratively diagnose patients. Due to specialized education, physicians need to pool their different knowledge bases in such situations, which often is difficult. Scripts are an instructional mean to foster collaborative processes. In this paper, we used adaptive and static information sharing scripts to facilitate the pooling of information during collaborative diagnosing. In total, 159 medical students were randomly distributed to one of three groups (adaptive, static, or no information sharing script). The results showed that both scripts increased the information sharing performance. However, only learners supported with an adaptive information sharing script were able to transfer their knowledge. This study informs researchers and educators on how to design and implement information sharing scripts to facilitate collaborative diagnosing.

Theoretical background

Diagnosing a patient collaboratively is part of many physicians' daily routine. That means, for instance, that physicians discuss their patients' symptoms or treatment plans with physicians who have different professional specializations. Because of their specialized education (San Martin-Rodriguez, Beaulieu, D'Amour, & Ferrada-Videla, 2005), physicians have different professional knowledge bases. When collaborating, it is necessary to pool the knowledge of the physicians to find the best diagnosis or treatment plan for their patient (Michinov, Olivier-Chiron, Rusch, & Chiron, 2008). There is, however, little empirical research on collaborative diagnosing (Kiesewetter, Fischer, & Fischer, 2017). The few available studies indicate that physicians have difficulties to pool their knowledge and to share information (Tschan et al., 2009). Hence, our goal is to investigate means to foster collaborative diagnosing and particularly information sharing skills.

A recent approach to assess and foster collaborative problem solving is agent-based collaboration, in which one or more learners collaborate with a computer agent to solve a problem (Graesser et al., 2018). This approach allows controlling the effect of possibly influencing variables such as motivation of the collaborators. Furthermore, agent-based collaboration allows focusing on the repeated training of particularly difficult sub-tasks (i.e., deliberate practice, Ericsson, 2004). In human-to-human collaboration, such a focus would probably undermine the motivation of the respective collaboration partner. To learn complex skills, instructional support beyond providing a problem scenario seems beneficial (e.g., Chernikova, Heitzmann, Fink, Timothy, & Fischer, 2019). *Collaboration scripts* are a form of scaffolding used for facilitating collaborative processes during collaborative learning by prompting specific collaborative activities (Vogel, Wecker, Kollar, & Fischer, 2017). For example, learners receive prompts to share specific information (e.g., Noroozi, Teasley, Biemans, Weinberger, & Mulder, 2013), or to negotiate conflicting ideas (e.g., Puhl, Tsovaltzi, & Weinberger, 2015). The idea of external collaboration scripts is to complement less functional cognitive script components, which are called internal collaboration scripts. By engaging learners in beneficial collaborative activities, external collaboration scripts can facilitate the internalization of functional script components (Fischer, Kollar, Stegmann, & Wecker, 2013). In the context of collaborative learning, collaboration scripts are beneficial for domain learning and collaboration skills (Vogel et al., 2017) by engaging learners in beneficial collaborative activities (Vogel et al., 2016). For the context of collaborative diagnosing, supporting learners with *information sharing scripts* should, hence, allow them to show better *information sharing performance* (i.e., the quality of information sharing when supported with scripts), which in turn enhances the *information sharing skills* (i.e., the quality of unsupported information sharing). For collaboration scripts to be effective, the literature suggests that collaboration scripts should avoid over- or under-scripting (Dillenbourg, 2002). This means that scripts providing detailed guidance could hinder the learning of more advanced learners. In the same way, collaboration scripts that provide little structure could overwhelm learners with low collaboration skills. These considerations suggest that providing adaptive support for learners could enhance the effectiveness of collaboration scripts. Indeed, there is evidence that adaptive scaffolds increases the learning effects in collaborative learning (e.g., Walker, Rummel, & Koedinger, 2014). For collaboration scripts, fading in and out is a typical approach to adapt instructional support

to the learners' needs. Wecker and Fischer (2011) found, for instance, that fading out is particularly effective for the learning of knowledge when combined with peer monitoring to ensure that the learner does not fall back in novice learning strategies. It seems plausible that prompting information sharing adaptively whenever the information sharing quality is too low could render the peer monitoring unnecessary. The presented empirical evidence has arisen in the context of collaborative learning. Therefore, the goals of the present study are to investigate whether the findings on collaboration scripts are applicable to information sharing scripts supporting information sharing during collaborative diagnosing in agent-based collaboration.

Research questions

1. To what extent do adaptive and static information sharing scripts positively affect the performance of information sharing during scripted collaborative diagnosing? We hypothesize that information sharing scripts increase the performance of information sharing compared to unsupported information sharing with adaptive information sharing scripts having larger effects compared to static information sharing scripts.
2. To what extent does the performance of information sharing predict the information sharing skill? We hypothesize that the performance of information sharing positively predicts the information sharing skill.
3. To what extent do adaptive and static information sharing scripts have positive effects on information sharing skills? We hypothesize that adaptive and static information sharing scripts increase the information sharing skills with adaptive scripts having larger effects compared to static scripts.

Method

Sample and design

We conducted an experiment with a one-factorial design with the three levels adaptive information sharing script, static information sharing script and no further instructional support (control group). In the study participate 159 medical students (3rd clinical year and higher) who were randomly distributed to one of three groups. The presented analyses include the data of a subsample of 119 students.

Learning environment

To facilitate collaborative diagnosing, we used a simulation of six fictitious patient cases, which required collaboration with a radiologist to solving the patient case. More specifically, all participants acted in the role of an internist who sequentially received health records of patients suffering fever. After revisiting the health record, learners filled in a request form to request a radiologic investigation. The request form prompted learners to share patient information that is important for the radiologist to interpret the radiologic findings. Only when learners shared sufficient patient information with the radiologist, the simulated radiologist conducted the respective test and interpreted the findings. Finally, the medical students solved the patient case by suggesting a final diagnosis.

Procedure and treatment

All participants first solved an unsupported patient case (pretest case) to assess their prior information sharing skills. During the learning phase, all participants solved four further patient cases (learning cases) according to their experimental condition. The first group received an adaptive information sharing script, the second group received a static information sharing script, and the third group received no additional support. Both information sharing scripts consisted of prompts that contained meta-knowledge about which information is relevant for the radiologist in specific situations, and why as well as the prompt to share respective patient information. Learners in the adaptive collaboration script condition received these prompts when their request was not sufficiently justified. The adaptive collaboration script identified which information was missing and provided respective support. Learners in the static collaboration script condition received the information sharing script in form of a letter from the radiologist at the beginning of the learning phase. The letter contained a guideline with meta-knowledge for different radiologic examinations. The learners could access the letter any time and as often as they wanted to. After the learning phase, learners were asked to return the letters. All participants completed a final patient case (posttest case) without further instructional support to assess the gain in information sharing skills.

Instruments

We assessed the *information sharing performance* using the learning cases and *information sharing skills* using the pretest and posttest cases based on sample solutions. The sample solution specified which information was relevant to share with the simulated radiologist. We calculated two scores each for the information sharing performance and the information sharing skills: a *hit rate* (proportion of shared relevant patient information to all

relevant patient information) and a *false alarm rate* (proportion of shared irrelevant patient information to all irrelevant patient information). Both measures ranged from 0 to 1. A high hit rate and a low false alarm rate indicate high information sharing quality.

Statistical analyses

Research questions 1 and 3 were answered conducting ANCOVAs with the prior information sharing skills (hit and false alarm rate) as covariate, and information sharing performance and information sharing skills (hit and false alarm rate) as dependent variables. We used Sidak corrected comparisons of adjusted means to identify differences between conditions for all ANCOVAs. To specify whether the information sharing performance in the learning cases predicts the information sharing skills, we conducted two linear regressions (RQ 2).

Results

We were interested in whether adaptive and static collaboration scripts affect the information sharing performance (RQ 1). The provision of an information sharing script significantly affected the hit rate during the learning process ($F(2,114) = 8.11$, $p < .01$, partial $\eta^2 = .13$). Comparisons of the adjusted means revealed that learners who received the adaptive information sharing script and the static collaboration script showed significantly higher hit rate compared to learners who received no instructional support (mean difference = 0.12, $SE = 0.03$, $p < .001$ and mean difference = 0.07, $SE = 0.03$, $p = .047$). Learners who learned with the static or the adaptive information sharing script showed no significant difference in the hit rate during the learning process (mean difference = 0.05, $SE = 0.03$, $p = .336$). With respect to the false alarm rate, the analyses showed that the information sharing scripts did not affect the false alarm rate in the learning process ($F(2,114) = 0.79$, $p = .46$, partial $\eta^2 = .01$).

We further assumed that information sharing performance predicts the information sharing skills in a posttest (RQ 2). The analyses revealed that the hit rate during the learning process positively predicted the hit rate of the posttest ($F(1,116) = 96.67$, $p < .01$, $R^2 = .45$). The influence of the learning process on the hit rate of the posttest was large ($\beta = .67$, $t(116) = 9.83$, $p < .01$). Concerning the false alarm rate, the learning process predicted the false alarm rate of the posttest as well ($F(1,116) = 524.71$, $p < .01$, $R^2 = .82$). The influence of the learning process on the false alarm rate of the posttest was large ($\beta = .91$, $t(116) = 22.91$, $p < .01$).

To answer research question 3, we analyzed whether the provision of a static or adaptive information sharing script affects the information sharing skills. The provision of a collaboration script significantly affected the hit rate of the posttest ($F(2,114) = 4.62$, $p = .01$, partial $\eta^2 = .08$). Comparisons of the adjusted means revealed that learners who received the adaptive information sharing script had a higher hit rate in the posttest compared to learners in the control group (mean difference = 0.11, $SE = 0.04$, $p = .014$), but not compared to learners who received a static information sharing script (mean difference = 0.09, $SE = 0.04$, $p = .078$). Learners who received the static information sharing script did not differ with respect to the hit rate of the posttest compared to the control group (mean difference = 0.03, $SE = 0.04$, $p = .89$). Concerning the false alarm rate, analyses showed that the information sharing scripts did not affect the false alarm rate of the posttest ($F(2,114) = 0.56$, $p = .57$, partial $\eta^2 = .01$).

Discussion

In this short paper, we compared static and adaptive information sharing scripts to learning without instructional support to gain a better understanding how information sharing scripts can be designed to support collaborative diagnosing. The results of our study show that adaptive and static information sharing scripts increase the information sharing performance. The information sharing performance predicted the information sharing skills in an unsupported posttest. However, both types of information sharing scripts improved the amount of shared relevant information, but they do not reduce the amount of shared irrelevant information. This is probably due to the design of the scripts that focused on missing information rather than redundant information. When analyzing the direct effect of information sharing scripts on information sharing skills it seems that only learners who received adaptive support were able to transfer their knowledge whereas learners who received static support were not. This suggests that by learning with an adaptive information sharing script, learners internalized which information to share (Fischer et al., 2013). However, that raises the question why learners learning with a static information sharing script were not able to transfer their skills. Prior research on collaboration scripts used effective scaffolds that did not vary depending on the learners' ability (e.g., Rummel, Spada, & Hauser, 2009). Meta-analytical evidence on the effect of collaboration scripts on collaborative learning suggests that also non-adaptive scripts enhance learners' collaboration skills (Vogel et al., 2017). One explanation is that learners who received the information sharing prompts in form of a letter might have been overwhelmed by the amount of information presented at a time. Although the static information sharing script contained the same information as the adaptive collaboration script, learners in the static script condition received all information at once. Hence,

the static information sharing script probably posed a higher extraneous cognitive load on learners (Sweller, 1994). Alternatively, learners in the static script condition were able to revise the letter of the radiologist any time they wanted to, whereas learners in the adaptive script condition saw their specific prompts only for a couple of minutes. To follow the prompts, learners in the adaptive condition needed to remember the prompts whereas learners in the static conditions did not. It is, hence, plausible to assume that learners in the static condition did rely on the information without storing it themselves.

Overall, this study shows that simulations of collaboration enriched with information sharing scripts can facilitate information sharing performance and skills in the context of collaborative diagnosing. In contexts in which sharing redundant information is particularly harmful, it is however necessary to modify the information sharing scripts to reduce the false alarm rate. The presented research can inform researchers and medical educators how to design learning environments to support the learning of complex skills such as collaborative diagnosing.

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