

## How Collaboration Scripts are Internalized: A Script Theory of Guidance Perspective

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**Abstract:** With respect to the Script Theory of Guidance (SToG), four open questions of importance are identified regarding the optimal scripting level principle. This principle concerns mainly the interaction between internal and external scripts as well as the effect of this interaction on knowledge acquisition. In an experimental study with  $N = 96$  participants (who learned in groups of three), we examined the effects of external scripting and fading on the development of an internal script and analyzed the role of the individual's initial internal script. The results are in line with the principles of the SToG so that the external script facilitated the internal script mediated by the application during the collaborative learning. In addition, the initial internal scripts interact positively with the external script regarding the effect on the development of individual's internal scripts.

Collaboration scripts have been used to scaffold various computer-mediated collaborations through a sequence of interaction phases with designated activities and roles (Kollar, Fischer, & Hesse, 2006), with the purpose of helping learners to engage in productive interaction and collaborative knowledge construction (Fischer et al., 2013), such as the construction of arguments. Through argumentation, students learned to think critically, articulate their own views, and negotiate their own thoughts with others' different perspectives. Despite much progress, the findings have been mixed with respect to the effects of structured instructional supports for groups (e.g., Stegmann, Weinberger, & Fischer, 2007) to foster argumentative knowledge construction. Hence, there are questions that deserve further investigation to understand the underlying principles associated with effective collaboration scripts. Recently, Fischer and colleagues (2013) outlined a Script Theory of Guidance that take a systematic view of central components that are shared among different scaffolding approaches and several leading principles to explain a broad range of findings from the CSCL literature.

The script theory of guidance describes how the learners' knowledge on collaboration can be described in terms of internal collaboration script components and how these internal collaboration script components guide learners in understanding of and acting in CSCL practices. Participation in these practices, in turn, facilitates the development of these hierarchically organized internal collaboration scripts. Four conceptual components were identified: The *Play* component constitutes general knowledge about the collaborative situation at the top level. The *Scene* components include knowledge about a specific situation in a play and the *Scriptlet* component refers to knowledge of activities and their sequence(s) in a particular scene. Finally, the *Role* components typically extend across several scenes and activities, which thereby constitute knowledge of how the activities are distributed during a scene within a group. The external collaboration script consists of scaffolds targeting at supporting the learner to employ internal collaboration script components that would not have been used spontaneously.

In addition, seven guiding principles were outlined in the Script Theory of Guidance (Fischer et al., 2013). One of the principles emphasizes the importance of being 'optimal' in regards to the degree of external collaboration scripts that are put into use (*Optimal External Scripting Level Principle*): "An external collaboration script is most effective for knowledge acquisition if it is directed at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner." However, striking the balance between too little scaffolding to be helpful and too much scaffolding to allow for group interactions is indeed a delicate issue (Dillenbourg, 2002). Against this background, the question arises of how to further conceptualize and manipulate the vague meaning of the 'optimal' level of scripting. The highlighted dynamic nature of scripting is based on the intrinsic component of the scaffolding system called 'internalization'. Accordingly, the specificity of the external script would need to gradually be reduced to ensure that learners are not given instruction they actually do not need – a process of reducing the amount of external instruction is known as fading (Pea, 2004). Despite the fact that SToG postulates that internal and external scripts need to be optimally combined to facilitate knowledge acquisition most effectively, the theory does not explicitly specify the role of fading for acquisition of internal scripts. A close-up analysis of how do external scripting and fading affect the internalization of collaboration scripts, therefore deserve further investigation through controlled experimental studies.

The *Transactivity Principle* outlined in the Script Theory of Guidance states that the acquisition of knowledge is positively associated with the amount of the transactive application through participation in a given CSCL practices: "The more a given CSCL practice requires the transactive application of knowledge, the

better this knowledge is learned through participation in this CSCL practice.” (Fischer et al., 2013, p. 58) While several empirical studies on the effects of external collaboration scripts from CSCL research show the effectiveness of external collaboration scripts regarding their positive effects on collaborative learning processes (Stegmann et al., 2007), past efforts did not lead to a unique and integrated model of the effects of collaboration scripts on the learning processes as well as outcomes. There still remains little research which provided empirical evidences for exploring the underlying relationships between the repeated application of script components and the assumed individual development of internal collaboration scripts.

From the perspectives of SToG, both of the internal and external collaboration play essential roles in guiding learner to understand and act in CSCL practices. On the one hand, “when participating in a CSCL practice, the learner’s understanding of and acting in this situation is guided by dynamically configured and re-configured internal collaboration scripts.” (*Internal Script Guidance Principle*), and on the other hand, “external collaboration scripts enable learners to engage in an instance of a CSCL practice at a level beyond what they would be able to without an external collaboration script.” (*External Script Guidance Principle*). Shortly, external collaboration scripts can create opportunities, but whether learners benefit from the instructional supports depends on the dynamic interplay between internal factors and external instructions. Kollar (2007) reported that the success of collaborative learning is also affected by learners’ internal collaboration scripts that guides them in collaborative settings. While researchers have adopted the importance of internal collaboration scripts largely for theoretical reasons, surprisingly little direct empirical evidence exists to actually verify these assumptions. The current work both divers and builds upon the previous study, rather than providing polarized treatments, either with or without collaboration scripts we explore the interplay between internal and external scripts when various degrees of scripting are manipulated.

### Research questions

The purpose of this study is to build in-depth understanding of the effects of an external script on the acquisition of an internal script and analyzed the role of the individual’s initial internal script. A set of research questions was formulated to address the interactive relationships between internal and external collaboration scripts.

RQ 1: To what extent does external scripting and fading affect application of internal script components during collaborative learning?

RQ 2: To what extent does external scripting and fading affect the development of an internal script?

RQ 3: To what extent is the positive effect of external scripting and fading on the development of an internal script mediated by the application of internal script components during collaborative learning?

RQ 4: To what extent is the positive effect external scripting and fading have on the development of internal script moderated by the initial internal script?

### Methods

Ninety-six ( $N = 96$ ) students at the University of Munich participated in this study during the summer term 2010. The collaborative learning task of the participants was to apply the Attribution Theory to five problem cases through argumentation and propose a final analysis for each case. A one-factorial experimental design with three conditions was implemented. The time on task, all together 80 minutes, was held constant for the three conditions. During the entire learning process, individuals were randomly assigned to groups of three and further to one of the three experimental conditions. In order to address the complex problem of ‘over-scripting’, a rather detailed external collaboration scripts in the *High Degree of Scripting* (HD) condition was developed (at the bottom level of *Scriptlets* targeting the specific activities). For instance, written prompts were delivered according to a simplified version of Toulmin’s model (1958) to guild the constructions of claim (i.e., a statement that advances the position learners take to analyze case with attribution theory), ground (i.e., evidence from case to support claim), or warrant (i.e. logical connections between the grounds and claims that present the theoretical reason why a claim is valid). The *Medium Degree of Scripting* (MD) was implemented through continuous fading-out of the prompts of the external script. The environment handles the fading levels according to a designed sequence with a fixed time interval specified by the researchers in advance. For example, in the end of the tenth phase, learners received only one textbox for creating a whole argumentation (*Scene*) instead of specifying the argument components (*Scriptlets*). Participants in the condition with *Low Degree of Scripting* (LD) received no additional support in solving the problem cases.

As the main data sources, all messages that learners put forward in the text-based communication were divided into units of analysis — syntactically meaningful sentences and subsequently coded on argumentation dimension, which reflects different desired activities to build formally complete arguments. Each segment was coded whether it was a claim, a ground, or a warrant. The SIDE tools (Mayfield & Rosé, 2010) for automatic classification were used for segmentation and coding. The inter-rater reliability was sufficiently high (Cohen’s Kappa between human coders and SIDE above .7 (Mu, Stegmann, Mayfield, Rosé, & Fischer, 2012). Content analyses on the argumentation dimension as described above have been applied to the pre-test case to assess the baseline *Initial Internal Scripts* (IS), the *Application of Internal Scripts* (IS) measured the average quality of argumentation as a trio-group on the same dimension but during the collaborative learning process of analyzing

three problem cases, as well as the *Development of Internal Scripts* (IS) assessed in the post/transfer case as the one of the indicators of internalized collaboration scripts.

Standard linear regression analysis and a set of two-level Hierarchical Linear Model models with the use of the software HLM 6.08 for windows was performed to analyze the clustered data collected in the present study. Through two dummy codes, namely *Scripting* (LD = 0, MD = 0, HD = 1) and *Fading* (LD = 0, MD = 1, HD = 0) the categorical variables of the experimental treatments can be rendered into quantitative forms.

## Results

*RQ 1: To what extent does external scripting and fading affect application of IS components during collaborative learning?* The regression model using the predictors Scripting and Fading explained about 33% of the variance of the application of internal scripts ( $R^2 = .33$ ,  $F_{(2, 29)} = 7.09$ ,  $p < .01$ ). Both of the predictors had significant positive effects on the application of IS ( $\beta_{\text{scripting}} = .62$ ,  $p < .01$ ;  $\beta_{\text{fading}} = .54$ ,  $p = .01$ ). Learners supported by scripts, either with high or medium degree did apply more collaboration scripts during online discussion compared with groups in the control condition. We did not find any significant difference between the groups with HD of scripting and MD of scripting ( $\beta = .08$ ,  $p > .50$ ).

*RQ 2: To what extent does external scripting and fading affect the development of IS?* For each outcome variable, the HLM analyses were performed in four stages. At the first stage, a null model was tested in which no independent variable was included. By adding the group-level intervention variables the second model was to address the effects of various degrees of scripting on learning outcomes.

Table 1 HLM Models: Degree of Scripting Affecting the Development of Internal Scripts

Parameter		Model 1	Model 2	Model 3	Model 4
Fixed effects	Intercept	0.60** (0.10)	0.35** (0.09)	0.34** (0.09)	0.60** (0.14)
Level 1 (Student)	Initial IS.			- 0.04 (0.06)	- 0.16 (0.08)
Level 2 (Group)	Application of IS				0.70* (0.32)
	Scripting		0.57* (0.26)	0.55* (0.24)	0.16 (0.69)
	Fading		0.16 (0.11)	0.15 (0.11)	- 0.18 (0.16)
	Scripting. $\times$ Initial.IS			1.47* (0.75)	1.48* (0.73)
	Fading. $\times$ Initial.IS			0.07 (0.19)	0.17 (0.18)
Random parameters	$\sigma^2_{u0}$	0.17** (0.41)	0.11** (0.33)	0.10** (0.32)	0.04** (0.19)
	$\sigma^2_{e0}$	0.47 (0.69)	0.47 (0.69)	0.42 (0.65)	0.42 (0.65)
-2*log likelihood		223.47	217.13	206.24	197.05

Note. Values in parentheses are standard errors. \* $p < 0.05$ ; \*\* $p < 0.01$ .

As shown in Table 1, the variance of the group level residual errors are estimated as 0.17, which is small but significantly different from zero ( $\chi^2 = 66.23$ ,  $df = 31$ ,  $p < .01$ ). By calculating intra-class correlation, 26% of the variances of the development of IS exist at the group level. The regression coefficient for Scripting is significant which means that on average students receiving external scripts with HD contribute 0.57 ( $p < .05$ ) units of analysis more than students in the control condition. However, no significant difference is found between other treatment groups. The deviances reported here as -2\*log likelihood function value reduced from the null model 223.47 to the full model 217.13 with a significant difference ( $\chi^2 = 6.34$ ,  $df = 2$ ,  $p < .05$ ), which indicates a better model-fit has been achieved by adding the variable at the group level. Summarily, the empirical finding was against this initial assumption in which fading was expected to foster the internalization of collaboration scripts. Learners with highly structured external scripts produced more formally complete arguments in the transferable post-case than learners in the other two conditions.

*RQ 3: To what extent is the positive effect external scripting and fading on the development of IS mediated by the application of IS components during collaborative learning?* The last two models are to determine if the application of IS can account for the variation in the slopes after controlling for the effects of various interventions. As shown in the third model, the coefficient associated with the relation between the dummy variable Scripting and development of IS is significant ( $\beta_{\text{Scripting}} = .55$ ,  $p < .05$ ). When further controlling the application of IS, it was significantly associated with the corresponding learning outcomes ( $\beta = .70$ ,  $p < .05$ ). The coefficient for the mediated effect dropped down from significant to insignificant ( $\beta_{\text{Scripting}} = .16$ ,  $p > .05$ ). The addition of learning process as a predictor yield substantially increased variances which can be explained at the group level, namely from 40% to 70%. The Sobel test indicates that the application of IS mediated the relationship between external scripting and development of IS ( $p = .01$ ). Meanwhile, the difference between the model deviances ( $\chi^2 = 9.20$ ,  $df = 1$ ,  $p < .01$ ) demonstrates a better model fit.

*RQ 4: To what extent is the positive effect external scripting and fading on the development of an internal script moderated by the learner's initial internal script?* The regression coefficient for the cross-level interaction is 1.47 ( $p < .05$ ) by multiplying the dummy coding variable Scripting. The significant moderating effect shown that learner with more internal collaboration scripts performed better than learners with less internal collaboration scripts when they were all supported by HD of scripting. MD of scripting did not interplay with internal collaboration scripts ( $\beta_{\text{Fading}} = .07$ ,  $p > .05$ ).  $R^2$  with predictors of degree of scripting and initial IS

excluding their interaction is close to zero at the individual level; inclusion of the interaction increase  $R^2$  to 0.11. A better model fit was achieved ( $\chi^2 = 10.89$ ,  $df = 3$ ,  $p < .05$ ).

## Discussion

The major research questions of this study were to address to what extent does external scripting and fading of an external script affect the application of internal script components during collaborative learning and the development of an internal script (RQ1 & 2). The findings suggested that external scripting and fading facilitate the application of internal scripts during collaborative learning, but the assumed negative effect of external scripts with HD of scripting on the acquisition of IS ('over-scripting') did not occur. In addition the MD of scripting manipulated with fading did not outperform as expected. To bridge the evidence gap in previous studies by addressing the "optimal" degree scripting (*Optimal External Scripting Level Principle*), the current study indicates that an absolute threshold (above which the scripting degree will be 'too much' for all learners) indeed does not exist. Rather, whether an external collaboration script being 'too much' or not, is relative to and depending on the available resource stored in the human mind as internal collaboration scripts (*Internal & External Script Guidance Principles*). This study contributes to the growing empirical literature on the interplay between the internal and external collaboration scripts by addressing to what extent is the positive effect external scripting and fading on the development of an internal script moderated by the learner's initial internal script (RQ 4). It is surprising that more experienced learner with more internal collaboration scripts benefited most of the full and continuous collaboration scripts, rather than from the fading condition. In the other treatment conditions, namely low and medium degree of scripting, the influence of internal collaboration scripts on argumentation vanished. Therefore, it might be explained that constructing a formally complete argument is challenging for learners due to little 'available' script components in minds, and thus the failure of fading might be due to the removal of external scripts too quickly, which allows the scaffolding residing outside of learner's ZPD and hence led to the unexpected effects. In addition, efforts are paid in the current study to elicit the nature of the relationship between the application and the development of internal collaboration scripts simply differ across external scripting (*Transactivity Principle*) by addressing to what extent is the positive effect external scripting and fading on the development of internal script mediated by the application of script components during collaborative learning (RQ 3). HD of scripting was found to strengthen the configuration/reconfiguration of internal collaboration scripts due to the intensive practices on argumentation provided in the condition with full and continuous instructional supports. The numerous studies on scientific argumentation have suggested that for the overwhelming majority, the appropriate use of valid argument does not come naturally, but rather is acquired through intensive practices (Kuhn, 1991). Thus learner might need more assistance and practice in terms of HD of scripting to complete the challenging task and hence result in internalized collaboration scripts. It can be also explained that the individual learners have been unable to benefit from fading, until experiencing a longer practicing period than the 80 minutes of the collaborative learning phase during which they mastered the relevant aspects of internal scripts. As another drawback of the current study, the learning environment handled the fading procedure according to a predetermined and fixed time-interval which is not truly adaptive to what happens during learning processes. This, thus, is subject to further examination the 'appropriate' rates of fading process that adapts to the learner's real-time performance in future research efforts.

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