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Epistemic cooperation scripts in online learning environments: fostering learning by reducing uncertainty in discourse?

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Abstract

Using online learning environments in higher education offers innovative possibilities to support collaborative learning. However, online learning creates new kinds of problems for participants who have not previously worked with each other. One of these problems is uncertainty which occurs when participants do not know each other. According to the uncertainty reduction theory, low uncertainty level increases the amount of discourse and decreases the amount of information seeking. Therefore, uncertainty may influence online discourse and learning. This study investigates the effects of an epistemic cooperation script with respect to the amount of discourse, information seeking and learning outcomes in collaborative learning as compared to unscripted collaborative learning. The aim was also to explore how and what kind of information learners seek and receive and how learning partners react to such information exchange. The participants were 48 students who were randomly assigned to groups of three in two conditions, one with and one without an epistemic script. The results indicate that the epistemic script increased the amount of discourse and decreased the amount of information seeking activities. Without an epistemic script, however, learners achieved better learning outcomes. The results of two qualitative case-based analyses on information seeking will also be discussed.

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29 *Keywords:* Collaborative learning; Online learning environment; Uncertainty reduction theory; Cooper-
30 ation script; Amount of discourse; Information seeking

31

32 1. Introduction

33 Online learning environments can, for example, enhance collaborative learning in
34 higher education by providing shared workspaces in which learners can work to-
35 gether on authentic problem cases (e.g., Strijbos, Kirschner, & Martens, 2004). How-
36 ever, online learning environments do not guarantee that learners will interact with
37 each other (Kreijns, Kirschner, & Jochems, 2003). People participating in online
38 learning courses often do not know each other and are unsure how to act in these
39 learning environments. In initial interaction situations there is some degree of uncer-
40 tainty (Berger & Bradac, 1985; Berger & Calabrese, 1975), and online, often physi-
41 cally distanced learning environments lack immediate feedback and non-verbal cues,
42 which might further increase uncertainty (e.g., Järvelä & Häkkinen, 2002; Roschelle
43 & Pea, 1999).

44 Uncertainty can appear at two different levels: at the socio-emotional level and at
45 the epistemic level (Mäkitalo, Pöysä, & Häkkinen, 2003). At the socio-emotional le-
46 vel uncertainty can occur, for example, when participants do not get immediate feed-
47 back on how others are reacting to their messages, whether they agree or disagree
48 with one's suggestions and how they will organize their joint work. At the epistemic
49 level, participants may be uncertain about the content-wise quality of their contribu-
50 tions: Are their contributions relevant regarding the issue? Do the learning partners
51 understand the content of the message (see Beers, Boshuizen, Kirschner, & Gijssela-
52 ers, this issue)? Due to the novelty and the complexity of its social context, online
53 collaborative learning courses can be regarded as a highly uncertain form of commu-
54 nication, in which learners may need additional support to reduce uncertainty.

55 One of the goals of the research presented here is to investigate discourses of on-
56 line learning environments with the help of the uncertainty reduction theory (Berger
57 & Bradac, 1985). This theory suggests that a high degree of uncertainty may hinder
58 participants from effectively communicating with each other with respect to attaining
59 shared goals (e.g., solving a problem together). In communication science, Berger
60 and his colleagues (Berger & Bradac, 1985; Berger & Calabrese, 1975) have devel-
61 oped the *uncertainty reduction theory*, seeking to explain how uncertainty affects
62 communication. Originally, this theory was not related to online learning. The
63 important components of this theory, which we are applying here to online learning,
64 are *uncertainty*, *amount of discourse*, and *information seeking*. Berger and his col-
65 leagues show that as the amount of verbal communication in initial interaction sit-
66 uations increases, the level of uncertainty decreases. Furthermore, as uncertainty is
67 reduced, the amount of verbal communication increases. They also point out that
68 information-seeking behavior is increased in uncertain situations. As uncertainty is

69 reduced, information-seeking behavior decreases (Berger & Bradac, 1985; Berger &
70 Calabrese, 1975). Therefore, uncertainty may influence online discourse. However,
71 the relationship between uncertainty and uncertainty reduction activities (e.g., infor-
72 mation seeking), with learning outcomes has not yet been systematically
73 investigated.

74 In collaborative learning environments, specific forms of discourse are consid-
75 ered important for learning. The kind of discourse in which participants ask certain
76 types of questions, evaluate suggestions, elaborate explanations and justifications,
77 hypothesize and summarize the ongoing discourse, seems to be especially effective
78 for learning in collaborative situations (King, 1999; Webb, 1989). Information
79 seeking itself does not necessarily foster collaborative learning, but it can be seen
80 as a mediator to learning processes, from comprehension to knowledge construc-
81 tion (King, 1999). According to King (1999), open-ended and thought-provoking
82 questions enhance the discourse, because they provoke explanations and reasons.
83 Elaborating explanations to learning partners is a good predictor of responder's
84 achievement (Webb, 1989). King (1999) points out that comprehension questions
85 are not very thought provoking, because they are memory-based and ask learners
86 only for recall of the presented material. Responding to comprehension questions
87 requires a learning partner to reformulate definitions and descriptions by para-
88 phrasing them in their own words, which enhances the responder's own thinking
89 and learning. On the other hand, learning takes place when the information seeker
90 receives the relevant help and understands it and has an opportunity to elaborate
91 the received information (Webb, 1989). The discourse pattern which includes infor-
92 mation seeking, responding to information seeking and receiving requested infor-
93 mation, is seen as an important process for collaborative learning (King, 1999;
94 Webb, 1989).

95 The activities of collaborative learning, such as knowledge articulation, expla-
96 nations, argumentation and other demanding epistemic activities can be supported
97 in different ways by communication tools and shared workspaces in online learn-
98 ing environments (e.g., Häkkinen, Arvaja, & Mäkitalo, 2004; Strijbos et al.,
99 2004). One of the recent approaches to facilitate online collaborative learning
100 at the process level is to provide learners with cooperation scripts that specify
101 and sequence their collaborative learning activities (Dillenbourg, 2002; Kollar,
102 Fischer, & Hesse, 2003; Weinberger, 2003). Cooperation scripts (i.e., a set of rules
103 that prescribe the way learners should interact with each other and collaboratively
104 work on a task) have been found to facilitate collaborative learning activities in
105 face-to-face learning environments (O'Donnell, 1999). Prior to collaborative learn-
106 ing, learners are verbally instructed to engage in specified activities at certain
107 times. In the context of online collaborative learning, the script is represented
108 by the interface design instead of verbal instructions and training. The interface
109 specifies and sequences activities during the actual collaborative learning phase,
110 for instance, by prompting learners to answer specific questions (Weinberger,
111 2003). Beers et al. (this issue) present an example of a tool, which scripts online
112 negotiation of meaning.

Typically, scripts give a complex set of instructions to collaborative learners with respect to several goal dimensions. The prototypical script of O'Donnell and Dansereau (1992), for instance, supports meta-cognitive and elaborative activities of collaborative learners. This script for text comprehension asks learners to read through paragraphs, repeat them in their own words, mutually monitor these summarizations for mistakes, and elaborate the given text. Scripts may also aim at specific process dimensions of collaborative learning, for example, to particularly support epistemic activities. An epistemic cooperation script aims to facilitate cognitive processes by providing collaborative learners with a strategy to solve a task. On one hand, epistemic scripts may enhance collaborative activities such as explaining (Coleman, 1998), questioning (e.g., Ge & Land, 2002; Hron, Hesse, Cress, & Giovis, 2000), and expert-like problem-solving behavior (Dufresne, Gerace, Thibodeau Haridiman, & Mestre, 1992). On the other hand, epistemic scripts may disturb epistemic activities if the scripts are too detailed (Baker & Lund, 1997; Dillenbourg, 2002) if they underestimate expert learners' capabilities (Cohen, 1994; Salomon & Globerson, 1989), or if they overrate novice learners' resources (Dansereau, 1988). One of the major questions in this field is to what extent interaction should be structured on an epistemic level in order to support the way learners cope with the uncertain situation of online learning.

2. Aim of this study

The aim of this study was to investigate the effects of an epistemic cooperation script on the amount of discourse, information seeking and individual learning outcomes in collaborative learning. More specifically, the following research questions were addressed:

Research question 1: *What effects does an epistemic script have on the amount of discourse in collaborative learning compared to unscripted collaborative learning?*

Based on the uncertainty reduction theory the following hypothesis was formulated. Hypothesis 1: *The epistemic script will increase the amount of discourse.* Based on the uncertainty reduction theory, we assume that it may be possible to reduce uncertainty by providing a specific task strategy with an epistemic script. Therefore, we expected that the epistemic script would increase the amount of discourse.

Research question 2: *What effects does an epistemic script have on the amount of information seeking in collaborative learning compared to unscripted collaborative learning?*

Hypothesis 2: *The epistemic script will reduce information seeking.* According to the uncertainty reduction theory, low uncertainty decreases information seeking. The theory also predicts that in highly uncertain situations participants seek more information. As the epistemic script is expected to reduce uncertainty, we assumed that the epistemic script would also lessen information seeking.

Research question 3: *What effects do epistemic scripts in collaborative learning have on individual learning outcomes in comparison to unscripted collaborative learning?*

154 So far, the uncertainty reduction theory does not provide a basis for hypotheses
155 on how uncertainty may be related to individual learning outcomes. Therefore, we
156 formulate the following explorative research questions that will be addressed using
157 a qualitative approach.

158 Research question 4: *How and what kind of information do learners seek?*

159 Research question 5: *How do learning partners react to information seeking?*

160 Research question 6: *How do information seekers react to the received information?*

161 3. Method

162 3.1. Participants and design

163 Participants in this study were 48 students at the University of Munich in their
164 first semester of educational sciences in an introductory course. They were randomly
165 grouped into triads ($N = 16$), and each triad was randomly assigned to one of the
166 two experimental conditions. The first experimental condition was the *epistemic*
167 *script* condition. The second experimental condition was the *unscripted* condition.
168 Time-on-task was held constant in both conditions. In order to preserve anonymity,
169 participants came from three different seminars and were given code names during
170 the learning session.

171 The results regarding the individual learning outcome data were part of an earlier
172 overview paper (Weinberger, Ertl, Fischer, & Mandl, in press). However, all process-
173 related data as well as their qualitative and quantitative analyses are original and
174 were not part of the Weinberger et al. overview.

175 3.2. Procedure

176 Students were placed in three separate rooms, and communicated with each other
177 via the online learning environment. First, the students' prior knowledge was tested
178 individually by means of a problem case. This test was used to control that the rand-
179 omization was successful. Second, the students were given 15 min to read a text
180 about [Weiner's attribution theory \(1985\)](#). Third, the online learning environment
181 was shortly introduced to the students. Fourth, an 80-min collaboration phase
182 started. At the end of the session the students took a post-test based on another
183 problem case.

184 3.3. Task and experimental conditions

185 Students worked together by applying theoretical concepts of attribution theory
186 ([Weiner, 1985](#)) to three problems presented in the online environment. These three
187 authentic cases were the central elements in the online learning environment (see
188 [Fig. 1](#) for a complete description of the "Math case"). The "Class case" described
189 a teacher who explained poor performance in natural sciences based on gender,

You participate in a school counselling as a student teacher of a high school with Michael Peters, a pupil in the 10th grade.

“Somehow I begin to realize that math is not my kind of thing. Last year I almost failed math. Ms Weber, who is my math teacher, told me that I really had to make an effort if I wanted to pass 10th grade. Actually, my parents stayed pretty calm when I told them. Well, mom said that none of us is ‘witty’ in math. My father just grinned. Then he told that story when he just barely made his final math exams with lots of copying and cheat slips. ‘The Peters family’, Daddy said then, ‘has always meant horror to any math teacher.’ Slightly cockeyed at a school party, I once have told this story to Ms Weber. She said that this was bad excuse, but good one either. Just an excuse that is, and you could come up with some more to justify to be bone idle. Last year barely made it, but I am really anxious about the new school year!”

Fig. 1. One of the three problem cases (Math case).

190 and the “Asian case” asked to interpret school performance differences between
191 Asian and American/European students using the attribution theory.

192 Students analyzed and discussed the problems via online discussion boards within
193 the groups of three students. In the online environment there were three online dis-
194 cussion boards, one for each problem.

195 The collaborative learning session in each condition lasted for 80 min. In the un-
196 scripted condition students were not provided with support to solve the three cases.
197 In the epistemic script condition, participants were guided to apply theoretical con-
198 cepts to problems with the help of prompts (see Fig. 2). The prompts were meant to
199 support the participants in identifying of the relevant problem information and
200 applying the concepts of the attribution theory to the given problem information.

Case information, which can be explained with the attribution theory:

Relevant terms of the attribution theory for this case:

- Does a success or a failure precede this attribution?
- Is the attribution located internally or externally?
- Is the cause for the attribution stable or variable?
- Does the concerned person attribute himself/herself or does another person attribute him/her?

Prognosis and consequences from the perspective of the attribution theory:

Case information which cannot be explained with the attribution theory:

Fig. 2. Prompts of the epistemic script to apply the concepts of the attribution theory of Weiner (1985) to the problem cases.

Ihre Aufgabe:
Diskutieren Sie die drei Fälle vor dem Hintergrund der Attributionstheorie und erstellen Sie mindestens eine abschließende Analyse zu jedem Fall.
Schreiben Sie eine erste Analyse des Falls Asien mit Hilfe der inhaltlichen Checkliste!
Zeitvorgabe: 10 Minuten
Darin verbleiben noch 4 Minuten

Fall Asien

In einem Seminar erfahren Sie von einer Studie, in der festgestellt wurde, dass asiatische Kinder gegenüber amerikanischen und auch europäischen Kindern wesentlich bessere mathematische Leistungen erbringen. Interessanterweise zeigte sich auch, dass sich die asiatischen Kinder hinsichtlich ihrer Begabung kaum von den amerikanischen und europäischen Kindern unterscheiden. In der Studie hat man dann sowohl die Schüler, als auch deren Eltern befragt, wie sie sich Erfolg und Misserfolg in naturwissenschaftlichen Schulfächern erklären. Dabei hat sich gezeigt, dass die asiatischen Eltern und Kinder vor allem günstigere Attributionsmuster im Hinblick auf die Dimensionen der Stabilität haben. Wie lassen sich die Leistungsunterschiede aus der Perspektive der Attributionstheorie erklären?

MIT DER ATTRIBUTIONSTHEORIE ERKLÄRBARE FALLINFORMATIONEN:

FÜR DIESEN FALL RELEVANTE BEGRIFFE DER ATTRIBUTIONSTHEORIE:

- GIBT DER ATTRIBUTION EIN ERFOLG ODER EIN MISSEFOLG VORAUSS?
- IST DIE LOKALITÄT DER ATTRIBUTION INTERNAL ODER EXTERNAL?
- WIRD AUF EINE STABILE ODER EINE VARIABLE URSACHE ATTRIBUIERT?
- ATTRIBUIERT DER BETROFFENE SELBST ODER WIRD VON AUSSEN FREMD ATTRIBUIERT?

PROGNOSE UND PÄDAGOGISCHE KONSEQUENZEN AUS DER PERSPEKTIVE DER ATTRIBUTIONSTHEORIE:

NICHT MIT DER ATTRIBUTIONSTHEORIE ERKLÄRBARE FALLINFORMATIONEN:

Fig. 3. The learning environment with orientation map, case description, and text window with prompts.

201 They included questions and proposals for pedagogical interventions regarding the
202 problem.

203 3.4. Online learning environment

204 The online learning environment can be used via the World Wide Web (WWW),
205 and it is built on standard html-format web-pages. The environment is a password
206 protected website in which three learners can post messages (see Fig. 3). In the upper
207 left corner of the screen learners find a task description and a timer, which can be
208 modified and adapted to different settings of the learning environments.

209 In the lower left corner there is a map of the three discussion boards, which should
210 facilitate orientation. The current discussion board is marked with a red X. On the
211 screen, there is also a description of the problem cases. Below the case information a
212 text message can be typed in text windows. In the epistemic script condition the text
213 windows of initial messages are pre-structured with prompts, to which learners are
214 supposed to react (see Fig. 3). After learners have sent in their contributions they
215 can access an overview page of the individual online discussion boards. Discussions
216 form a threaded structure in the overview page, which is typical for standard discus-
217 sion boards.

218 3.5. Data sources and instruments

219 The written discussion data consisted of 16 group discussions (including three
220 problem solving cases) from eight groups in two different conditions. We approached
221 the data both quantitatively and qualitatively. Both quantitative and qualitative ap-
222 proaches as well as theory-based and data-driven approaches may complement each

223 other (Häkkinen, Järvelä, & Mäkitalo, 2003). The use of different methods allows the
224 researcher to examine different facets of a phenomenon in a more holistic way
225 (Tashakkori & Teddlie, 1998). The data was aggregated and analyzed at the group
226 level.

227 First, we segmented the discourse corpora into propositions. Agreement between
228 two coders in identifying these units of analysis was acceptable ($K = 0.72$). In the
229 quantitative procedure we used word counts of all messages within groups in order
230 to measure the amount of discourse. Information seeking was analyzed with the help
231 of the social modes of co-construction dimension in the “Coding system of a multi-
232 level analysis of knowledge co-construction” (Weinberger, Fischer, & Mandl, 2002;
233 $K = 0.81$). If a learner aimed to get a response from the learning partners, this at-
234 tempt was classified as information seeking. This is typically done by asking ques-
235 tions, for example, “What do you mean by that?”.

236 The post-test based on a problem case measured individual learning outcomes.
237 The problem case involved a university student who failed a course, a first for him
238 and explained his poor performance as being related to a lack of talent, while 50%
239 of the students also failed that same course. Students were given 10 min to analyze
240 the problem case without Weiner’s theoretical text. Several concepts of attribution
241 theory were needed to solve the individual problem cases. Applicable knowledge
242 was measured on the basis of the amount of adequate relations between theoretical
243 concepts and case information in the solution. The relations made between theoret-
244 ical concepts and case information were identified as adequate with respect to the
245 theoretical text and an expert solution. Six central relations between theoretical con-
246 cepts and case information were identified for the students’ post-test analyses. These
247 six central relations were (1) A failure precedes the attribution, (2) “A lack of talent”
248 is an internal attribution, (3) “A lack of talent” is a stable attribution, (4) “A lack of
249 talent” is an attribution on ability, (5) “Talent” equals ability and, (6) “50% failures”
250 can be attributed to task difficulty. The effects of the epistemic script on the amount
251 of discourse, information seeking and individual learning outcomes were tested for
252 statistical significance with a t test for unpaired samples. The α -level was set to 5%
253 for every t test.

254 We also studied the ongoing discourse with the help of case-based analyses. Two
255 case-based analyses from different conditions were chosen for more detailed qualita-
256 tive analysis. The discourses were translated from German to English, and the writ-
257 ten mistakes and format were kept as similar as possible in comparison to the
258 original discourse.

259 The qualitative analysis was partly theory driven (Berger & Bradac, 1985; Berger
260 & Calabrese, 1975; King, 1999; Webb, 1989) and partly data driven. We narrowed
261 our focus of the qualitative analyses of both case-based analyses to information seek-
262 ing processes only. The information seeking units were identified by quantitative
263 analysis, while the qualitative content analysis was completed in exploring both
264 the way learners seek information and the type of information they seek. We also
265 investigated the way in which the learning partners react to information seeking
266 and how information seekers react to the received information. This approach pre-

267 serves the group as the primary unit of analysis (Barron, 2003). By focusing on the
 268 group, we explored interaction that captures the dynamic interplay of information-
 269 seeking discourse between the participants and the types of contributions they make.
 270 At the first round, we found out four different information seeking types: seeking (1)
 271 facts (e.g., “Where does the information in the newspaper come from?”), (2) ideas (e.g.,
 272 “Do you have an idea here?”), (3) opinions (e.g., “Do you think that this is part of
 273 it?”), and (4) verifications (e.g., “But isn’t it actually about the laziness of the
 274 boy?”). Further, we identified two different ways to seek information. The direct
 275 way for seeking information was asking questions (e.g., “What do you mean by
 276 that?”). Participants also used indirect information seeking and they did it mostly
 277 by isolated question marks (e.g., “????”) or claims followed by a question mark in
 278 brackets (e.g., “Stable. (?)”). Two types of reactions were defined, response (a reply)
 279 and no response (no reply) at all. Finally, the analysis focused on the response to re-
 280 ceived information, if information seekers elaborated on the offered information.

281 4. Results

282 In this section, the quantitative results will be presented. Subsequently, the case-
 283 based analyses will be portrayed.

284 4.1. The amount of discourse, information seeking and individual learning outcomes

285 Our first research question was to study the effects an epistemic script has on *the*
 286 *amount of discourse* in collaborative learning compared to unscripted collaborative
 287 learning. The amount of discourse was higher in the epistemic script condition than
 288 in the unscripted condition (see Table 1). A *t* test revealed a significant effect for the
 289 epistemic script, $t(15) = 2.67$, $p < 0.05$ (one-tailed). As expected, the epistemic script
 290 increased the amount of discourse.

291 The second research question was to study the effects that an epistemic script has
 292 on *information seeking* in collaborative learning in comparison to unscripted collab-
 293 orative learning. The results show that learners sought information in the epistemic
 294 script condition less often than in the unscripted condition (see Table 1). A *t* test re-
 295 vealed a marginally significant effect of the epistemic script, $t(15) = 1.57$, $p < 0.10$
 296 (one-tailed). These results only partly support the hypothesis that the information

Table 1

Means and standard deviations for the amount of discourse and information seeking in the unscripted and the epistemic script groups

Groups:	Unscripted		Epistemic script	
	<i>M</i>	SD	<i>M</i>	SD
Amount of discourse	17.44	4.95	24.85	6.10
Information seeking	6.75	5.85	3.00	3.38

297 seeking scores should be lower in the epistemic script condition, and such findings
298 should be interpreted with caution.

299 Finally, the results show that *individual learning outcomes* were higher in the un-
300 scripted condition than in the epistemic script condition (Fig. 4). There were signif-
301 icant differences between the learning outcomes in the unscripted condition in
302 comparison with the epistemic script condition, $t(15) = 2.50$, $p < 0.05$ (two-tailed).

303 4.2. Case-based analyses on information seeking

304 Two case-based analyses were conducted to further explore the relation of infor-
305 mation seeking and learning. The qualitative analysis focused on exploring how and
306 what kind of information learners seek and how learning partners react to the infor-
307 mation seeking and the received information. The selection of these two cases (one of
308 each condition) is based on the quantitative results with respect to the amount of dis-
309 course, information seeking and individual learning outcomes. The epistemic script
310 group of three students represents a typical case with a high amount of discourse
311 (number of words), but low individual learning outcomes. The unscripted group
312 of three students was selected for its high level of information seeking and high indi-
313 vidual learning outcomes.

314 Every excerpt is accompanied by information pertaining to which of these three
315 problem cases were involved, the order number of the message, the time the message
316 was sent, and who sent it (see Fig. 5; *explanation is in italics*). A previous message,
317 when included in the new message by the sender, is marked with a '>' at the begin-
318 ning of the sentence. Original and new messages have no marks, except for the line
319 numbers. The prompts included in epistemic script conditions are shown in capital
320 letters.

321 The sentences that are referred to in the analyses are marked in italics in the ex-
322 cerpts. In order to improve readability, the messages are also cut short, which is
323 marked with three dots.

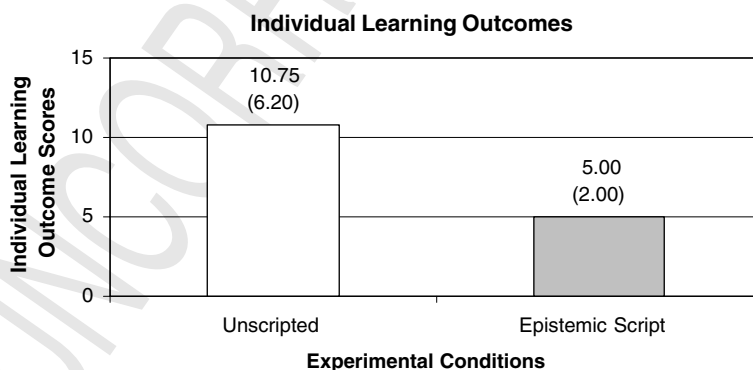


Fig. 4. Means and standard deviations scores of individual learning outcomes in unscripted and epistemic script conditions.

Excerpt X. **M** (the letter code addresses different cases; M= Math case, A= Asian and C= Class case) **23** (the order number of message in the particular case discussion board meaning, for instance, the 23rd message that has been sent in this discussion board); **14:04:13** (time when the message was sent); **Maria** (and by whom)

- 1..>So Michael gives a reason for his bad math by an internally, stable
2. >attribution, so he just not as able as his parents. The teacher's opinion is that
3. >it is just laziness = internal variable effort
(the '>'-mark indicates that the previous message is being quoted)
- ... (three dots mean that a part of the original message has been left out)
4. I think that Michael doesn't blame himself, but his inherited genes.
5. Can you then really label this as an internal stable attribution?
(the original message has no marks, except the line numbers)
(line numbers help to point out the important allusions)

Fig. 5. Explanations of the abbreviations and format aspects of the excerpts which are presented in the case-based analysis.

324 *Unscripted group.* This group sent 88 messages during the conference in three dif-
 325 ferent online case boards. In the Math case board there was a total amount of 46
 326 messages, in the Class case board 29 and in the Asian case board 13 messages.
 327 The unscripted group started to work at 14:53, and the first message was sent to
 328 the Math board after 11 min from the start. The last message was sent to the Class
 329 case board at 15:13.

330 In the unscripted group, the members sought information by using questions. The
 331 questions focused on seeking ideas (see Excerpt 1, line 1) and verifications (Excerpt 2,
 332 line 4). In Excerpt 1, Birgit pointed out that time was running short, and she re-
 333 quested that the learning partners explore some new *ideas* to solve and complete
 334 the math case.

335 Excerpt 1. M33; 14:22:13; Birgit

336 1. (Half the time is nearly gone!) *Can you think of anything else about this analysis?...*

337
 338 There were also questions focusing on *verifying* definitions (see Excerpt 2, line 4).
 339 This particular discussion thread (includes Excerpts 2–6) presents how one of the
 340 learning partners was seeking verification (Excerpt 2, line 4), how the other learning
 341 partner was responding to information seeking (Excerpt 3, lines 1–2) and how the
 342 information seeker was reacting to the received information (Excerpt 4, line 1). This
 343 example also shows how the learning partner had offered the information reacted the
 344 information seeker's response (Excerpt 5, line 1) and how the third learning partner
 345 was also joining into the discourse by elaborating the offered information (Excerpt 6,
 346 line 1). The participants were discussing the internal stable attribution. Maria
 347 doubted (see lines 3–4) that one could diagnose an internal stable attribution in this
 348 case and she wanted to verify definitions and see if Stefanie shared her point of view
 349 (see lines 1–2).

350 Excerpt 2. M23; 14:04:13; Maria...

351 1. >So Michael gives a reason for his bad math by an internal, stable attribution, so
352 he is

353 2. >just not as able as his parents.

354 3. *I think that Michael doesn't blame himself, but his inherited genes.*

355 4. *Can you really label this as an internal stable attribution?*

356

357 In her reply, Stefanie backed up her earlier statement and explained the reason
358 why it can be seen as an internal stable attribution (see Excerpt 3, lines 1–2).

359 Excerpt 3. M24; 14:10:26; Stefanie

360 1. *Yes, you can. He says he isn't talented and talent is an internal cause.*

361 2. *Which is stable. You can't assume that he will be more talented later.*

362

363 Maria supported and accepted Stefanie's explanation, and then she pointed out a
364 new issue by mentioning training (Excerpt 4, lines 1). In her reply, she elaborated the
365 received information.

366 Excerpt 4. M25; 14:15:37; Maria

367 1. *Yes, that's right! Unless training would make him see that his bad performance in*

368 *2. math doesn't attribute to talent.*

369

370 After this, Stefanie supported and accepted Maria's idea about the training (Ex-
371cerpt 5, line 1).

372 Excerpt 5. M26; 14:24:00; Stefanie

373 1. *That is finally a good idea. He should simply do reattribution training.*

374

375 Birgit was also joining the discussion, adding another issue concerning the train-
376ing and the parents (Excerpt 6, line 1). In the ongoing discourse she used the oppor-
377tunity to elaborate the received information sought by the other group member.

378 Excerpt 6. M27; 14:29:41; Birgit

379 1. *And so should the parents.*

380

381 In another situation, Stefanie states that she did not understand an internal stable
382 attribution of others (see Excerpt 7, lines 3–4), which was mentioned by Maria. She
383 was making reference to Maria's earlier message (lines 1–2).

384 Excerpt 7. C9; 14:44:18; Stefanie

385 1. >In this case, I would talk about internal stable attribution of others, which of
386 course.

387 2. >expands – to self attribution. Finally the girls adopt the public opinion.

388 3. *What about an internal stable attribution of others?*

389 4. *I don't understand that*

390

391 It was Birgit who was replying to Stefanie's message and explaining to her about
392 the attribution of others (Excerpt 8, lines 1–5).

393 Excerpt 8. C10; 14:52:53; Birgit

394 1. *You are right. I think that there isn't one anyway.*

395 2. *attribution from the parents and teachers, who encourage the girls in their opinion*

396 3. *that they are not as talented as the boys. This becomes internal stable self-attribution*

397 4. *and can probably be solved – according to attribution theory – with reattribution*

398 5. *Training.*

399

400 Summing up, this group sought information by asking questions regarding ideas
401 and by verifying definitions. The learning partners reacted to information seeking by
402 responding to a message. The information seekers, but also the learning partners
403 who were not seeking this information in the first place responded to the received
404 information by elaborating it. The information seeking processes of this group in-
405 cluded information request, response and reception.

406 *Epistemic script group.* This group sent 27 messages during the conference in three
407 different case boards. In the Math case board there was a total of 11 messages, in the
408 Class case board 7 and in the Asian case board 9 messages. The first message was
409 sent at 14:12 to the Math case board, but during this 80-min online conference the
410 messages appeared irregularly in different boards. The last message was sent to the
411 Class case board at 15:20. In this group, with the help of prompts (see Fig. 1), the
412 learners analyzed the cases and used the prompts regularly.

413 Here the members were seeking facts (Excerpt 9, lines 1–2), ideas (Excerpt 10, line
414 1), opinions (Excerpt 11, line 5), and verifications (Excerpt 12, line 2). In Excerpt 9
415 (lines 1–2), Susanne sought *facts* by asking where the information was available and
416 who the writer of the newspaper article was.

417 Excerpt 9. C4; 14:33:10; Susanne. . .

418 1. *Where does the information in the newspaper come from?*

419 2. *Who has said this?*

420

421 Julia analyzed the Math case, but apparently she was not able to respond to the
422 last prompt, which asked for case information that cannot be explained with the
423 attribution theory, so she asked if her learning partners had any *ideas* (see Excerpt
424 10, line 1).

425 Excerpt 10. M1; 14:12:37; Julia. . .

426 1. *do you have an idea here? i do not so far! i am looking forward to answers*

427

428 In Excerpt 11 (see line 3), Julia asked if her learning partners shared the *opinion*
429 about training that cannot be explained with the attribution theory.

430 Excerpt 11. C3; 14:32:35; Julia

- 431 1. girls are thinking about their abilities different from boys!
 432 2. reinforced by parents and teachers!
 433 3. training with girls: *do you think that this is part of it?*

434
 435 Katrin wanted Susanne to explain why she had referred to a stable attribution in
 436 her previous message and added her own opinion that the attribution was more vari-
 437 able in this case (see Excerpt 12, 1–3). Despite this clear disagreement uncovered by
 438 Katrin, Susanne did not reply to this *verification* question.

439 Excerpt 12. M5; 15:03:30; Katrin

- 440 1. I thought he was more skeptical than really excited.
 441 2. *But isn't it actually about the laziness of the boy?* You can stop the laziness and so
 442 3. it is variable.

443
 444 The group members seemed to adopt different styles to seek verifications. They
 445 were using question mark after claims or isolated question marks without any sen-
 446 tence (see Excerpt 13, lines 1 and 4 and Excerpt 14, lines 4 and 6) for seeking veri-
 447 fications from the others instead of using direct questions.

448 Excerpt 13. M3; 14:21:03; Susanne...

- 449 1. Internally: Michael thinks math is not his thing, *lack of interest (?)*.
 450 2. CASE INFORMATION WHICH CANNOT BE EXPLAINED WITH THE
 451 3. ATTRIBUTION THEORY:
 452 4. ????

453
 454 Excerpt 14. A4; 14:52:28; Katrin

- 455 1. CASE INFORMATION WHICH CAN BE EXPLAINED WITH THE
 456 2. ATTRIBUTION THEORY: ...
 457 3. But all children are equally gifted. *Asians are thinking that reasons are temporally*
 458 4. *stable(?)*.
 459 5. - IS THE CAUSE FOR THE ATTRIBUTION STABLE OR VARIABLE? ...
 460 6. *Stable. (?)* ...

461
 462 Excerpt 10 includes an example of seeking ideas and Excerpt 15 illustrates how the
 463 learning partners reacted to this question. In Excerpt 10 (line 1) Julia analyzed the
 464 Math case using every prompt in the intended manner, except for the last one. At
 465 the last prompt she sought ideas by asking her learning partners if they had any ideas
 466 on this topic. The question also included an invitation to joint discourse, as she told
 467 she was looking forward to reading about their ideas (Excerpt 10, line 1). Julia's
 468 question ("Do you have an idea here?") did not lead the discourse any further to-
 469 wards ideas on the prompt "case information which cannot be explained with the
 470 attribution theory". Instead, one of the learning partners reminded them on organ-
 471 izational issues (See Excerpt 15, lines 1–2).

472 Excerpt 15. M2; 15:07:31; Katrin

473 1. *Hi guys, we need a summary!!!!!!!!!!!!!!!!!!!!!!*

474 2. *I will quickly write something for this case, won't I!*

475

476 Katrin announced that they needed to quickly write a summary (see line 1), be-
477 cause the time was up. This response did not offer any relevant information for Ju-
478 lia's information seeking. The third member did not even reply to Julia's request.

479 In Excerpt 16 (lines 3 and 6) Susanne was doing an analysis about the Asian case,
480 and she did not present any direct questions, but used question marks at the end of a
481 phrase and then at the end of the last prompt. She got two replies for that message,
482 one from Katrin (Excerpt 17, lines 1–4) and one from Julia (Excerpt 18, lines 1–22).
483 Both answers were connected to the content of the previous message.

484 Excerpt 16. A1; 14:43:07; Susanne. . .

485 1. RELEVANT TERMS OF THE ATTRIBUTION THEORY FOR THIS CASE:

486 2. - DOES A SUCCESS OR A FAILURE PRECEDE THIS ATTRIBUTION?

487 3. *Success, isn't it? . . .*

488 4. CASE INFORMATION WHICH CANNOT BE EXPLAINED WITH THE

489 5. ATTRIBUTION THEORY:

490 6. ?

491

492 Katrin complained about the case description (Excerpt 17, line 1), but she agreed
493 on the success of Asian children and the reasons as to their success. She also men-
494 tioned that the instructional approaches may be better in Asian countries. It seemed
495 that Katrin was not directly responding to Susanne's indirect questions (question
496 marks), and she ignored the last question, which concerned case information that
497 cannot be explained by the attribution theory.

498 Excerpt 17. A2; 14:57:19; Katrin

499 1. *The text is shit, isn't it? But I have to agree that in the Asian countries much*

500 2. *more effort shows in comparison to us for example they certainly give*

501 3. *much more thought on pedagogy and they know that one has to praise children for*

502 4. *them to be more successful. Probably they won't have to do reattribution.*

503

504 With respect to Katrin's response, Julia commented on most of the ideas Susanne
505 was presenting (Excerpt 18, lines 6, 10–11, 14, 18 and 22). With respect to the second
506 prompt, Julia declared that she was not sure about the idea of success (see lines 10–
507 11), but nobody continued on this point. She also directly posed the question, "*What*
508 *do you mean by that?*" (line 14) but she never got a reply from Susanne. Julia replied
509 to Susanne's question mark in the last prompt at the end of the message by just men-
510 tioning that she did not have an idea on that issue either (see line 22). This example
511 may be seen to indicate that the learning partners did interpret the isolated question
512 marks as information seeking. In this group this kind of indirect information seeking

513 was not very successful, however, as the learning partners responded by offering non-
514 relevant information or did not respond at all.

515 Excerpt. 18. A3; 15:04:49; Julia

- 516 1. >CASE INFORMATION, WHICH CAN BE EXPLAINED WITH THE
517 2. ATTRIBUTION THEORY:
518 3. >How do the parents and pupils explain success and failure in scientific
519 subjects?
520 4. >Asian parents and children have more favorable attribution patterns as far as
521 the
522 5. >dimension of stability is concerned.
523 6. *i could not formulate it better!*
524 7. >RELEVANT TERMS OF THE ATTRIBUTION THEORY FOR THIS
525 CASE:
526 8. >-DOES A SUCCESS OR A FAILURE PRECEDE THIS ATTRIBUTION?
527 9. >Success, isn't it?
528 10. *i think it's both success of the Asian children and failure of American and*
529 *European*
530 11. *children. But I am not fully sure which success is meant ...*
531 12. >- IS THE CAUSE FOR THE ATTRIBUTION STABLE OR VARIABLE?
532 13. >stable, it was mentioned in the text
533 14. *what do you mean by that? where was it mentioned?*
534 15. >- DOES THE CONCERNED PERSON ATTRIBUTE HIMSELF/HER-
535 SELF OR
536 16. >DOES ANOTHER PERSON ATTRIBUTE HIM/HER?
537 17. >He is attributed. The others are searching for a reason for good achievements.
538 18. *exactly! There has been a study on that ...*
539 19. >CASE INFORMATION WHICH CANNOT BE EXPLAINED WITH
540 THE
541 20. >ATTRIBUTION THEORY:
542 21. >?
543 22. *in this regard I don't have any special idea either*

544
545 There were direct information seeking moves such as, “*What do you mean by*
546 *that?*” (Excerpt 18, line 14), or “*But isn't it actually about the laziness of the boy?*”
547 (Excerpt 12, line 2) which can be seen as opportunities to deepen the discourse at
548 the epistemic level, but the learners hardly noticed these opportunities.

549 In summary, the participants of the epistemic script group sought various forms
550 of information such as facts, ideas, opinions and verifications. They sought informa-
551 tion indirectly, and hardly responded to information seeking activities of their learn-
552 ing partners. Therefore, the information seekers did not have a chance to receive and
553 elaborate the information.

554 5. Discussion

555 Based on the uncertainty reduction theory, two hypotheses have been tested on
556 how the levels of uncertainty in scripted and unscripted collaborative learning con-
557 ditions affect the amount of discourse and information seeking. Furthermore, two
558 conditions of collaborative learning with varying degrees of uncertainty have been
559 analyzed with regard to individual learning outcomes. The findings support our
560 hypothesis that the amount of discourse will increase in the epistemic script condi-
561 tion, as suggested by the uncertainty reduction theory. As also hypothesized, infor-
562 mation seeking decreased in the epistemic script condition. The marginally
563 significant effect of the epistemic script on information seeking may be cautiously
564 interpreted as supportive to the hypothesis. With respect to individual learning out-
565 comes, the results further indicate that the unscripted uncertainty condition im-
566 proved learning outcomes.

567 The pattern of results could be regarded as implying that learning environments
568 should provide some degree of uncertainty. With respect to the uncertainty reduction
569 theory, results suggest that uncertainty is not always a barrier to successful interac-
570 tions. Our study shows that some degree of uncertainty with regard to the task may
571 actually enhance learning compared to a highly certain situation. An explanation for
572 this effect might be that uncertainty facilitates beneficial interaction patterns, which
573 includes information seeking. In collaborative learning, information seeking can im-
574 prove discourse when learning partners are responding to information seeking and
575 acting appropriately when receiving information. This kind of discourse pattern is
576 known to enhance individual learning outcome (e.g. King, 1999; Webb, 1989).

577 The qualitative case-based analyses provided some insights that may inform the
578 formulation of hypotheses for future research. While both groups sought various
579 forms of information, such as ideas and verifications, they took different steps with
580 respect to information seeking, responding to information seeking and receiving
581 information. In this study the unscripted group sought information in a direct and
582 successful manner, while the scripted group sought information more indirectly
583 and less successfully. Participants in the epistemic script group were less active in
584 responding to information seeking. Indirect information seeking with respect to
585 the terminology or the ideas was not successful, as the learning partners were not
586 reacting to them. Therefore, there was little information for the information seekers
587 to receive and elaborate. Participants in the unscripted group, in contrast, sought
588 information more directly by clearly indicating their lack of understanding. They re-
589 sponded to information seeking by providing the information, ideas or verifications
590 that had been asked for. Moreover, the learning partners of the unscripted condition
591 discussed the terminology and definitions more often than the epistemic script group
592 did. The participants in the unscripted group also elaborated the received informa-
593 tion. It should be noted, that using a combination of qualitative and quantitative
594 analyses helped in obtaining detailed information regarding processes of online inter-
595 action and in revealing unexpected results of the pedagogical structuring of online
596 learning.

597 A potential limitation of the study, however, is that no subjective measure of
598 uncertainty was used. Therefore, the assumption that the script reduced the subjective
599 experienced uncertainty cannot be directly supported by the data. Further research
600 should include subjective measures of uncertainty. Uncertainty measurement
601 approaches are used, for example, in social psychology (Budescu, Rapoport, & Sulei-
602 man, 1990; Gärling, Biel, & Gustafsson, 1998) and in the clinical and health policy
603 (Balsa, Seiler, McGuire, & Bloche, 2003; McCormick, 2002). These approaches
604 might be adapted to applications in the field of collaborative learning in higher edu-
605 cation and online learning contexts.

606 Another possible shortcoming of the study is the operationalization of uncer-
607 tainty, as the control condition included a number of structural elements (e.g., task
608 description, cases, theory text, threaded discussion boards) that themselves might
609 have substantially reduced uncertainty. There are online environments with much
610 less structured task descriptions and we cannot rule out the possibility that the used
611 epistemic scripts would have more positive effects there. Another possible limitation
612 with respect to the epistemic script might be that it perhaps restricted the learners too
613 much, in the sense that its prompts were rather closed questions and therefore not
614 very strong in facilitating elaborative processes (see Dillenbourg, 2002, for a discus-
615 sion on the notion of coercion). Future research may focus on multiple and more ex-
616 treme levels of uncertainty to further explore a presumably non-linear relationship
617 between uncertainty or degrees of freedom in an online collaborative learning envi-
618 ronment and individual learning outcomes.

619 A final limitation worth mentioning might be the focus on the cognitive aspects of
620 processes and outcomes. Crucial problems concerning interaction in online learning
621 environments may also occur at the social and emotional levels (see also Gunawar-
622 dena, 1995). Kreijns, Kirschner, Van Buuren, and Jochems (2004) point out that the
623 sociability, that is to say, how well the online environments can facilitate the emer-
624 gence of social space will be one crucial contribution to the success of online learn-
625 ing. These are the aspects which need further studies in online learning, but which
626 also can be enriched with the theoretical and empirical analyses of uncertainty reduc-
627 tion theory.

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