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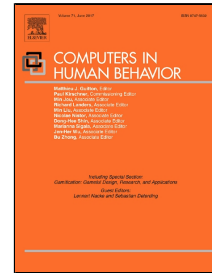
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Highlights

- We studied the effects of scaffolding level on searching for information in videos
- Micro and macro levels have specific effects on navigation and semantic searches
- Combining the two levels of scaffolding facilitates the search activity
- Results are discussed in terms of mental model building with or without scaffolding

Facilitating information-seeking activity in instructional videos:

The combined effects of micro- and macroscaffolding

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The authors certify that there was no financial or personal interest that could have influenced their objectivity in this study.

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Abstract

1
2 With the development of e-learning, and more specifically MOOCs, searching for information in
3 videos is becoming a key activity in education. Many studies have focused on learning in video-
4 based environments, but to our knowledge, they have left aside the question of search tasks. We
5 hypothesized that information-seeking activity can be improved by adapting features of the
6 learning environment, more particularly by providing micro- and/or macroscaffolding. To test
7 this hypothesis, we assessed the effects of presentation during a search activity in a video-based
8 environment. A total of 80 students were divided into four groups, then exposed to a video 1)
9 with or without a table of contents (macroscaffolding), and 2) with or without markers in the
10 timeline (micro-scaffolding). Results showed that micro- and macroscaffolding both have positive
11 effects on search outcomes, but also that they need to be used in combination to improve search
12 times. One possible interpretation is that, in the absence of scaffolding, users have to compensate
13 by constructing their own mental representations of the video segmentation, which is cognitively
14 very costly and highly time consuming.

15
16 *Keywords:* Information seeking, video-based environments, MOOC,
17 scaffolding

19 **Facilitating information-seeking activity in instructional videos: The** 20 **combined effects of micro- and macroscaffolding**

21 **1. Introduction**

22 Videos are increasingly being used in learning, to the point of becoming an integral part
23 of learning environments (Delen, Liew, & Willson, 2014; Giannakos, 2013; Kay, 2012). In

24 parallel, the development of the Internet has considerably widened access to information (Sharit,
25 Hernández, Czaja, & Pirolli, 2008), making it far easier to broadcast videos (Marchionini, 2003).
26 In particular, massive online open courses (MOOCs) offer new educational opportunities, as they
27 are accessible any time and any place (Joseph & Nath, 2013; Yadav et al., 2015). Given their
28 impact, there is a real need to study MOOCs in the education field, for on the most popular
29 platforms, courses can easily attract more than 500 registrations (Hew & Cheung, 2014;
30 Koutropoulos et al., 2012). Many videos are now being created for learning purposes, and more
31 and more research is being conducted on video-based learning (Giannakos, 2013), thus testing
32 many of the features of this particular presentation format (e.g., Arguel & Jamet, 2009; Derry,
33 Sherin, & Sherin, 2014; Ganier & de Vries, 2016; Schwan & Riempp, 2004). Even so, no design
34 standards or guidelines have yet been proposed (Chen & Wu, 2015; Ilioudi, Giannakos, &
35 Chorianopoulos, 2013). The video format has its own specific characteristics and constraints,
36 compared with written and illustrated documents, the most important one probably being the
37 transient delivery of the information (Wong, Leahy, Marcus, & Sweller, 2012). In order to tackle
38 these issues, the effects of video presentation on students' activities need to be investigated,
39 particularly those involved in learning issues. The current study focused on search activity, and
40 exploring the benefits of providing scaffolding to users.

41 **1.1. Information-seeking activity.**

42 **1.1.1. Definition.**

43 Information seeking relies on the ability of users to locate one particular item of
44 information among others, in order to achieve an explicit goal (Guthrie & Mosenthal, 1987).
45 Individuals are continually searching for information, and can now do so using more and more
46 digital devices (Dinet, Chevalier, & Tricot, 2012). Indeed, this problem-solving ability is

47 becoming central in both professional and personal areas of life (Wopereis, Brand-Gruwel, &
48 Vermetten, 2008). The information-seeking process can improve learning and facilitate
49 adaptation to new issues in education (Guthrie & Mosenthal, 1987; Merkt & Schwan, 2014), and
50 its steps (Lazonder & Rouet, 2008) have been described in several theoretical models.

51 **1.1.2. *Models of the information-seeking activity.***

52 Many theoretical models focus on describing and predicting human behavior during
53 information searches, whether in paper or in web documents (e.g., Guthrie & Mosenthal, 1987;
54 Kitajima, Blackmon, & Polson, 2000; Lazonder & Rouet, 2008; Puustinen & Rouet, 2009; Sharit
55 et al., 2008; Wopereis et al., 2008). A common feature of all these models is the localization of
56 information (or sources) and a choice that has to be made by the individual. More specifically, to
57 define the way that an individual searches for information, Sharit et al. (2008) developed a model
58 of the localization activity containing three subprocesses. The first subprocess is the construction
59 of a mental representation of the problem by the searcher. The second subprocess is planning,
60 where the individual generates a method of finding a solution, generally dividing the problem
61 into subgoals. The third subprocess is execution, where the searcher performs the previously
62 planned operations. The current study focused on these three subprocesses, looking at ways of
63 making them more relevant in order to improve the information-seeking activity. One solution
64 may be to adapt the video presentation format, in order to act upon the user's mental model and
65 simplify the execution of the procedure.

66 **1.1.3. *The role of a relevant mental model.***

67 Mental models are constructed by users during their interaction with the environment
68 (which can be a video-based environment). They represent the structure of the system and have a
69 predictive and explanatory power (Borgman, 1986; Norman, 1983; Storey, Fracchia, & Müller,

70 1999). Users need mental models to anticipate their actions upon a system before they interact
71 with it (Rowe & Cooke, 1995). Borgman (1986) specifies that if users do not spontaneously
72 construct a mental model, they will need to rely on the provision of a conceptual model.
73 Conceptual models are invented by teachers or designers, and represent the target system
74 (Norman, 1983). Although they are not mental models, they can contribute to their construction.
75 The aim of adapting the video presentation format is to accompany users in their information-
76 seeking activity, in particular scaffolding their mental models of the video system.

77 **1.2. Adaptation of the video presentation format.**

78 Information in videos is delivered transiently, requiring costly and continuous processing
79 in working memory by users, and can therefore lead to a loss of relevant information (Hasler,
80 Kersten, & Sweller, 2007; Merkt, Weigand, Heier, & Schwan, 2011). Consequently, it may be
81 useful to focus on this inherent limitation of video presentation, in order to make them easier to
82 overcome.

83 **1.2.1. *Avoiding a continuous flow of information: microlevel activities.***

84 To deal with the transitory aspect of the information in video-based environments, some
85 authors recommend giving users control over the information flow (e.g., Hasler et al., 2007;
86 Lawless & Brown, 1997; Mayer & Chandler, 2001; Schwan & Riempp, 2004). When faced with
87 complex content, users may want to review some passages or tailor the speed of the video to
88 their cognitive abilities (Merkt et al., 2011). Playing, pausing, rewinding and fast-forwarding a
89 video (Delen et al., 2014) are all described as *microlevel* activities, as they control the processing
90 of information at a local level (Merkt et al., 2011).

91 **1.2.2. *Building structural representations: macrolevel activities.***

92 When users can jump to specific parts of the video, this facilitates their navigation
93 (Zhang, Zhou, Briggs, & Nunamaker, 2006), inevitably leading to better localization of the
94 information (Lorch, Lemarié, & Grant, 2011). For this to happen, users have to learn how the
95 document is structured, which is an important but costly activity (Sanchez, Lorch, & Lorch,
96 2001). The use of *macrolevel* features (table of contents, index, visual organizer, etc) allows this
97 navigation to take place at a more general level than microlevel activities do (Chun & Plass,
98 1996; Merkt et al., 2011). Providing hierarchical cues can therefore lead to hierarchical, rather
99 than linear, encoding of the document's structure, and to better recall of the parts or chapters of
100 the document that are presented (Lorch et al., 2011; Sanchez et al., 2001).

101 **1.2.3. The role of scaffolding.**

102 As indicated above, scaffolding can help to promote information-seeking activities. The
103 various possible ways of acting upon the document, defined under the *learner control principle*
104 (Scheiter & Gerjets, 2007), need support in order to be effective (Scheiter, 2014), and scaffolding
105 can be offered at both micro- and macrolevels of activity. Its goal is to promote the construction
106 of a mental model during an information-seeking activity by providing users with a conceptual
107 model (Norman, 1983). When it takes the form of tools or structures, it supports users'
108 understanding of the document (Azevedo & Hadwin, 2005). This guidance also helps them
109 improve their processing skills, in particular their planning skills (Reiser, 2002, 2004). In 2014,
110 Merkt and Schwan compared the effects of micro- and macroscaffolding during learning and
111 search tasks. Four conditions were tested: enhanced video condition (with micro- and
112 macroscaffolding), common video condition (with microscaffolding), noninteractive video
113 condition, and illustrated textbook condition. Results showed that, in terms of the number of
114 information items found, participants in the enhanced video condition outperformed those in the

115 common video condition, who in turn outperformed those in the noninteractive video condition.
116 However, the authors did not test the effect of macroscaffolding on its own. Moreover, while
117 adding macroscaffolding to microscaffolding (i.e., in the enhanced video) seemed to promote
118 searching activity, only the presence of an index appeared to be predictive of performance, and
119 no effect of table of contents was found. In line with this research, the current study was
120 designed to ascertain the specific effects of micro- and macroscaffolding during information-
121 seeking activity.

122 1.3. The current study.

123 The current experiment was designed to study the potential effects of micro- and
124 macrolevel scaffolding on information seeking in a video-based environment, as well as their
125 interaction when they referred each other. Here, *microscaffolding* took the form of markers along
126 the video's timeline that were intended to foster microlevel activities and thence control over the
127 information flow. *Macroscaffolding* took the form of a table of contents that was intended to
128 foster macrolevel activities and thence general navigation. We assumed that the failure of
129 previous research in this area to demonstrate an effect of table of contents (see Merkt & Schwan,
130 2014) stemmed from the way the scaffolding was presented. The table of contents was not near
131 the video, and users had to click on a button next to the video to display it. The spatial contiguity
132 principle (e.g., Ginns, 2006; Mayer, 2005) states that learning is enhanced when related sources
133 or documents are displayed near to each other on the screen. We can therefore assume that it
134 applies to information-seeking activity in the same way as it does to a learning activity, and that
135 different sources of information (here, levels of scaffolding) should refer to each other within the
136 video-based environment.

137 Regarding the three subprocesses described by Sharit et al. (2008), we assumed that
138 scaffolding would serve as a conceptual model, and thus support mental representations. As for
139 the other two subprocesses (planning and execution,) we assumed that they would be facilitated
140 in two ways by scaffolding: use of an enhanced mental model and direct use of the cues
141 provided. These concrete actions upon a video-based environment can be placed under the
142 heading of *interactivity*, and have already been shown to alleviate users' difficulties in a video
143 browsing task (Zhang et al., 2006). If no conceptual model is provided (or only an incomplete
144 one, where there is only one level of scaffolding), users need more time to construct their own
145 mental model and thus improve their performances. Once the mental model has been created,
146 performances should become just as good as those made possible by the provision of a
147 conceptual model. We therefore decided to take a closer look at this dynamic aspect, by
148 introducing a temporal analysis. To this end, participants were asked nine questions whose
149 answers were all in the video.

150 We made a series of predictions, based on six hypotheses:

151 Hypothesis 1. *Success*: Participants with micro- or macroscaffolding would perform the
152 task better than participants without any scaffolding, especially when there were two levels of
153 scaffolding. Moreover, when there was only micro- or macroscaffolding, or even no scaffolding
154 at all, performances for each question would improve over time, reflecting the construction of a
155 relevant mental model.

156 Hypothesis 2. *Response time*: Participants with micro- or macroscaffolding would spend
157 less time seeking information than participants without any scaffolding. This effect would be
158 greater for participants with two levels of scaffolding. Moreover, when there was only micro- or

159 macroscaffolding, or even no scaffolding at all, the amount of time spent on each question would
160 decrease over time, for the same reason that performances would improve (Hypothesis 1).

161 Hypothesis 3. *Relevance of the first click*: For each search activity (i.e., for each question
162 in the task), participants with micro- or macroscaffolding would make more relevant first clicks
163 (nearer the target segment) than participants without any scaffolding. This effect would be
164 greater for participants with two-level scaffolding. Moreover, when there was only micro- or
165 macroscaffolding, or even no scaffolding at all, the relevance of the first click would increase
166 over time, reflecting the construction of a mental model.

167 Hypothesis 4. *Perceived difficulty*: Participants with micro- or macroscaffolding would
168 perceive the task to be less difficult than participants without any scaffolding. This effect would
169 be greater for participants with two-level scaffolding.

170 Hypothesis 5. *Perceived control*: Participants with microcaffolding would have more
171 perceived control than participants without microcaffolding.

172 Hypothesis 6. *Number of recalled chapters*: Participants with macroscaffolding would
173 recall more chapters of the video than participants without macroscaffolding, owing to the
174 presence of a table of contents.

175

176 **2. Method**

177 **2.1. Participants.**

178 A total of 80 students (59 women, 21 men) from the University of Brittany (France)
179 volunteered to take part in the study. Their mean age was 21.33 years ($SD = 3.05$). They were
180 recruited via advertisements posted across the university. All of them received a cinema ticket

181 for their participation. The experiment was conducted in accordance with the principles of the
182 Declaration of Helsinki.

183 **2.2. Materials and experimental design.**

184 The video we used was taken from the Canal U website (<http://www.canal-u.tv/>). Its topic
185 was *water in the universe* (Doressoundiram, 2012), and it lasted about 13 minutes. According to
186 the website, the video was thematically segmented into 12 chapters.

187 We designed a specific learning environment to display this video (see Fig. 1). A timeline
188 below the video allowed participants to browse it with the mouse as much as they wanted. We
189 used a 2 x 2 factorial design: the video either had or did not have a table of contents
190 (macroscaffolding), and the timeline either did or did not display markers (12 sections
191 corresponding to the chapters; microscaffolding). Next to the computer screen, each participant
192 had a tablet, on which the nine questions for the information-seeking activity were presented. A
193 timer above the question indicated how much time was left to answer. Each question was limited
194 to 5 minutes, and the countdown was launched as soon as the question appeared. A button below
195 the question allowed participants to skip to the next question if they answered in less than 5
196 minutes. The nine questions were presented in a counterbalanced order, in groups of three
197 questions, thus forming three different orders of presentation (1-2-3, 2-3-1 and 3-1-2).
198 Counterbalancing these questions allowed us to analyze a time factor for some variables.
199 Answers were written on nine different sheets of paper placed on the desk. The nine questions
200 were followed by a post-task questionnaire displayed on the computer screen. Questions about
201 perceived difficulty and control were presented in a random order. Participants were randomly
202 assigned to one of the four experimental groups. In the control condition ($n = 19$), participants
203 could use the timeline to browse the video, and could stop the video at any given time (see Fig.

204 1). No table of contents or markers on the timeline were available. There was, however, an
205 indicator of the video's running time and total duration. The participants in the microscaffolding
206 condition ($n = 19$) were exposed to the same material as those in the control condition, but
207 benefitted from markers on the timeline (see Fig. 1). These markers segmented the timeline into
208 12 sections corresponding to the 12 chapters, although participants were not given the headings
209 of these sections. The participants in the macroscaffolding condition ($n = 20$) were again exposed
210 to the same material as those in the control condition, but were given a table of contents on the
211 left side of the video (see Fig. 1). All 12 chapters were represented, but there was no reference to
212 them in the timeline. Nor was it possible to click on a specific chapter to directly access it at the
213 corresponding point in the video. In the two-level scaffolding condition ($n = 22$), the video was
214 presented with both table of contents and corresponding markers in the timeline (see Fig. 1). To
215 ensure that they referred to each other, numbers were assigned to each chapter and were
216 displayed below each corresponding segment in the timeline.

217 -----
218 Insert Figure 1 here
219 -----

220 2.3. Measures.

221 2.3.1. *Interest in the topic and perceived competence (control variables).*

222 Two questions were administered before the task, to check that interest and perceived
223 individual competence on the topic were evenly distributed across the conditions. Participants
224 indicated the degree to which they were interested in the topic on an 11-point scale (“*On a scale*
225 *of 0 to 10, how interested are you in this topic?*”) and how competent they felt (“*On a scale of 0*
226 *to 10, how competent do you feel on this topic?*”).

227 **2.3.2. Successful responses.**

228 Responses were deemed to be correct when participants noted the information they
229 sought and the point in the video at which they found it. Responses were deemed not to be
230 correct when participants noted another item of information than the one they should have been
231 searching for and/or the wrong point in the video. A missing response was also deemed to be
232 incorrect.

233 **2.3.3. Response times.**

234 We used a screen recorder to analyze the duration of each information search by
235 participants. Response times were calculated from when participants started searching (first
236 click) to when they found the information (pause button). Information search time was limited to
237 5 minutes per question.

238 **2.3.4. Relevance of the first click.**

239 The screen recorder meant we had access to the location of the first click participants
240 made during each search. We noted on an 11-point scale how far (number of segments between
241 the target segment and clicked one) the participant was initially from the segment containing the
242 response. If the participant clicked on or very close to the target segment (i.e., low initial error
243 rate), we took this as an indicator of high relevance.

244 **2.3.5. Perceived difficulty and control.**

245 Perceived difficulty and perceived control were assessed with items adapted from studies
246 of these concepts (Kraft, Rise, Sutton, & Røysamb, 2005; Trafimow, Sheeran, Conner, & Finlay,
247 2002). We used three perceived difficulty items (e.g., “I found this information-seeking activity
248 difficult”, “Searching for information was easy”). We also used three perceived control items
249 (e.g., “I had full control over this information seeking activity”, “I felt a lack of control during

250 the search activity”). Participants indicated the degree to which they agreed to these statements
251 on a 7-point Likert scale. Cronbach’s alphas were .81 for the perceived difficulty items used in
252 this study, and .75 for the perceived control items.

253 **2.3.6. Number of chapters recalled.**

254 After the information-seeking activity, participants were asked to name the 12 parts
255 discussed in the video. For those in the macroscaffolding and two-level scaffolding conditions,
256 this constituted a memory task, as the table of contents had remained visible throughout the
257 information-seeking activity. For those who were in the control and microscaffolding conditions,
258 and who had not been shown the table of contents, it was more of an inferential task. The number
259 of recalled chapters (whether they were right or wrong) was extracted as an indicator of
260 macrostructure.

261 **2.4. Procedure.**

262 Participants were greeted, then installed at a desk. First, they answered the questions
263 about their interest in the topic of *water in the universe* and their perceived competence (pre-task
264 questionnaire). The experimenter then explained the instructions to them (answer the questions
265 by searching in the video) and described the material (table of contents and/or markers on
266 timeline in experimental groups). All participants were informed of all the measures that would
267 be carried out, and were told that they were free to leave the experiment whenever they wanted.
268 The experimenter then launched the screen recorder. The participants were asked to wear
269 headphones to listen to the video. They started the task whenever they wanted, by clicking on the
270 touchpad to make the first question appear. They then had 5 minutes to answer each question
271 using the video. When they found the answer and its point in the video, they wrote it on the
272 corresponding sheet of paper. They could then go on to the next question. If they did not find the

273 answer in five minutes, the next question automatically appeared. The participants therefore did
274 not write an answer on the corresponding sheet of paper, and continued the task with the new
275 question. At the end of the nine questions, the experimenter stopped the video and administered
276 an online post-task questionnaire. This comprised three perceived difficulty items, three
277 perceived control items, a question about chapter recall, and two demographic questions (sex,
278 age). Finally, once the participants had finished this questionnaire, the experimenter gave each
279 one a cinema ticket to thank them for their participation.

280

281 **3. Results**

282 **3.1. Control variables.**

283 The aim of the pre-task questionnaire was to ensure that the participants in the four
284 experimental conditions did not differ on their prior interest in and perceived competence on the
285 video topic. Analyses of variance (ANOVAs) revealed no significant differences between
286 experimental conditions on either interest, $F(3, 76) = 1.133, p = .341$, or perceived competence,
287 $F(3, 76) = .290, p = .833$.

288 **3.2. Search task.**

289 **3.2.1. Prerequisites for data analysis**

290 To analyze the data from the search task, we chose to distinguish between responses and
291 failures. A failure was defined as not finding the answer to a question within 5 minutes. We used
292 a chi-square test to determine whether the number of failures differed across conditions (see
293 Table 1 for descriptive statistics). Results showed a significant difference, $\chi^2(3,$
294 $N = 720) = 17.182, p < .001$. Descriptive statistics indicated that the participants failed less often

295 when they benefitted from two-level scaffolding. To explore response times, we removed the
296 failures from the data and focused on the successful searches.

297 -----
298 Insert Table 1 here
299 -----

300 All 9 questions were presented to each participant, meaning that the independence
301 assumption was violated (Field, Miles, & Field, 2012). We therefore used linear mixed models
302 (Gueorguieva & Krystal, 2004), a statistical method that takes into account the nonindependence
303 of data into account. To assess the effect of a variable in the mixed models, we compared nested
304 models. More specifically, for each tested effect, we compared two models: one without the
305 variable (i.e., baseline model) and one with the variable (more complex model with more degrees
306 of freedom) (see, for example, Baayen, Davidson, & Bates, 2008). To assess the contribution of
307 each variable, we measured the difference in deviance (chi square) between these two nested
308 models. The significance threshold for p values was set at $\alpha = 0.05$. For each dependent variable,
309 we tested the main effects of microlevel scaffolding, macrolevel scaffolding, and their additive
310 and interaction effects, as well as the additive and interaction effects of question rank. For
311 example, to measure the effect of microlevel scaffolding on success, we compared two models:
312 one that included no predictor, and one that included the microscaffolding variable. If the latter
313 significantly reduced the deviance ($p < .05$), it was considered to be the better one (i.e., this
314 independent variable had a significant influence on the dependent variable). Every model
315 included random effects of question and participant, to take the nonindependence of the data into
316 account (Baayen et al., 2008).

317 **3.2.2. Response success.**

318 Concerning task scores, each question was coded either 0 (wrong answer) or 1 (right
319 answer). We therefore used logistic regression to process these binomial data (Field et al., 2012),
320 whereas for response times and relevance, we used linear regression. Results showed a
321 significant effect of macroscaffolding, $\chi^2(1, N = 720) = 9.3575, p = .002$, on success rate, but no
322 significant effect of microscaffolding, $\chi^2(1, N = 720) = 3.4779, p = .062$. Results also showed an
323 additive effect of micro- and macroscaffolding, $\chi^2(2, N = 720) = 13.0474, p = .001$, but no
324 interaction between these two levels, $\chi^2(1, N = 720) = 2.0789, p = .149$. Given that there was no
325 main effect of microscaffolding, in order to confirm the additive effect of microscaffolding on
326 macroscaffolding, we compared the macro-effect (i.e., main effect of macroscaffolding) and
327 micro-macro effect (i.e., additive effect of macro- and microscaffolding) models. We failed to
328 find a significant contribution of microscaffolding to macroscaffolding, $\chi^2(1, N = 720) = 3.6898,$
329 $p = .055$. Descriptive statistics showed that success seemed to be greater in the two-level
330 scaffolding condition than in the three others (see Fig. 2).

331 To go one step further, we analyzed how the success rate changed over time, according to
332 question rank. More specifically, we analyzed the success rate according to condition and
333 question rank, ranging from 1 (first question presented) to 9 (last question presented). We
334 compared the macro-effect model (selected as the best fit for the macroscaffolding effect),
335 additive model (i.e., additive effect of question rank) and interaction model (i.e., interaction
336 effect of question rank). Results showed an additive effect of question rank, $\chi^2(1, N = 720) =$
337 $4.8036, p = .028$, as well as an interaction between macro scaffolding and question rank, $\chi^2(1, N$
338 $= 720) = 6.7257, p = .010$. Descriptive statistics showed that the success rate increased over time
339 and with question rank, and that the difference between the two-level scaffolding condition and
340 the other three conditions seemed to disappear over time (see Fig. 2).

341

342

Insert Figure 2 here

343

344

3.2.3. Response times.

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We analyzed the response times for each of the nine questions, in order to identify differences between conditions. Results showed that microscaffolding, $\chi^2(1, N = 659) = 7.365, p = .007$, and macroscaffolding, $\chi^2(1, N = 659) = 12.572, p < .001$, each had a significant effect on response times. They also revealed an additive effect of micro- and macroscaffolding, $\chi^2(2, N = 659) = 20.575, p < .001$, as well as an interaction between these two levels, $\chi^2(1, N = 659) = 14.538, p < .001$. Descriptive statistics indicated that response times were shorter in the two-level scaffolding condition than in the three others (see Fig. 3).

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We also analyzed how the amount of time allocated to the search activity changed in the course of the task. We compared the scaffolding interaction model (selected as the best fit for micro- and macroscaffolding effects), additive model (i.e., additive effect of question rank) and double interaction model (i.e., interaction effect of question rank). Results showed an additive effect of question rank, $\chi^2(1, N = 659) = 34.214, p < .001$, as well as an interaction between the two levels of scaffolding and question rank, $\chi^2(3, N = 659) = 11.078, p = .011$. Descriptive statistics showed that response times decreased over time and with question rank, and that the difference between the two-level scaffolding condition and the other three conditions seemed to disappear over time (see Fig. 3).

361

362

Insert Figure 3 here

363

364 **3.2.4. Relevance of the first click.**

365 As the error rate was assumed to reflect relevance, we ran analyses on the distance
366 between the target segment and the clicked one. Results showed that microscaffolding, $\chi^2(1, N =$
367 $720) = 5.9198, p = .015$, and macroscaffolding, $\chi^2(1, N = 720) = 15.586, p < .001$, each had a
368 significant effect on the error rate. They also revealed an additive effect of micro- and
369 macroscaffolding, $\chi^2(2, N = 720) = 22.1337, p < .001$, as well as an interaction between these
370 two levels, $\chi^2(1, N = 720) = 6.5117, p = .011$. Descriptive statistics indicated that the error rate
371 was lower in the two-level scaffolding condition than in the three others (see Fig. 4).

372 We analyzed how the error rate changed over time depending on question rank. We
373 compared the scaffolding interaction model (selected as the best fit for micro- and
374 macroscaffolding effects), additive model (i.e., additive effect of question rank) and double
375 interaction model (i.e., interaction effect of question rank). Results revealed an additive effect of
376 question rank, $\chi^2(1, N = 720) = 43.637, p < .001$, as well as an interaction between the two levels
377 of scaffolding and question rank, $\chi^2(3, N = 720) = 14.778, p = .002$. Descriptive statistics
378 indicated that the error rate decreased over time and with question rank, and relevance therefore
379 seemed to increase over time. Moreover, the difference between the two-level scaffolding
380 condition and the other three conditions disappeared over time (see Fig. 4).

381 -----
382 Insert Figure 4 here
383 -----

384 **3.3. Post-task questionnaire.**

385 **3.3.1. Perceived difficulty.**

386 A 2 x 2 ANOVA revealed main effects of both microscaffolding, $F(1, 76) = 11.53$,
387 $p = .001$, $\eta^2_p = .13$, and macroscaffolding, $F(1, 76) = 7.08$, $p = .010$, $\eta^2_p = .09$, as well as an
388 interaction between the two, $F(1, 76) = 5.04$, $p = .028$, $\eta^2_p = .06$ (see Table 2 for descriptive
389 statistics). The data showed that users had lower perceptions of task difficulty, but only when the
390 two levels of scaffolding were combined.

391 **3.3.2. Perceived control.**

392 A 2 x 2 ANOVA revealed a main effect of microscaffolding, $F(1, 76) = 12.66$, $p < .001$,
393 $\eta^2_p = .14$, but no main effect of macroscaffolding, $F(1, 76) = 3.12$, $p = .082$, and no interaction
394 between the two, $F(1, 76) = .27$, $p = .605$ (see Table 2 for descriptive statistics). The data showed
395 that users only perceived themselves to have more control over the task when they benefitted
396 from microscaffolding.

397 **3.3.3. Number of recalled chapters.**

398 A 2 x 2 ANOVA revealed a main effect of macroscaffolding, $F(1, 76) = 10.77$, $p = .002$,
399 $\eta^2_p = .12$, but no main effect of microscaffolding, $F(1, 76) = 2.58$, $p = .112$, and no interaction
400 between the two, $F(1, 76) = 0.00$, $p = 0.990$ (see Table 2 for descriptive statistics). The data
401 showed that users only recalled a greater number of chapters when they benefitted from
402 macroscaffolding.

403 -----
404 Insert Table 2 here
405 -----

406 **4. Discussion**

407 The present study was designed to identify the effects of micro- and macroscaffolding,
408 both separately and in interaction, during information-seeking activity. Our hypotheses were that

409 the scaffolding of microlevel and/or macrolevel activities helps users to construct a relevant
410 mental model of the document, thereby facilitating the search for specific information. For this to
411 happen, we assumed that scaffolding improves the efficiency, accuracy, and relevance of the
412 search activity, mainly by increasing control, facilitating use and/or making the document's
413 structure more salient.

414 Regarding response success, results showed a significant effect of macroscaffolding, but
415 no microscaffolding effect. Participants provided more correct responses when they benefitted
416 from macrolevel scaffolding (i.e., table of contents) than when they did not, but no advantage
417 came with microscaffolding, partly validating Hypothesis 1. Results on response times according
418 to condition showed that two-level scaffolding helped to reduce the amount of time allocated to
419 the search. Overall, participants with micro- and macroscaffolding spent less time on the
420 information-seeking activity than the others. This was consistent with Hypothesis 2. The same
421 pattern could be observed for the error rate for the first click on each question. Results showed
422 that participants made smaller errors (i.e., more relevant, closer to the target segment) when they
423 benefitted from two-level scaffolding than when they did not, thus validating Hypothesis 3.
424 Concerning these three variables, results highlighted the beneficial effects on information-
425 seeking activity of scaffolding documents. Macrolevel scaffolding helps to improve the accuracy
426 of the response, and when the two levels of scaffolding are combined, they improve search
427 efficiency and relevance. These results build on previous ones (i.e., Merkt & Schwan, 2014), by
428 demonstrating the superiority of two-level scaffolding on video (i.e. enhanced video) over other
429 video formats. Another original feature of this study is that it sheds new light on changes in
430 users' performances across the task. We assumed that scaffolding has these beneficial effects
431 because it provides the searcher with a *ready-to-use* conceptual model of the video content.

432 Tables of contents and related markers on the timeline make it easier to locate and access
433 information. In the case of the response success score, unlike microscaffolding, macroscaffolding
434 carried meaningful information, which could be the reason why it was the only level that
435 contributed to semantic success. More generally, when a scaffolding level was missing, or when
436 there was no scaffolding at all, in order to make sense of the document, users had to develop
437 their own mental model-more specifically, a mental representation of the missing level of
438 scaffolding in the video. This construction could be the reason for the disparity between
439 performances, and explain why there was no longer any difference by the end of the task. Once
440 the construction was complete, searchers could use it as their own mental scaffolding. We
441 therefore made two assumptions: 1) the proposed scaffolding serves as a conceptual and external
442 model for the user, and is immediately usable for information-seeking activity, thus improving
443 performances; 2) in the absence of scaffolding, searchers construct their own internal
444 representations of the video-based environment, such that they eventually perform just as well as
445 they would have done had they benefitted from scaffolding. This construction process is
446 cognitively costly, as seen with the results on perceived difficulty, confirming Hypothesis 4.

447 Furthermore, adding microscaffolding to a video-based environment significantly
448 improves the feeling of having control over the situation, in accordance with Hypothesis 5 and
449 with previous research (e.g., Delen et al., 2014; Merkt et al., 2011). Finally, the number of
450 recalled chapters improved with macro-scaffolding, confirming Hypothesis 6, as well as previous
451 studies of hierarchical cues and their impact on text recall (e.g., Lorch et al., 2011; Sanchez et al.,
452 2001). These results shed light on the specific features of these scaffolding levels. While
453 microscaffolding was used to navigate within the video, macroscaffolding supplied information
454 about its content. The activity of searching for information is clearly, therefore, a complex and

455 two-level activity. These two levels were mostly complementary, and their combined presence
456 had a significant impact on information-seeking performances. The construction of relevant
457 mental models by the searchers themselves can overcome the difficulties they encounter in the
458 absence of scaffolding, but it is more costly in terms of time and cognitive demands. Scaffolding
459 helps users to achieve success at their first try, when they would otherwise only have performed
460 correctly many questions later.

461 Nonetheless, this study had several limitations. First, only university students took part.
462 They could be regarded as information-seeking *experts*, and it would be interesting to test the
463 effects of scaffolding on children who have not yet encountered information-seeking demands in
464 video-based environments. Second, although our main assumption concerned participants'
465 mental models, we did not directly measure their construction over time. Several authors have
466 described ways of measuring mental models during a task without relying solely on performance
467 scores (e.g., Azevedo, Cromley, & Seibert, 2004; He, Erdelez, Wang, & Shyu, 2008;
468 Marchionini, 1989).

469

470 **5. Conclusion**

471 Our results indicate that micro- and macrolevels play an important role in information-
472 seeking activity. We had previously noticed that a common step in all theoretical models in this
473 field is the localization of information. The two components of localization appear to be
474 identifying the information being sought and navigating within the video to find it, respectively
475 promoted by macro- and microscaffolding. Concretely, these results allow us to make several
476 recommendations about the design of video-based environments when they are used for
477 information-seeking activity. The presence of the two levels of scaffolding (i.e., segmentation of

478 the timeline and table of contents) enables users carry out their task in a less costly, quicker and
479 more efficient manner.

480 We can also assume that scaffolding provides an external representation of the video-
481 based environment, and that without scaffolding searchers have to construct mental models by
482 themselves. To confirm this hypothesis, future studies will have to focus on measuring this
483 mental model construction, without relying solely on the performance score and without altering
484 the information-seeking activity. It would be interesting to analyze how this construction
485 changes over time and how effectively the constructed mental model compensates for the
486 absence of scaffolding. Finally, if the information-seeking activity results in the construction of
487 an operational mental model, we can assume that this improves learning (Johnson-Laird, 1983;
488 Norman, 1983). So, in future works, it would also be interesting to measure incidental learning
489 during information seeking activity. Adding an information-seeking step in the learning process
490 could therefore enhance learners' representations and increase the saliency of the relevant
491 information.

492

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References

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495 Arguel, A., & Jamet, E. (2009). Using video and static pictures to improve learning of
496 procedural contents. *Computers in Human Behavior*, 25(2), 354–359.
497 <https://doi.org/10.1016/j.chb.2008.12.014>

498 Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate
499 students' ability to regulate their learning with hypermedia? *Contemporary*
500 *Educational Psychology*, 29(3), 344–370.
501 <https://doi.org/10.1016/j.cedpsych.2003.09.002>

502 Azevedo, R., & Hadwin, A. F. (2005). Scaffolding Self-regulated Learning and
503 Metacognition – Implications for the Design of Computer-based Scaffolds.
504 *Instructional Science*, 33(5–6), 367–379. <https://doi.org/10.1007/s11251-005-1272-9>

505 Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed
506 random effects for subjects and items. *Journal of Memory and Language*, 59(4), 390–
507 412. <https://doi.org/10.1016/j.jml.2007.12.005>

508 Borgman, C. L. (1986). The user's mental model of an information retrieval system: an
509 experiment on a prototype online catalog. *International Journal of Man-Machine*
510 *Studies*, 24(1), 47–64.

511 Chen, C.-M., & Wu, C.-H. (2015). Effects of different video lecture types on sustained
512 attention, emotion, cognitive load, and learning performance. *Computers & Education*,
513 80, 108–121. <https://doi.org/10.1016/j.compedu.2014.08.015>

514 Chun, D. M., & Plass, J. L. (1996). Facilitating reading comprehension with multimedia.
515 *System*, 24(4), 503–519.

- 516 Delen, E., Liew, J., & Willson, V. (2014). Effects of interactivity and instructional scaffolding
517 on learning: Self-regulation in online video-based environments. *Computers &*
518 *Education*, 78, 312–320. <https://doi.org/10.1016/j.compedu.2014.06.018>
- 519 Derry, S., Sherin, M., & Sherin, B. (2014). Multimedia learning with video. *The Cambridge*
520 *Handbook of Multimedia Learning*, 785–812.
- 521 Dinet, J., Chevalier, A., & Tricot, A. (2012). Information search activity: An overview. *Revue*
522 *Européenne de Psychologie Appliquée/European Review of Applied Psychology*,
523 62(2), 49–62. <https://doi.org/10.1016/j.erap.2012.03.004>
- 524 Doressoundiram, A. (2012). *Du temps, de l'espace et de l'eau. A la recherche de l'eau dans*
525 *l'Univers*. Retrieved from [https://www.canal-](https://www.canal-u.tv/video/canal_uved/du_temps_de_l_espace_et_de_l_eau.9857)
526 [u.tv/video/canal_uved/du_temps_de_l_espace_et_de_l_eau.9857](https://www.canal-u.tv/video/canal_uved/du_temps_de_l_espace_et_de_l_eau.9857)
- 527 Field, A., Miles, J., & Field, Z. (2012). *Discovering Statistics Using R*. SAGE Publications.
528 ISBN-13.
- 529 Ganier, F., & de Vries, P. (2016). Are instructions in video format always better than
530 photographs when learning manual techniques? The case of learning how to do
531 sutures. *Learning and Instruction*, 44, 87–96.
532 <https://doi.org/10.1016/j.learninstruc.2016.03.004>
- 533 Giannakos, M. N. (2013). Exploring the video-based learning research: A review of the
534 literature: Colloquium. *British Journal of Educational Technology*, 44(6), E191–E195.
535 <https://doi.org/10.1111/bjet.12070>
- 536 Ginns, P. (2006). Integrating information: A meta-analysis of the spatial contiguity and
537 temporal contiguity effects. *Learning and Instruction*, 16(6), 511–525.
- 538 Gueorguieva, R., & Krystal, J. H. (2004). Move over anova: Progress in analyzing repeated-
539 measures data and its reflection in papers published in the archives of general
540 psychiatry. *Archives of General Psychiatry*, 61(3), 310–317.

- 541 Guthrie, J. T., & Mosenthal, P. (1987). Literacy as Multidimensional: Locating Information
542 and Reading Comprehension. *Educational Psychologist*, 22(3–4), 279–297.
543 <https://doi.org/10.1080/00461520.1987.9653053>
- 544 Hasler, B. S., Kersten, B., & Sweller, J. (2007). Learner control, cognitive load and
545 instructional animation. *Applied Cognitive Psychology*, 21(6), 713–729.
546 <https://doi.org/10.1002/acp.1345>
- 547 He, W., Erdelez, S., Wang, F.-K., & Shyu, C.-R. (2008). The effects of conceptual description
548 and search practice on users' mental models and information seeking in a case-based
549 reasoning retrieval system. *Information Processing & Management*, 44(1), 294–309.
550 <https://doi.org/10.1016/j.ipm.2007.03.008>
- 551 Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online
552 courses (MOOCs): Motivations and challenges. *Educational Research Review*, 12,
553 45–58. <https://doi.org/10.1016/j.edurev.2014.05.001>
- 554 Ilioudi, C., Giannakos, M. N., & Choriantopoulos, K. (2013). Investigating Differences among
555 the Commonly Used Video Lecture Styles. In *WAVE 2013 The Workshop on Analytics
556 on Video-based Learning (Vol. i, pp. 21–26)*.
- 557 Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language,
558 inference, and consciousness*. Harvard University Press.
- 559 Joseph, A. M., & Nath, B. A. (2013). Integration of Massive Open Online Education (MOOC)
560 System with in-Classroom Interaction and Assessment and Accreditation: An
561 extensive report from a pilot study. In *Proceedings of the International Conference on
562 e-Learning, e-Business, Enterprise Information Systems, and e-Government (EEE)* (p.
563 105). The Steering Committee of The World Congress in Computer Science,
564 Computer Engineering and Applied Computing (WorldComp).

- 565 Kay, R. H. (2012). Exploring the use of video podcasts in education: A comprehensive review
566 of the literature. *Computers in Human Behavior*, 28(3), 820–831.
567 <https://doi.org/10.1016/j.chb.2012.01.011>
- 568 Kitajima, M., Blackmon, M. H., & Polson, P. G. (2000). A Comprehension-based Model of
569 Web Navigation and Its Application to Web Usability Analysis. In S. McDonald, Y.
570 Waern, & G. Cockton (Eds.), *People and Computers XIV — Usability or Else!* (pp.
571 357–373). London: Springer London.
- 572 Koutropoulos, A., Gallagher, M. S., Abajian, S. C., de Waard, I., Hogue, R. J., Keskin, N. Ö.,
573 & Rodriguez, C. O. (2012). Emotive vocabulary in MOOCs: Context & participant
574 retention. *European Journal of Open, Distance and E-Learning*, 15(1).
- 575 Kraft, P., Rise, J., Sutton, S., & Røysamb, E. (2005). Perceived difficulty in the theory of
576 planned behaviour: Perceived behavioural control or affective attitude? *British Journal*
577 *of Social Psychology*, 44(3), 479–496. <https://doi.org/10.1348/014466604X17533>
- 578 Lawless, K. A., & Brown, S. W. (1997). Multimedia learning environments: Issues of learner
579 control and navigation. *Instructional Science*, 25(2), 117–131.
- 580 Lazonder, A. W., & Rouet, J.-F. (2008). Information problem solving instruction: Some
581 cognitive and metacognitive issues. *Computers in Human Behavior*, 24(3), 753–765.
582 <https://doi.org/10.1016/j.chb.2007.01.025>
- 583 Lorch, R., Lemarié, J., & Grant, R. (2011). Signaling Hierarchical and Sequential
584 Organization in Expository Text. *Scientific Studies of Reading*, 15(3), 267–284.
585 <https://doi.org/10.1080/10888431003747535>
- 586 Marchionini, G. (1989). Making the transition from print to electronic encyclopaedias:
587 adaptation of mental models. *International Journal of Man-Machine Studies*, 30(6),
588 591–618.

- 589 Marchionini, G. (2003). Video and learning redux: New capabilities for practical use.
590 *EDUCATIONAL TECHNOLOGY-SADDLE BROOK THEN ENGLEWOOD CLIFFS*
591 *NJ-*, 43(2), 36–41.
- 592 Mayer, R. E. (2005). Principles for reducing extraneous processing in multimedia learning:
593 Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity
594 principles. *The Cambridge Handbook of Multimedia Learning*, 183–200.
- 595 Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user
596 interaction foster deeper understanding of multimedia messages? *Journal of*
597 *Educational Psychology*, 93(2), 390.
- 598 Merkt, M., & Schwan, S. (2014). How does interactivity in videos affect task performance?
599 *Computers in Human Behavior*, 31, 172–181.
600 <https://doi.org/10.1016/j.chb.2013.10.018>
- 601 Merkt, M., Weigand, S., Heier, A., & Schwan, S. (2011). Learning with videos vs. learning
602 with print: The role of interactive features. *Learning and Instruction*.
603 <https://doi.org/10.1016/j.learninstruc.2011.03.004>
- 604 Norman, D. A. (1983). Some observations on mental models. *Mental Models*, 7(112), 7–14.
- 605 Puustinen, M., & Rouet, J.-F. (2009). Learning with new technologies: Help seeking and
606 information searching revisited. *Computers & Education*, 53(4), 1014–1019.
607 <https://doi.org/10.1016/j.compedu.2008.07.002>
- 608 Reiser, B. J. (2002). Why scaffolding should sometimes make tasks more difficult for
609 learners. In *Proceedings of the Conference on Computer Support for Collaborative*
610 *Learning: Foundations for a CSCL Community* (pp. 255–264). International Society
611 of the Learning Sciences.
- 612 Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and
613 problematizing student work. *The Journal of the Learning Sciences*, 13(3), 273–304.

- 614 Rowe, A. L., & Cooke, N. J. (1995). Measuring mental models: Choosing the right tools for
615 the job. *Human Resource Development Quarterly*, 6(3), 243–255.
- 616 Sanchez, R. P., Lorch, E. P., & Lorch, R. F. (2001). Effects of Headings on Text Processing
617 Strategies. *Contemporary Educational Psychology*, 26(3), 418–428.
618 <https://doi.org/10.1006/ceps.2000.1056>
- 619 Scheiter, K. (2014). The learner control principle. *The Cambridge Handbook of Multimedia
620 Learning*, 487–512.
- 621 Scheiter, K., & Gerjets, P. (2007). Learner Control in Hypermedia Environments. *Educational
622 Psychology Review*, 19(3), 285–307. <https://doi.org/10.1007/s10648-007-9046-3>
- 623 Schwan, S., & Riempp, R. (2004). The cognitive benefits of interactive videos: learning to tie
624 nautical knots. *Learning and Instruction*, 14(3), 293–305.
625 <https://doi.org/10.1016/j.learninstruc.2004.06.005>
- 626 Sharit, J., Hernández, M. A., Czaja, S. J., & Pirolli, P. (2008). Investigating the Roles of
627 Knowledge and Cognitive Abilities in Older Adult Information Seeking on the Web.
628 *ACM Transactions on Computer-Human Interaction*, 15(1), 1–25.
629 <https://doi.org/10.1145/1352782.1352785>
- 630 Storey, M.-A., Fracchia, F. D., & Müller, H. A. (1999). Cognitive design elements to support
631 the construction of a mental model during software exploration. *Journal of Systems
632 and Software*, 44(3), 171–185.
- 633 Trafimow, D., Sheeran, P., Conner, M., & Finlay, K. A. (2002). Evidence that perceived
634 behavioural control is a multidimensional construct: Perceived control and perceived
635 difficulty. *British Journal of Social Psychology*, 41(1), 101–121.
- 636 Wong, A., Leahy, W., Marcus, N., & Sweller, J. (2012). Cognitive load theory, the transient
637 information effect and e-learning. *Learning and Instruction*, 22(6), 449–457.
638 <https://doi.org/10.1016/j.learninstruc.2012.05.004>

- 639 Wopereis, I., Brand-Gruwel, S., & Vermetten, Y. (2008). The effect of embedded instruction
640 on solving information problems. *Computers in Human Behavior*, 24(3), 738–752.
641 <https://doi.org/10.1016/j.chb.2007.01.024>
- 642 Yadav, K., Shrivastava, K., Mohana Prasad, S., Arsikere, H., Patil, S., Kumar, R., &
643 Deshmukh, O. (2015). Content-driven Multi-modal Techniques for Non-linear Video
644 Navigation (pp. 333–344). ACM Press. <https://doi.org/10.1145/2678025.2701408>
- 645 Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker, J. F. (2006). Instructional video in e-
646 learning: Assessing the impact of interactive video on learning effectiveness.
647 *Information & Management*, 43(1), 15–27. <https://doi.org/10.1016/j.im.2005.01.004>

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ACCEPTED MANUSCRIPT

Figure Captions

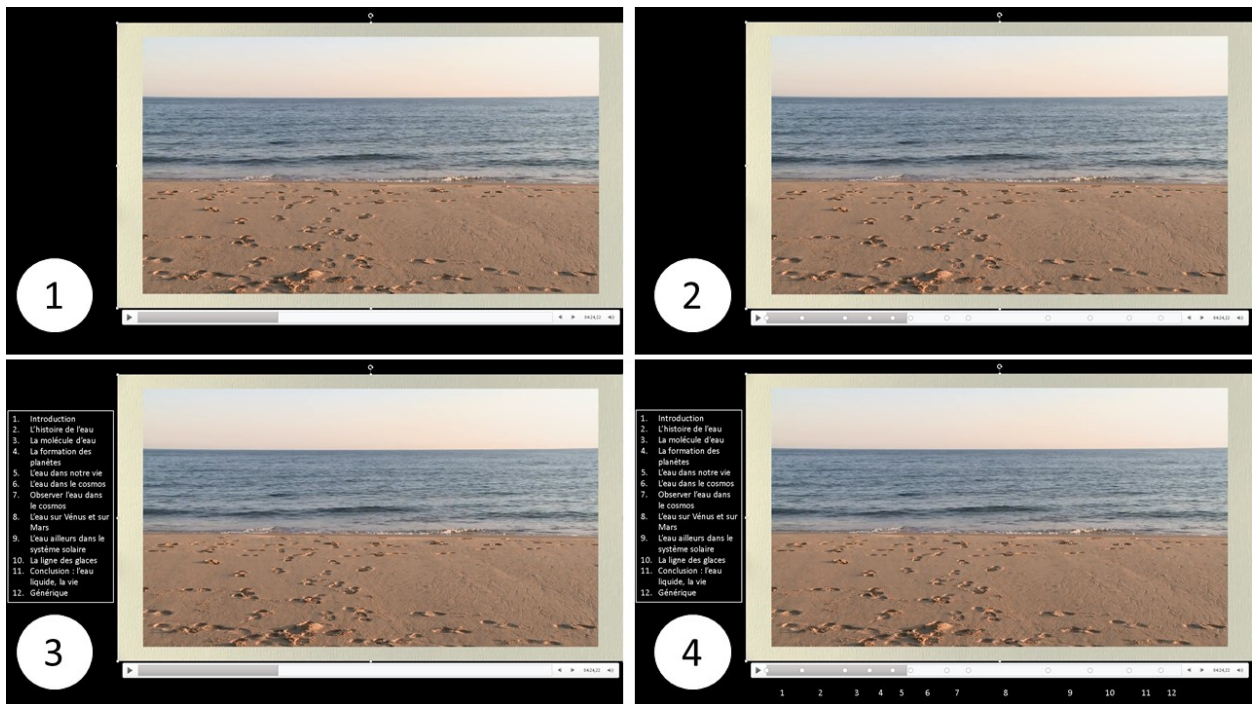


Fig. 1. Screenshot of the video-based environment in the control (1), microscaffolding (2), macroscaffolding (3), and two-level scaffolding (4) conditions.

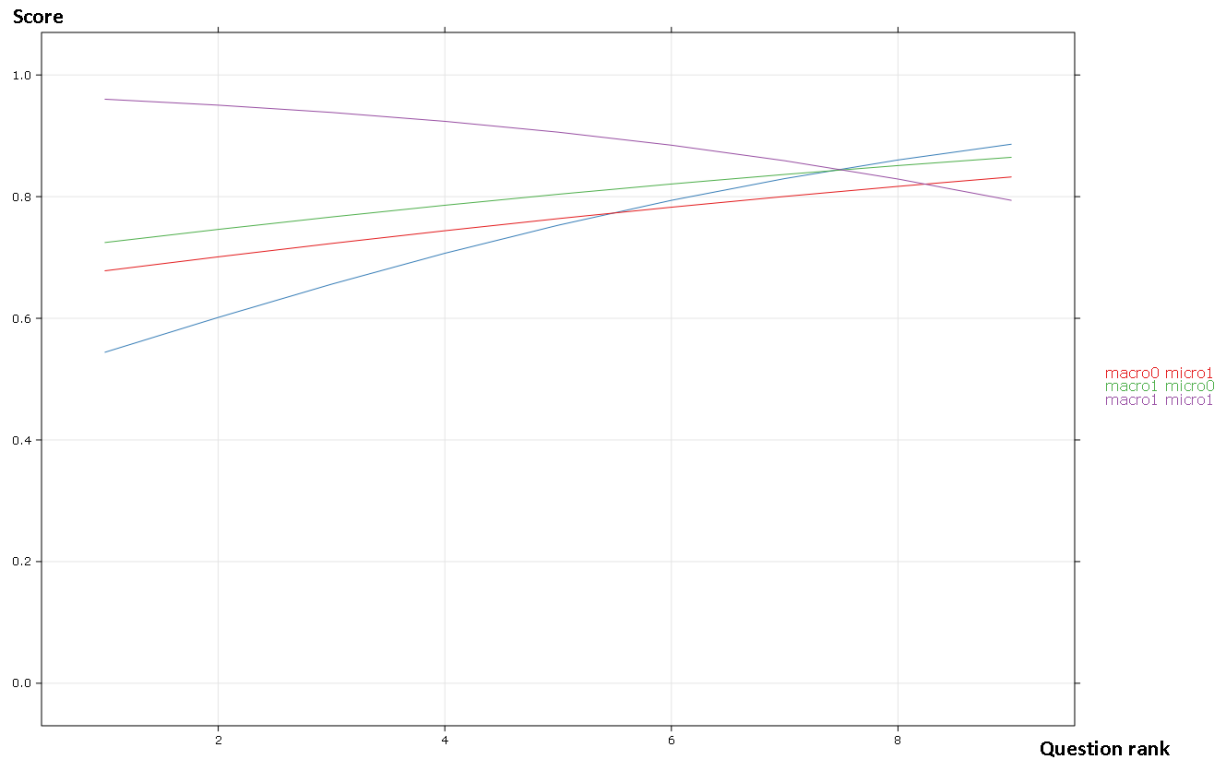


Fig. 2. Diagram showing response success rate according to question rank in the four experimental conditions.

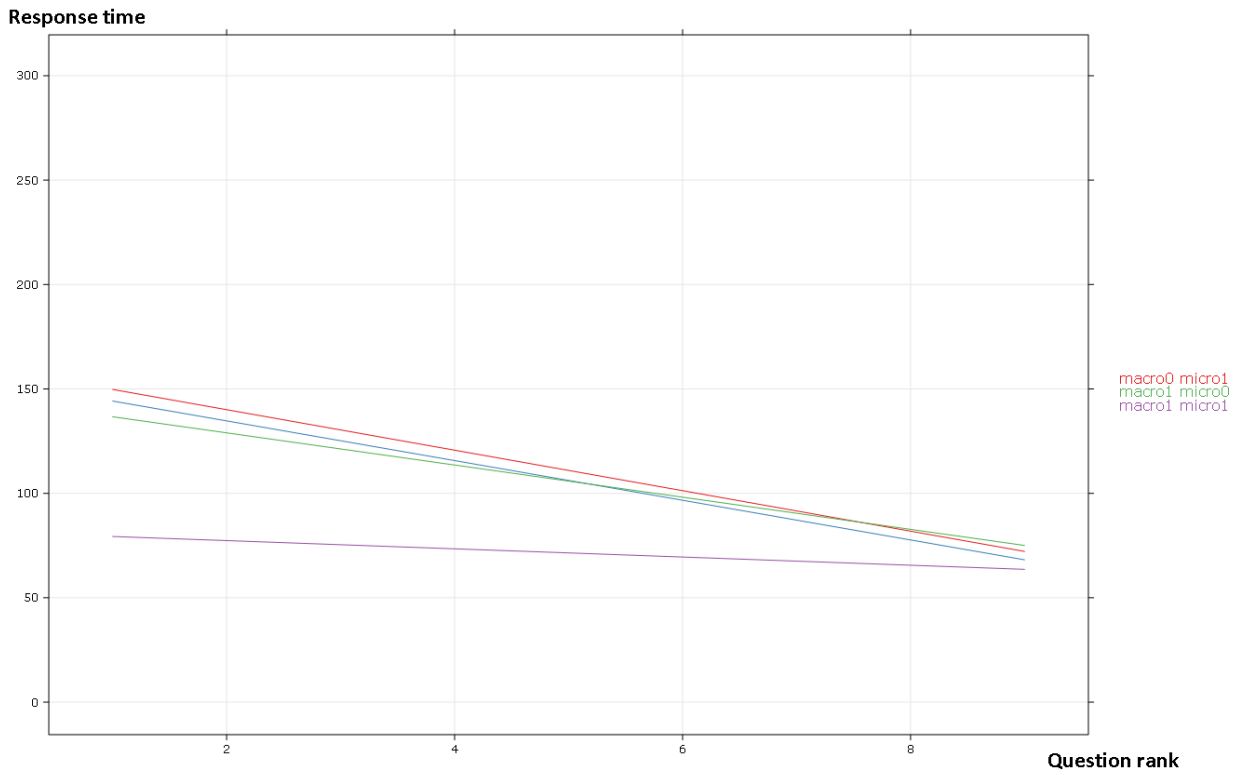


Fig. 3. Diagram showing response times (in s) according to question rank in the four experimental conditions.

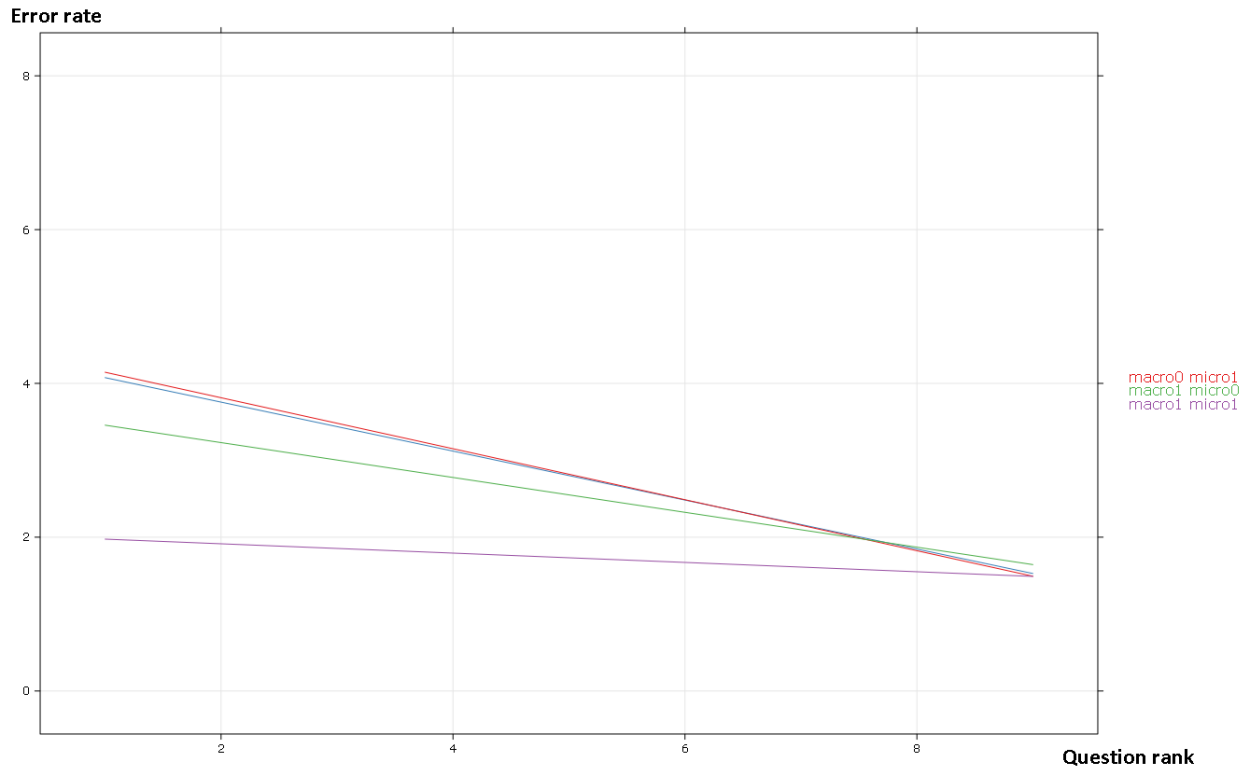


Fig. 4. Diagram showing error rate according to question rank in the four experimental conditions.

Table 1

Descriptive statistics for information-seeking failures

Condition	<i>n</i>	% (condition)	% (total)
Control	22	12.866	3.056
Microscaffolding	20	11.696	2.778
Macroscaffolding	15	8.333	2.083
Twolevel scaffolding	4	2.020	.556

Table 2

Descriptive statistics for perceived difficulty, perceived control and number of recalled chapters

Condition	Perceived difficulty		Perceived control		Recalled chapters	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control	8.737	2.600	13.211	3.780	4.684	1.945
Microscaffolding	8.053	3.613	16.158	2.566	5.579	2.244
Macroscaffolding	8.550	3.456	14.800	3.286	6.500	2.328
Twolevel scaffolding	4.909	1.875	17.000	3.101	7.409	3.217