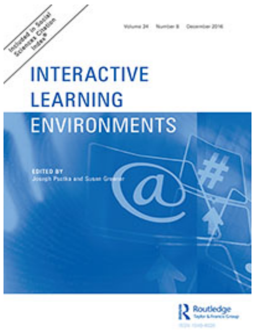

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The effects of goal-oriented instructions in digital game-based learning

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Few studies have investigated the effects of the instructions provided in educational computer games on cognitive processing and learning outcomes. In our experiment, we sought to compare the effects on learning outcomes of two different types of goal-oriented instructions: *mastery-goal* instructions, which prompt learners to develop skills or master new knowledge, and *performance-goal* instructions, which are frequently used in game environments and which encourage individuals to demonstrate their ability to succeed, particularly by surpassing others. Results showed that a mastery-goal instruction elicited deeper learning (as assessed with a transfer task) than a performance-goal instruction. No effect of instruction was observed on either learning (demonstration consultation) times at the start of the game or on training task (solving riddles) performances during it. These results are discussed in terms of learning processes. This study demonstrates that mastery goal-oriented instructions can promote active processing of educational content in a serious game environment.

Keywords: digital game-based learning; adult learning; game instructions

1. Introduction

1.1. *Digital game-based learning (DGBL)*

DGBL, a competitive activity in which students are set educational goals intended to promote knowledge acquisition, is a rapidly growing educational trend. Many researchers have therefore turned their attention to educational computer games (ECGs), the environments that allow for the implementation of DGBL. ECGs may either be used to promote the development of cognitive skills or else take the form of simulations allowing the development of skills in a virtual environment. Several definitions of ECGs have been put forward. According to Prensky (2001), for instance, this medium can be seen as a combination of serious learning and interactive entertainment. In other words, ECGs can be viewed as an entertainment medium designed to induce cognitive changes in its users. A number of authors have attempted to characterize ECGs (Mayer, 2011). In a recent meta-analytic review, Wouters and van Oostendorp (2013) summarized all their major features, describing an ECG as an environment that is interactive, based on a set of rules and constraints, and directed toward a clear goal set by a challenge. This definition included the presence of feedback (either as a score or as changes in the game world) enabling

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players to monitor their progress. It also indicated that a competitive activity (against the computer, another player, or oneself) is not necessarily a prerequisite. This definition is a good starting point for designing a game-based learning environment. However, in order to be effective, a game must also feature an artwork combining a universe (entertainment scenarios) with adequate sensory stimulation (graphics, sound, animations; Schell, 2008). The presence of such an artwork clearly distinguishes a classic learning environment from an ECG. To avoid confusion with some conventional learning environments, Wouters and van Oostendorp's (2013) definition therefore needs to encompass more features relating to this aspect.

1.2. *The actual benefits of ECGs in terms of deep learning*

Many researchers have analyzed the benefits of digital games on learning and motivation (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Gee, 2005; Prensky, 2001; Shaffer, 2006). Mayer (2011) suggests dividing their studies into three categories: those adopting a cognitive consequence approach, looking at what is learned from playing computer games on one's own; those adopting the *value-added* approach, assessing how various features in a game can affect learning and motivation; and those adopting a media comparison approach, exploring whether people learn better with an ECG or with a conventional medium.

A media comparison approach is always useful when seeking to understand the potential of an innovative environment like an ECG, and over the past few years, many studies have tested the benefits of this medium compared with more conventional learning environments, reporting mixed results (see Connolly et al., 2012; Girard, Ecalle, & Magnan, 2013; Papastergiou, 2009; Tobias & Fletcher, 2008 for recent reviews). A recent meta-analysis conducted by Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) concluded that ECGs improve learning and retention compared with more conventional media. However, no effect on motivation was observed.

To better understand how specific features of ECGs may improve learning and motivation, many researchers have recently favored a *value-added* approach (see Adams, Mayer, MacNamara, Koenig, & Wainess, 2012, for a recent example of this approach). The value-added approach consists in testing the effects on learning quality of adding features to an educational game. This perspective has already been adopted to examine the potential benefits of elaborative feedback (Moreno & Mayer, 2004), self-explanation (Johnson & Mayer, 2010) and competition (DeLeeuw & Mayer, 2011).

In their meta-analysis of research adopting the value-added approach, Wouters and van Oostendorp (2013) showed that the use of a broad range of techniques and methods in ECGs may improve learning outcomes. The benefits are particularly noteworthy for knowledge and skill acquisition. This meta-analysis also revealed that ECGs fail in encouraging learners to actively engage in organization and integration processes – in other words – deep learning. These conclusions are in line with Graesser, Chipman, Leeming, and Biedenbach (2009), who claimed that ECGs impose considerable constraints that "make it extremely difficult to integrate deep content, strategies, and skills" (p. 12). In other words, ECGs lead to poorer quality cognitive processing of educational content. Kester, Kirschner, and Corbalan (2007) referred to this as "surface learning," corresponding to "the tacit acceptance of information and memorization as isolated and unlinked facts." These authors contrasted surface learning with deep learning, which involves "the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts" (see also Mayer, 2005, for a similar approach). The notion of deep learning can also be found in Sweller's (1999) theory of *cognitive load*. According to Sweller (1999, 2005), the effort engaged by learners in information processing (*germane cognitive load*) is a central component of learning activity. No matter which framework we choose, they all have in common that the learners who do not actively invest in information processing are liable to engage in mere surface learning, and achieve only poor learning performances.

1.3. *The impact of instructions on cognitive processes in a learning context*

One way of helping learners to engage in deep learning with ECGs is to provide them with instructions to that effect. Many studies have analyzed the effects of instruction type on the cognitive processes engaged in text reading (Mc Crudden, Magliano, & Schraw, 2010). For example, van den Broek , Lorch, Linderholm, and Gustafson (2001) manipulated two reading conditions with undergraduates: reading texts adapted from popular science magazines in either a study condition or an entertainment condition. A thinkaloud procedure revealed that readers in the study condition drew significantly more associative and predictive inferences than those in the entertainment condition. By contrast, the authors observed that more opinions about the text and associations with personal experiences were produced in the entertainment condition than in the study one. However, memory for the texts was better in the study condition. Adopting the same perspective, Erhel and Jamet (2013) sought to analyze the effects of two different types of instruction (learning vs. entertainment). In their first experiment, they found that a learning instruction could elicit deeper learning than an entertainment one. However, an entertainment instruction accompanied by feedback on performance prompted learners to actively process the information (Experiment 2). To sum up, studies so far have revealed that instructions can have a considerable impact on learners' strategies. Likewise, several studies have demonstrated that encouraging learners to pursue one specific goal can have a considerable impact on learning outcomes and processing strategies. For example, Vollmeyer and Burns (2002) found that setting learners a specific goal ("find 20 dates") in a problem-solving situation had a detrimental effect on their learning compared with a nonspecific goal ("explain the reasons for the war"). According to Künsting, Wirth, and Paas (2011), goal specificity can affect both strategy use and instructional efficiency in a computer-based learning environment, especially during problem solving (mazes, mathematical and dynamic problems).

Research on achievement goals has highlighted a similar effect. Linnenbrink-Garcia, Tyson, and Patall (2008) defined achievement goals as specific goal orientations that shape individual engagement in achievement settings. Many studies have looked at achievement goals (see Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; Linnenbrink-Garcia et al., 2008; Wirthwein, Sparfeldt, Pinquart, Wegerer, & Steinmayr, 2013 for reviews). The focus has been on two facets of goal-directed striving for achievement: *mastery goals and performance goals* (Ames & Archer, 1988; Pintrich, 2000). Moos and Marroquin (2010) have defined these two achievement goals. *Mastery goals* refer to "the desire to develop skills or to master new knowledge or new sets of abilities" (e.g. improving one's knowledge about a particular topic). *Performance goals*, on the other hand, refer to "the desire to demonstrate one's ability to succeed, particularly by surpassing others while expending as little effort as possible" (e.g. achieving the highest score in a game).

Subscribing to one or other type of goal is thought to lead to different learning outcomes. Mastery goals favor the use of adaptive response patterns, such as organization, listening and engagement in self-regulation activities. Many authors acknowledge the existence of a link between mastery goals and deep-learning strategies, whereas performance goals are mostly linked to surface learning (Belenky & Nokes-Malach, 2013; Bell & Kozlowski, 2002; Elliot & McGregor, 2001; Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Hulleman et al., 2010; Wirthwein et al., 2013).

Most studies have examined the effects of achievement goals that correspond to a natural tendency to pursue specific goal orientations (Belenky & Nokes-Malach, 2013; Bernacki, Byrnes, & Cromley, 2012; Elliott & Dweck, 1988; He, 2008; Hulleman et al., 2010; Linnenbrink-Garcia et al., 2008). These *dispositional* goal orientations can have a considerable impact on the information-processing strategies that are implemented during learning. Nevertheless, we decided to focus our attention on another area of the literature that deals with achievement-goal manipulation. One or two studies have already attempted to highlight the effect of using specific instructions to induce achievement goals. Overall, they showed that goal manipulation significantly influences the quality of the cognitive processes implemented during learning (Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Moos & Azevedo, 2006), although the effects of goal manipulation are far from systematic (see Linnenbrink-Garcia et al., 2008 for a review).

In a princeps study, Elliot and Harackiewicz (1996) sought to show how a mastery-goal structure, performance-approach goal structure or performance-avoidance goal structure can affect learning processes. A group of students were assigned four problem-solving activities and instructed to use one of these distinct goal structures. Results showed that a performance-avoidance goal structure undermines learning outcomes, whereas mastery and performance-approach goal structures are related to an increase in intrinsic motivation and better learning outcomes. In line with Elliot and Harackiewicz (1996), Elliot, Shell, Henry, and Maier (2005) conducted two studies designed to assess the effects of achievement goals on learning outcomes. These studies confirmed that the performance-avoidance goal structure undermines learning, compared with performance- and mastery-goal approaches. In order to identify the cognitive processes that are triggered as a result of goal structure manipulation, Moos and Azevedo (2006) manipulated the goal structure in a scientific document using different kinds of instructions. Students were assigned to one of three conditions: mastery-goal structure, performance-approach goal structure and performance-avoidance goal structure. Using a thinkaloud protocol and post-test measures, these authors found that, compared with the two performance-goal structures, the mastery-goal structure was related to self-regulated strategies bound up with deeper cognitive processes.

Overall, these studies indicate that manipulating achievement goals can influence learning processes. However, all of them were performed in conventional learning environments (i.e. written texts). To our knowledge, no study has so far explored the effects of achievement-goal manipulation on information processing and learning outcomes in an ECG. The present study was intended to fill this gap by exploring the impact of goal-oriented instructions in this specific context.

1.4. *Overview of the present experiment*

Instructions can have a significant impact on the cognitive processing of educational content. Depending on their nature, they can encourage learners to subscribe to different goals that have a differing impact on information processing and learning outcomes. As seen previously, a mastery goal-oriented instruction promotes deep-learning strategies, whereas a performance goal-oriented instruction may have a detrimental effect on learning outcomes. In many videogames, players are likely to pursue performance goals, in the sense that they want to surpass the others and achieve the highest scores. Many features of ECGs are quite similar to those of video games (e.g. challenges, rules, constraints), and, consequently, learners may also be inclined to subscribe to performance goals.

To avoid the possible detrimental effect of these goals, an ECG should be accompanied with instructions that explicitly encourage learners to adopt mastery goals (i.e. that emphasize the mastery of knowledge and skill development). Our general hypothesis was that a mastery-goal orientation favors deeper processing of instructional content than a performance-goal orientation.

To test this hypothesis, we administered an English learning ECG in either a mastery-goal condition, where participants were told to consult the ECG in order to improve their mastery of the present perfect tense, or a performance-goal condition, where they were asked to achieve as high a score as possible. Working on the assumption that goal-oriented instructions do indeed affect the depth of processing during this activity, we predicted that the mastery-goal instruction would lead to longer consultation times for the present perfect tense demonstration than the performance-goal instruction (Hypothesis 1).

We further predicted that the mastery-goal instruction would result in deeper processing than the performance-goal instruction, and would therefore induce significantly higher scores on the training task (riddle resolution) during the game (Hypothesis 2) and on the transfer-type assessment performed after the game (Hypothesis 3).

2. Methods

2.1. *Participants*

A total of 47 undergraduates (5 men and 42 women) aged 19–23 years ($M = 20.19$, SD = 0.77) took part in this study. They were all in their second year of a cognitive psychology program at Rennes University. All the participants had normal or corrected-to-normal vision, and French was their native language.

The group in the mastery goal-oriented condition was made up of 23 participants (4 men and 19 women) with a mean age of 20.39 years. The group in the performance goal-oriented condition was made up of 24 participants (1 man and 23 women) with a mean age of 20.00 years.

2.2. *Material*

The participants interacted with the ECG for approximately 30 min. The ECG was based on the English language and, more particularly, on the present perfect tense. All the experimental material was designed in collaboration with an English teacher.

The preliminary part of the environment was designed to assess participants' perceived competence in English and prior knowledge. Participants were asked to rate their mastery of English on a Likert-like scale ranging from 1 (*very low*) to 7 (*very high*). They then completed a prior knowledge questionnaire containing 10 items about English vocabulary and grammar. Six of these were multiple-choice items (e.g. *Complete*: "When I was a child, I _________ in ghosts" (1) *believe*, (2) *have believe*, (3) *believed*, and (4) *had believe*), two were drag-and-drop items (e.g. matching the item with the correct image) and two were open questions (e.g. "What are the past participles of the verbs to sleep, to shine, and to hide?"). These items enabled us to assess their English language abilities.

Following the pre-tests, the environment gave the learners instructions: either (1) a mastery-goal instruction that promoted the desire to develop skills or master the present perfect; or (2) a performance-goal instruction that promoted the desire to demonstrate one's ability to succeed, surpassing others with as little effort as possible (see Figure 1). These instructions, adapted from a previous study by Moos and Azevedo (2006), were manipulated as a between-participants factor.

Once the instructions had been provided, the ECG began. The game was based on the following synopsis: a main protagonist discovers that he has won a fabulous prize: a trip to a paradise island. During the flight, the plane crashes and he finds himself marooned in a lost archipelago. The purpose of the game was to help the protagonist escape from these lost islands by solving riddles. Theses riddles drew on the learners' mastery of the present perfect tense.

At the beginning of the game, the main protagonist was introduced to the learners. This sequence, embedded in the game, showed the main protagonist remembering his favorite teacher teaching him the present perfect tense. This demonstration insisted on the present perfect's characteristics and applications (see Figure 2). The learners could watch this demonstration at their own pace, and the *Next* buttons were delayed to prevent them from skipping important information. The number of seconds spent watching the demonstration was recorded in a log file.

At the end of this demonstration, the learners started to play the game. This ECG was a three-step game represented by three islands. On each island, the learners had to solve three riddles in order to help the main protagonist escape (Figure 3). By the end of the game, the learners had therefore responded to nine riddles. For each riddle, the learners had to answer a multiple-choice item where they had to pick the correct response from three possible answers (e.g. *"So, if you are here, I guess you want to flee this island. If you find me, maybe we could go away together … Well, here's what I can tell you* ***(1) I took the right path, (2) I have taken the one on the left, but (3) I had taken the middle one****. I can't say anymore, I must be cautious … Still, hopin' to see you soon."* Responses to these riddles were scored 0 or 1. As a function of

1 "In previous research, we have found that most students make a lot of mistakes in their use of the present perfect tense. ***The aim of the present study is therefore to collect as much information as possible, in order to help students master the rules of English grammar, especially the present perfect.***
In the next few minutes, you will have an opportunity to play a game while at the same time learning the present perfect rule. In this game, you will have to help the protagonist collect as many points as possible, so that he can go on a wonderful holiday. ***Nevertheless, you must bear in mind that what interests us is getting you to master this rule.***"

2 "In previous research, we have found that most students make a lot of mistakes in their use of the present perfect tense. ***The aim of the present study is therefore to find out why some people have problems, while others seem to stand out from the rest, making far fewer mistakes.***
In the next few minutes, you will have an opportunity to play a game while at the same time learning the present perfect rule. In this game, you will have to help the protagonist collect as many points as possible, so that he can go on a wonderful holiday, and ***show that you have done better than most of the other students.***"

Figure 1. The mastery-goal instruction (1) and performance-goal instruction (2).

Figure 2. Present perfect tense demonstration.

their answers, participants were provided with feedback on their success or failure, and an explanation of the correct solution. It must be emphasized that the correct solution was not systematically the present perfect, in order to avoid bias in response choices.

At the end of these three steps, the environment provided a questionnaire containing 10 transfer questions. These multiple-choice questions were intended to gauge the learners' comprehension of the present perfect tense (e.g. "I'm delighted to tell you that you ________ your exam": choose the correct expression: (1) "have passed"; (2) "passed"; (3) "pass"). The transfer questions were characterized by the fact that the explicit responses to them could not be found in the ECG. To answer correctly, participants therefore had to master the present perfect tense. Responses to each of the 10 questions were scored 1 point. The scoring grid, constructed before the session, indicated the correct score to be assigned to each response, according to its degree of accuracy. Participants could score up to 10 points on the transfer questionnaire.

The game sequences, pedagogical agent, texts, illustrations and riddles were exactly the same in both experimental conditions. The entire material was developed with Articulate Storyline©.

2.3. *Procedure*

The experiment took place in a room divided into four booths, each containing a computer. Participants were randomly assigned to one of the two conditions.

In the first experimental phase (pre-test), participants rated their perceived level of English. They then filled out the prior knowledge questionnaire. At this stage, no feedback on their score was given, in order to avoid metacognitive strategies being implemented

Figure 3. An example of a riddle provided in the ECG.

during the ECG. We made sure that the questions used in the pre-test would not help the learners answer either the riddles or the final transfer questionnaire.

In the second phase, the participants played the ECG. They were not told that their mastery of the present perfect tense would be assessed at the end of the game. Once they had read through the relevant instructions, participants were introduced to the main protagonist and given some information about the game scenario. After this sequence, a present perfect tense demonstration was provided, in the form of reminiscences about a favorite English teacher.

In the third phase, the learners embarked on the first step of the game step, in which a plane crash leaves the main protagonist marooned on an island. The role of the learners was to help him escape by solving three riddles based on the present perfect tense. As they were leaving the first island, the learners were reminded of their overall score (out of 3) for that island. The same procedure was repeated for each of the other two islands. Participants were provided with nine riddles and could score up to 9 points altogether.

In the fourth phase, which followed the game session, participants were asked to answer a transfer questionnaire. This questionnaire, embedded in the environment, contained 10 transfer questions gauging their mastery of the present perfect tense

3. Results

3.1. *Pre-tests*

Levene's test of homogeneity of variances indicated that the prior knowledge score variances were equal, $F(1, 45) = 0.68$, $p = .41$. Mean scores on this pre-test were 5.61 (SD = 1.72) for

Table 1. Mean scores on riddle resolution (maximum 9) and transfer questionnaire (maximum 10).

	Riddle resolution		Transfer questionnaire		
Instruction	*M*	SD	*M*	SD	*n*
Mastery goal	5.53	1.50	6.82	1.58	23
Performance goal	5.00	1.89	5.75	2.02	24

the mastery goal-oriented group and 5.46 (SD = 1.47) for the performance goal-oriented group. An analysis of variance (ANOVA) failed to reveal any significant difference between the scores of the experimental groups ($F < 1$).

Participants rated their perceived level of English on a 7-point Likert-like scale. Levene's test of homogeneity of variances showed that the rating variances were equal, $F(1, 45) = 1.91$, $p = .17$. Mean ratings were 3.48 (SD = 1.27) for the mastery goal-oriented group and 3.00 (SD = 0.98) for the performance goal-oriented group. An ANOVA failed to reveal any significant difference between the ratings provided by the two experimental groups, $F(1, 45) = 2.09$, mean squared error (MSE) = 1.28, $p = .15$.

3.2. *Consultation times for the present perfect tense demonstration*

Levene's test showed that the demonstration time variances were equal ($F < 1$). Contrary to our hypothesis, the difference in the amount of time the performance goal-oriented group ($M = 186.83$, SD = 33.48) and the mastery goal-oriented group ($M = 179.96$, SD = 41.72) spent watching the demonstration was not significant ($F < 1$).

3.3. *Riddle resolution scores*

According to Levene's test, the riddle resolution score variances were equivalent, $F(1, 45) = 1.37$, $p = .25$. Contrary to our expectations, the difference between the scores of the performance goal-oriented group ($M = 5.00$, SD = 1.89) and the mastery goal-oriented group ($M = 5.43$, SD = 1.50) was not significant ($F < 1$).

3.4. *Transfer questionnaire scores*

Table 1 gives the mean scores and standard deviations for the mastery-goal instruction and performance-goal instruction groups on the transfer questions.

Levene's test showed that variances for the transfer scores were equal, $F(1, 45) = 2.18$, $p = .15$. In line with our hypothesis, the ANOVA showed that the participants in the mastery-goal instruction condition ($M = 6.82$, SD = 1.58) performed significantly better than those in the performance-goal instruction condition ($M = 5.75$, SD = 2.02), $F(1, 45) = 4.08$, MSE = 3.35, $p = .049$, $\eta^2 = .08$.

4. Discussion

Results partially validated our hypotheses. Contrary to our expectations, we failed to observe any effect of the achievement-goal instruction on either riddle-solving scores (Hypothesis 2) or the amount of time spent watching the demonstration of the present perfect tense (Hypothesis 1). By contrast, the achievement-goal instruction did generate significant differences in performances on the transfer questionnaire (Hypothesis 3). More specifically, participants exposed to a mastery-goal instruction scored significantly higher on the transfer questionnaire than those exposed to a performance-goal one. This result therefore suggests that a mastery-goal instruction encourages the implementation of deeper processing than a performance-goal instruction. By flagging up a link between the use of mastery goals and deep-learning strategies, it corroborates previous findings (Belenky & Nokes-Malach, 2013; Bell & Kozlowski, 2002; Darnon & Butera, 2005; Elliot & McGregor, 2001; Harackiewicz et al., 2000). As in the study by Moos and Azevedo (2006), it indicates that a mastery-goal instruction, urging participants to deepen their knowledge, elicits the implementation of deeper cognitive processes than a performance-goal instruction, which encourages participants to demonstrate their ability to succeed by surpassing others while expending minimum effort.

Our results are also reminiscent of those yielded by studies probing the effects of reading instructions (Mc Crudden et al., 2010; Mc Crudden, Schraw, & Hartley, 2006; Peshkam, Mensink, Putnam, & Rapp, 2011). In particular, they are consistent with van den Broek et al. (2001), who established that using a learning instruction as opposed to an entertainment instruction promotes the implementation of deeper cognitive text processing. They also corroborate the conclusions of Erhel and Jamet (2013), by showing that superficial cognitive processes are more likely to be observed in situations where learners are not explicitly encouraged to learn. In other words, encouraging learners to use ECGs for entertainment probably activates surface cognitive processes that are detrimental to learning quality.

Although the results of the present study highlight the beneficial effect of instructions on transfer questionnaire performances, we did not observe any effect of instruction on demonstration consultation times. There are several possible explanations for this. First, the mastery-goal instruction may indeed trigger different types of information processing, but the measurement method we used may not have been sensitive enough to bring this effect to light: studies seeking to demonstrate links between processing speed and processing depth generally use either learner-controlled segmented presentation (Haberlandt, Graesser, Schneider, & Kiely, 1986) or eye-tracking (Kaakinen, Hyona, & Keenan, 2003) methods. The second possible explanation is that the performance instruction induced processes of a different nature, but which were just as costly in terms of time. In other words, while participants in the mastery-goal condition implemented inferential processes linked to the mastery and learning objectives, those in the performance-goal condition may have used other processes that were more to do with personal experience, as reading research has also demonstrated (van den Broek et al., 2001). The findings reported by Narvaez, van den Broek, and Ruiz (1999) suggest that the use of different instructions may trigger different types of inferential processes, but does not systematically bring about variations in consultation times. Applying a thinkaloud protocol or tracking eye movements would have allowed us to collect more relevant data about the nature of the cognitive processes recruited by the demonstration and to validate one or other of these explanations.

Regarding the effect of instructions on the riddle scores, one possible explanation is that the difference in learning quality we observed in the final test stemmed not from the way the participants had earlier processed the riddles, but rather from the way in which they processed the feedback they were given. It may well be that the learners in the mastery-goal instruction condition attended more closely to the feedback they received at the end of each riddle. This would have allowed them to construct more relevant mental representations, leading to higher scores on the transfer questionnaire. To verify this particular hypothesis, we would have had to conduct more accurate measures, such as eye movement recordings, in order to see whether feedback processing was more intense in the mastery-goal instruction condition.

One of the limitations of the present study concerned the absence of data, enabling us to check that the achievement goals induced by the initial instruction were maintained throughout the interaction with the ECG. In a recent study, Senko and Harackiewicz (2005) specifically explored the question of goal stability during learning. These authors postulated that achievement goals are regulated by competence feedback. More specifically, they found that learners regulated their goals according to how the feedback affected their level of perceived competence. This regulation may involve either switching to new goals or intensifying the goals that are already being pursued. This study's findings raise questions about the stability of the goals that were induced at the start of the game. The use of feedback at the end of each riddle, plus the island hopping, may have modulated the learners' level of perceived competence in English, thereby affecting their maintenance of the goals that had initially been induced.

Another limitation of the present study was the absence of subjective measures of, say, the learners' intrinsic motivation at the end of the interaction with the ECG. Several studies (Barron & Harackiewicz, 2001) have shown that mastery goals are linked to increases in intrinsic motivation. Although we did not set out to establish a link between mastery goals and intrinsic motivation, this measure would have allowed us to strengthen our conclusions about the beneficial effects of mastery goals.

The present study nonetheless makes a substantial contribution by revealing that instructions could be a key design factor in ECGs. If we want to encourage deep cognitive processing of educational content, we need to encourage the wider use of mastery-goal instructions in ECGs. In other words, the instructions provided to learners in an ECG should explicitly stress the mastery of knowledge and skill development. Encouraging learners to use ECGs for their own enjoyment, which is what often happens, could undermine the educational quality of this medium.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Adams, D. M., Mayer, R. E., MacNamara, A., Koenig, A., & Wainess, R. (2012). Narrative games for learning: Testing the discovery and narrative hypotheses. *Journal of Educational Psychology*, *104* (1), 235–249. doi:10.1037/a0025595

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Student learning strategies and motivation processes. *Journal of Educational Psychology*, *80*, 260–267.

Barron, K. E., & Harackiewicz, J. M. (2001). Achievement goals and optimal motivation: Testing multiple goal models. *Journal of Personality and Social Psychology*, *80*, 706–722.

Belenky, D. M., & Nokes-Malach, T. J. (2013). Mastery-approach goals and knowledge transfer: An investigation into the effects of task structure and framing instructions. *Learning & Individual Differences*, *25*, 21–34. doi:10.1016/j.lindif.2013.02.004

Bell, B. S., & Kozlowski, S. W. (2002). Goal orientation and ability: Interactive effects on self-efficacy, performance, and knowledge. *Journal of Applied Psychology*, *87*, 497–505.

Bernacki, M. L., Byrnes, J. P., & Cromley, J. G. (2012). The effects of achievement goals and self-regulated learning behaviors on reading comprehension in technology-enhanced learning environments. *Contemporary Educational Psychology*, *37*(2), 148–161. doi:http://dx.doi.org/10.1016/j.cedpsych.2011.12.001

van den Broek, P., Lorch, R. F., Linderholm, T., & Gustafson, M. (2001). The effects of readers' goals on inference generation and memory for texts. *Memory and Cognition*, *29*, 1081–1087.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, *59*, 661–686. doi:10.1016/j.compedu.2012.03.004

Darnon, B., & Butera, F. (2005). Buts d'accomplissement, stratégies d'étude, et motivation intrinsèque: présentation dun domaine de recherche et validation française de l'échelle d'Elliot et McGregor (2001). *L'année Psychologique*, *105*(1), 105–131. doi:10.3406/psy.2005.3821

DeLeeuw, K. E., & Mayer, R. E. (2011). Cognitive consequences of making computer-based learning activities more game-like. *Computers in Human Behavior*, *27*, 2011–2016. doi:10.1037/0022–0663.100.1.223

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology*, *70*, 461–475.

Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*, 501–519. doi:10.1037/0022–3514.80.3.501

Elliot, A. J., Shell, M. M., Henry, K. B., & Maier, M. A. (2005). Achievement goals, performance contingencies and performance attainment: An experimental test. *Journal of Educational Psychology*, *97*(4), 630–640.

Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology*, *54*(1), 5–12.

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education*, *67*, 156–167. doi:10.1016/j.compedu.2013.02.019

Gee, J. P. (2005). Learning by design: Good video games as learning machines. *E-Learning*, *2*(1), 5–16. doi:10.2304/elea.2005.2.1.5

Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: How effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning*, *29*(1). doi:10.1111/j.1365–2729.2012.00489.x

Graesser, A. C., Chipman, P., Leeming, F., & Biedenbach, S. (2009). Deep learning and emotion in serious games. In U. Ritterfeld, M. Cody, & P. Vorderer (Eds.), *Serious games: Mechanisms and effects* (pp. 81–100). New York, NY: Routledge, Taylor & Francis.

Haberlandt, K. F., Graesser, A. C., Schneider, N. J., & Kiely, J. (1986). Effects of task and new arguments on word reading times. *Journal of Memory and Language*, *25*(3), 314–322.

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., Carter, S. M., & Elliot, A. J. (2000). Short-term and long-term consequences of achievement goals: Predicting interest and performance over time. *Journal of Educational Psychology*, *92*, 316–330.

He, T. (2008). Reading for different goals: The interplay of EFL college students' multiple goals, reading strategy use and reading comprehension. *Journal of Research in Reading*, *31*(2), 224–242. doi:10.1111/j.1467–9817.2007.00355.x

Hulleman, C. S., Schrager, S. M., Bodmann, S. M., & Harackiewicz, J. M. (2010). A meta-analytic review of achievement goal measures: Different labels for the same constructs or different constructs with similar labels? *Psychological Bulletin*, *136*(3), 422–449. doi:10.1037/a0018947

Johnson, C. I., & Mayer, R. E. (2010). Applying the self-explanation principle to multimedia learning in a computer-based game-like environment. *Computers in Human Behavior*, *26*, 1246–1252. doi:10.1016/j.chb.2010.03.025

Kaakinen, J. K., Hyona, J., & Keenan, J. M. (2003). How prior knowledge, WMC, and relevance of information affect eye fixations in expository text. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(3), 447–457.

Kester, L., Kirschner, P. A., & Corbalan, G. (2007). Designing support to facilitate learning in powerful electronic learning environments. *Computers in Human Behavior*, *23*, 1047–1054. doi:10.1016/j.chb.2006.10.001

Künsting, J., Wirth, J., & Paas, F. (2011). The goal specificity effect on strategy use and instructional efficiency during computer-based scientific discovery learning. *Computers & Education*, *56*(3), 668–679.

Linnenbrink-Garcia, L., Tyson, D. F., & Patall, E. A. (2008). When are achievement goal orientations beneficial for academic achievement? A closer look at main effects and moderating factors. *Revue Internationale de Psychologie Sociale*, *21*, 19–70.

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). New York, NY: Cambridge University Press.

Mayer, R. E. (2011). Multimedia learning and games. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 281–305). Charlotte, NC: Information Age.

Mc Crudden, M. T., Magliano, J. P., & Schraw, G. (2010). Exploring how relevance instructions affect personal reading intentions, reading goals and text processing: A mixed methods study. *Contemporary Educational Psychology*, *35*, 229–241. doi:10.1016/j.cedpsych.2009.12.001

Mc Crudden, M. T., Schraw, G., & Hartley, K. (2006). The effect of general relevance instructions on shallow and deeper learning and reading time. *Journal of Experimental Education*, *74*(4), 293–310. doi:10.3200/JEXE.74.4.291–310

Moos, D. C., & Azevedo, R. (2006). The role of goal structure in undergraduates' use of self-regulatory processes in two hypermedia learning tasks. *Journal of Educational Multimedia and Hypermedia*, *15*(1), 49–86.

Moos, D. C., & Marroquin, E. (2010). Multimedia, hypermedia, and hypertext: Motivation considered and reconsidered. *Computers in Human Behavior*, *26*(3), 265–276. doi:10.1016/j.chb.2009.11.004

Moreno, R., & Mayer, R. E. (2004). Personalized messages that promote science learning in virtual environments. *Journal of Educational Psychology*, *96*, 165–173. doi:10.1037/0022–0663.96.1.165

Narvaez, D., van den Broek, P., & Ruiz, A. B. (1999). The influence of reading purpose on inference generation and comprehension in reading. *Journal of Educational Psychology*, *91*, 488–496.

Papastergiou, M. (2009). Exploring the potential of computer and video games for health and physical education: A literature review. *Computers & Education*, *53*, 603–622. doi:10.1016/j.compedu.2009.04.001

Peshkam, A., Mensink, M. C., Putnam, A. L., & Rapp, D. N. (2011). Warning readers to avoid irrelevant information: When being vague might be valuable. *Contemporary Educational Psychology*, *36*, 219–231. doi:10.1016/j.cedpsych.2010.10.006

Pintrich, P. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 452–502). San Diego, CA: Academic Press.

Prensky, M. (2001). *Digital game-based learning*. New York, NY: McGraw Hill.

Schell, J. (2008). *The art of game design: A book of lenses*. Burlington, MA: Morgan Kaufmann.

Senko, C., & Harackiewicz, J. M. (2005). Regulation of achievement goals: The role of competence feedback. *Journal of Educational Psychology*, *97*(3), 320–336.

Shaffer, D. W. (2006). *How computer games help children learn*. New York, NY: Palgrave Macmillan.

Sweller, J. (1999). *Instructional design in technical areas*. Melbourne: ACER Press.

Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 19–30). New York, NY: Cambridge University Press.

Tobias, S., & Fletcher, J. D. (2008). *What do we know about the learning effectiveness of computer games?* Paper presented at the Annual meeting of AERA, New York.
Vollmeyer, R., & Burns, B. D. (2002). Goal specificity and learning with a hypermedia program. *Experimental Psychology*, *49*(2), 98–108.
Wirthwein, L., Sparfeldt, J. R., Pinquart, M., Wegerer, J., & Steinmayr, R. (2013). Achievement goals and academic achievement: A closer look at moderating factors. *Educational Research Review*, *10*, 66–89. doi:http://dx.doi.org/10.1016/j.edurev.2013.07.001
Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *105* (2), 249–265.
Wouters, P., & van Oostendorp, H. (2013). A meta-analytic review of the role of instructional support in game-based learning. *Computers & Education*, *60*, 412–425. doi:10.1016/j.compedu.2012.07.018