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The effects of purpose instructions and strategy-focused instructions on reading processes and products

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Abstract

In educational settings, students read for multiple purposes, such as preparing for an exam, practicing a new reading strategy, writing an essay, and more. Because reading is a goal-directed activity, providing students with task instructions can help them create goals for reading and develop a plan to meet these goals. In the current experiment, we investigated the effects of purpose instructions and strategy-focused instructions on cognitive processes during reading and learning from a single text. Participants were randomly assigned to one cell of a 2×2 factorial design. Participants in all four conditions provided typed constructed responses during reading and completed a comprehension and transfer test after reading. For purpose instructions, participants either received information about the post-reading assessment or were just asked to read (control). For strategy-focused instructions, participants received either self-explanation instructions or think-aloud instructions (control). We coded the quantity and quality of the cognitive processes in readers' constructed responses. Self-explanation instructions promoted the quantity and quality of cognitive processes students used during reading. Also, purpose and self-explanation instructions interacted, which promoted the quality of cognitive processes and reading comprehension compared to purpose-only instructions or self-explanation-only instructions. These findings indicated that purpose instructions and self-explanation instructions differentially affected reading processes and reading outcomes. These results underscore that different task instructions have varying effects, which has important implications for theory and practice.

Keywords Task instructions · Reading comprehension · Reading processes · Self-explanation

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Introduction

The ability to read well is crucial for academic success. University students read texts for a variety of academic reasons, such as preparing for class, preparing for exams, writing essays, and preparing for presentations. While engaging in these types of reading activities, students may use different strategies to process the information in these texts. For example, some students might connect what they are reading with what they have learned previously (i.e., elaborations), while others might process the text at a surface level. Students who make elaborations during reading may demonstrate better understanding of text because connecting text information with prior knowledge is a component of successful text comprehension (Kintsch, 1988; McNamara, 2004). Thus, how readers engage with text affects their comprehension, and students who process texts in less effective ways may struggle with comprehension.

To promote learning from texts, instructors often provide students with task instructions to guide their reding of assigned texts. Task instructions are statements instructors give students to help orient them to reading tasks (McCrudden & Schraw, 2007; Rouet & Britt, 2011; Zhang et al., 2019). Pre-reading task instructions can affect how readers engage with texts while reading (i.e., reading processes, such as the use of elaborations and paraphrases), and what they remember from the texts they have read (i.e., reading products) (Anmarkrud et al., 2013; Bohn-Gettler & McCrudden, 2018; Kaakinen & Hyona, 2005; Rapp and Mensink, 2011). However, different types of task instructions can affect how readers engage with texts and what they remember (McCrudden & Schraw, 2007; McCrudden et al., 2010). Moreover, the effect of the task instructions on students' reading processes may subsequently impact their reading products. For example, Kim (2003) found participants who were asked to read texts to write a report explaining the texts to their friends (summary group) made more elaborations during reading and generated a more coherent memory representation for the reading texts after reading than participants who were asked to read for a memory test (memory group) or just a test (control group).

In this paper, we consider how purpose instructions and strategy-focused instructions affect reading processes and products. Purpose instructions inform or cue readers to the purpose of reading a particular text. Strategy-focused instructions explicitly prompt readers to use certain strategies during reading. While purpose instructions emphasize the desired outcome of the reading activity (product), they do not typically provide explicit guidance on the specific strategies that readers could use while reading (processes) to generate this outcome. In contrast, strategy-focused instructions focus on the reading strategies that can be used during reading to facilitate learning (processes) but may not explicitly specify the desired outcome of the reading activity (product). This study aimed to investigate the independent and combined influence of strategy-focused instructions and purpose instruction on reading processes and outcomes of reading.

Importantly, purpose instructions and strategy-focused instructions are reflected in the PISA (Programme for International Student Assessment) reading framework, and emphasize different aspects of reading, yet are complementary. The OECD (Organisation for Economic Co-operation and Development) developed PISA assessments to determine the extent to which students have acquired skills in reading, math, science, and problem-solving that are essential for their future adult lives (Schleicher et al., 2009). The PISA reading framework identifies three aspects of reading that readers utilize to navigate their way through, around, and between texts: access and retrieve, integrate and interpret, and reflect and evaluate. *Access and retrieve* involves locating and retrieving one or more distinct pieces of information within a given information space, which aligns with purpose instructions, and encourages readers to develop criteria for determining text relevance (McCrudden & Schraw, 2007). *Integrate and interpret* involves making inferences for information that is not stated in the text and making connections between text ideas. This aligns with strategy-focused instructions, especially self-explanation instructions (McNamara, 2004), which guide readers to go beyond the text to make sense of the information. Thus, although purpose instructions and strategy-focused instructions frame the reading tasks differently, their combination may be complementary and maximize the benefits of task instructions on reading processes and products.

The present study aimed to investigate the effects of purpose instructions and strategy-focused instructions on reading processes and learning. Participants generated typed constructed responses (verbal protocols) while reading. Verbal protocols provide information about the processes individuals use while reading (Magliano & Millis, 2003). Although prior research indicates that typed verbal protocols might affect the overall frequency of some cognitive processes compared to oral verbal protocols, format (typed vs. oral) does not substantively affect the quality of those processes; thus, typed responses are a valid measure of cognitive processes during reading (Higgs et al., 2015; Muñoz et al., 2006). To evaluate reading processes, we assessed the quantity and quality of readers' constructed responses. We coded constructed responses for the presence of different cognitive processes, such as elaborations and bridging inferences, and rated the quality of those processes. To evaluate reading products, we asked participants to complete post-reading measures of comprehension and transfer.

Task-based reading

Two frameworks for understanding the effects of task instructions on reading are the TRACE model (Task-based Relevance Assessment and Content Extraction; Rouet, 2006) and RESOLV model (REading as problem SOLVing; Britt et al., 2018; Rouet et al., 2017). According to the TRACE model, readers form a task model, which involves constructing a representation of reading task goals and a plan to complete those goals. The formation of a task model can be influenced by external resources (i.e., task specifications, information resources, reader-generated resources) and internal resources (i.e., permanent resources and transitory resources in reading; Rouet and Britt, 2011). In the present study, we focus on task instructions, which fall into the category of task specifications. Task specifications are the verbal and nonverbal cues that specify reading tasks; task instructions are the verbal statements that signal the reading assignment (Rouet & Britt, 2011). According to the TRACE model, pre-reading task instructions, such as purpose instructions, affect the formation of a reader's goals and task model. For instance, asking readers to write an explanatory essay after reading can help them create a task model and goal for writing an explanatory essay. Given this goal, readers may create an outline and consider which textual information to include in the essay as they read. Further, asking readers to use certain strategies during reading (i.e., strategy-focused instructions) can influence how they attempt to meet their goals. For example, asking readers to explain how events in a text are related may help readers to write an explanatory essay. As such, purpose instructions and strategy-focused instructions can affect readers' goals for reading and actions to complete the goals.

The RESOLV model builds upon and extends the TRACE model to explain how students mentally represent and understand various reading assignments. According to the RESOLV model, when presented with a task assignment, readers develop both a task model and a context model (Britt et al., 2018; Rouet et al., 2017). The context model is a reader's representation of the reading situation, which is influenced by five main contextual features. These are: (a) the *requester* (e.g., the teacher), (b) the *request* (i.e., the task assignment), (c) the *audience* (e.g., teachers, classmates), (d) the *supports for* and *obstacles to* task completion presented by the task context (e.g., the materials available, time constraints), and (e) readers' *self-assessment* of their task-related competencies (e.g., self-efficacy). As in the TRACE model, the task model refers to the task goals that learners adopt and their plans to complete their goals. Learners construct their task models by selecting important task-related cues from the context model, interpret these, and use them to set and update goals throughout the task. One way to provide students with these contextual features of reading situations is task instructions. Readers can interpret the information conveyed by task instructions to obtain the contextual information, such as what the assignment is, the supports for (e.g., reading strategies) and obstacles (e.g., time constraints) to task completion. Thus, readers can construct their context models based on their interpretation of purpose instructions and strategy-focused instructions. Given the context models, readers then form their task model including their reading goals and plans to complete the goals (McCrudden & Schraw, 2007; Rouet, 2006; Rouet & Britt, 2011; Rouet et al., 2017). In the next two sections, we review these two instructions.

Purpose instructions

Purpose instructions inform readers about reasons to read, expected reading outcomes, post-reading assessment, or what they will do after reading, all of which can influence what readers do as they read (Bohn-Gettler & Kendeou, 2014; Rouet, 2006; Rouet & Britt, 2011; van den Broek et al., 2001). Previous research has examined the effect of purpose instructions on reading processes and products. van den Broek et al. (2001) used think-alouds to compare the cognitive processes of readers who received either read-to-study instructions (i.e., imagine reading to prepare for an essay exam) or read-for-entertainment instructions (i.e., imagine you are browsing through a magazine and come upon an article of interest). Participants in the read-to-study condition generated more coherence-building inferences, such as predictions and bridge inferences, and recalled more information from the texts than those in the read-for-entertainment condition. Linderholm and van den Broek (2002) also found that participants in the read-to-study group (i.e., read to prepare for an essay exam) made more bridging inferences, paraphrases, text repetitions, and metacognitive comments during reading. Further, participants in the read-to-study condition recalled more information from the texts. Thus, purpose instructions can affect reading processes and products.

However, different kinds of purpose instructions can inform readers about different kinds of expected reading outcomes, which can affect reading outcomes. For instance, in Geiger and Millis (2004), participants read procedural and descriptive texts and were asked to either read to summarize the texts, perform the procedures, or be able to answer questions. Participants who read to perform the procedures recalled more text ideas and had better text understanding than participants in the question-answering group. Participants who read to perform and summarize did not differ. As another example, Bråten and Strømsø (2010) randomly assigned participants to one of three conditions and asked them to read multiple texts about climate change and imagine they would need to prepare a report. They asked the argument group to imagine they would need to express and justify their opinions about the influence of climate change on life on Earth and the causes of climate change. They asked the summary group to summarize how climate change may influence life on Earth and the causes of climate change. They asked the general understanding group to impart an understanding of climate change. Participants in argument and summary groups showed a better understanding of the texts than participants in the general understanding group. In sum, more specific purpose instructions enhanced learning from texts.

Thus, previous research indicates that more specific purpose instructions affect students' reading processes and products. While prior studies compared the effect of different instructions on reading, in the present study, we examined the effect of purpose instructions on reading processes and products by giving participants either purpose instructions (i.e., providing information about post-reading assessment) or control instructions (i.e., asking participants to read a text). The control instructions were meant to reflect students' natural and default reading purpose.

Strategy-focused instructions

The goal of strategy-focused instructions is to provide readers with information about what to do during reading, and these instructions can impact reading processes and products. Magliano et al. (1999) examined the effect of strategy-focused instructions on cognitive processes and memory by prompting students either to explain, predict, associate, or to understand text while reading silently or while thinking aloud as they read. Think-aloud results indicated that participants were more likely to engage in the strategies they were prompted to use and less likely to use the other three strategies. For example, participants in the explanation group made more explanations and fewer associations than participants in the association group. In addition, when reading silently, participants in the read-to-explain group recalled more information than participants in the other groups.

Similarly, Horiba (2000) examined the effect of strategy-focused instructions on reading by prompting participants to either read for coherence or to read freely. Participants in the read-for-coherence condition were asked to think about how the current sentence was related to previously read sentences and to upcoming sentences in the text. In contrast, participants in the read-freely condition were asked to read as they would normally read. Participants in the read-for-coherence condition made more backward and forward inferences and commented more frequently about the text structure than participants in the read-freely condition. Thus, asking readers to use a specific strategy (Magliano et al., 1999) or prompting them to read for coherence (Horiba, 2000) can affect cognitive processes during reading.

Training university-level readers to use multiple reading strategies can also affect processing. McNamara (2004) used self-explanation reading training (SERT) to examine the effectiveness of combining self-explanation and instructions to use reading strategies while reading text. SERT is instructor-led training and provides students with a description of self-explanation and six reading strategies. Participants practiced using SERT after learning about strategies that are characteristic of effective self-explanation (e.g., paraphrasing, elaboration, bridging) through in-person training. The results showed that students with low prior knowledge who received SERT engaged in deeper level cognitive processes, such as more comprehension monitoring, predictions, and correct elaborations, and showed better test performance than students who did not receive SERT.

However, due to the relatively high cost of instructor-led SERT, McNamara et al. (2004) developed interactive strategy training for active reading and thinking (iSTART), a Web-based one-on-one training program. In iSTART, instead of a person providing face-to-face instruction, the learner observes a class discussion between three animated agents (one instructor and two students), where definitions and examples of self-explanation strategies are provided. During the practice phrase, the instructor agent in iSTART provides feedbacks to the trainee about their self-explanation responses. Several studies have found that students with lower prior knowledge of reading strategies who received iSTART comprehend texts better than students who did receive iSTART (McNamara & the CSEP Lab, 2004; O'Reilly et al., 2004).

SERT and iSTART involve extended modeling and practice in the use of reading strategies. Self-explanation can also be beneficial when readers are merely prompted to self-explain; that is, in the absence of instructor-led training. Linderholm et al. (2014a) conducted two studies to investigate the effect of a self-explanation prompt (in the absence of instructor-led training) on reading processes and comprehension. In the first study, they asked participants to think aloud while reading. They coded participants' comments for strategy use and found that self-explanation strategies were significantly correlated with comprehension. In the second study, they prompted participants to either self-explain or to read for comprehension. Participants who self-explained had better comprehension than participants who read for comprehension. In another article, Linderholm et al. (2014b) conducted two experiments in which participants were assigned to one of three conditions: (a) read for comprehension, (b) provided a definition of self-explanation and asked to self-explain; or (c) provided a definition and modeling of self-explanation and asked to self-explain. The results from both experiments showed that participants who received a definition of self-explanation and were asked to self-explain did better on the comprehension measures than participants who read for comprehension, which indicated that self-explanation prompts can promote text comprehension.

Taken together, previous research indicates strategy-focused task instructions affect students' reading processes and products. The present study investigated the influence of strategy-focused instructions by randomly assigning participants to either self-explain or think-aloud. The think-aloud instructions served as the control instructions because they were meant to elicit participants' natural reading processes.

Present study

Reading to learn from text involves building connections between sentences, and between text information and prior knowledge. Constructed responses during reading can allow researchers to measure such cognitive processes. Purpose instructions and strategy-focused instructions might, individually or in combination, affect the quantity and quality of cognitive processes during reading. Thus, we investigated the impact of purpose and strategy-focused task instructions on reading processes and learning.

Participants were randomly assigned to one cell of a 2 (purpose instructions: yes vs. no) x 2 (self-explanation instructions vs. think-aloud instructions) between-subject experimental design to investigate the impact of purpose and self-explanation instructions on reading processes and learning. Participants in all four conditions provided typed constructed responses during reading and completed a comprehension and transfer test after reading. Participants who received the purpose instructions were informed that, after reading, they would be asked to explain the reasons for particular events in the text. They were also shown an example of a student's post-reading explanation (about an unrelated topic). In contrast, participants who did not receive purpose instructions were not given an explicit reading purpose or information about the nature of the post-reading assessment. Participants who received self-explanation instructions were asked to explain the text to themselves as they read. They were also shown examples of self-explanations (about an unrelated topic). In contrast, participants who did not receive the self-explanations were asked to state the thoughts that immediately came to mind while reading and were shown examples of general comments a student made while reading (about an unrelated topic). The combination of online self-explanation (i.e., making self-explanations moment-by-moment during reading) and offline explanation (i.e., asking students to explain the reasons for particular events in the texts after reading) allowed us to investigate the potential additive effect of combining strategy-focused instructions and purpose instructions.

We had two main research questions. Our first research question was: How do self-explanation instructions and purpose instructions affect reading processes? To address this question, we collected typed constructed responses to measure cognitive processes during reading. Constructed responses provide information about students' reading process (Higgs et al., 2015; Magliano & Millis, 2003; Muñoz et al., 2006).

We predicted that participants who received purpose instructions would generate cognitive processes (e.g., elaborations, predictions) with greater frequency and of higher quality than participants who received the control instructions. The purpose instructions informed participants that we would assess their understanding of the text after they read and provided an example of a post-reading explanation (about an unrelated topic). As such, we expected they would have a more specific goal and more developed task model for reading. Conversely, the control instructions asked participants to simply read the text. As such, we expected they would develop a general goal of reading-to-understand.

We also predicted that participants who received self-explanation instructions would generate cognitive processes (e.g., elaborations, predictions) with greater frequency and of higher quality than participants who received think-aloud instructions (McNamara, 2004). This is because the self-explanation instructions asked participants to explain the meaning of text to themselves. In contrast, the think-aloud instructions asked participants to report the thoughts that immediately came to mind while reading, which reflects naturally occurring processes during reading.

We also expected a significant interaction between self-explanation instructions and purpose instructions. Specifically, we expected the combination of self-explanation instructions and purpose instructions would lead to more and higher-quality cognitive processing. Purpose instructions contribute to constructing a task model with a specific reading goal. Self-explanation instructions encouraged participants to use the reading strategy of self-explanation to achieve the reading goal. When combined, we expected an additive effect of self-explanation and purpose instructions on cognitive processes.

The second research question was: How do self-explanation instructions and purpose instructions affect reading products? We expected a main effect for both self-explanation instructions and purpose instructions on reading products. Previous research indicates that purpose instructions and self-explanation instructions promote performance on post-reading outcome measures (van den Broek et al., 2001; Linderholm et al., 2014a, b). Further, we expected a significant interaction between self-explanation instructions and purpose instructions. Providing both types of instructions may help readers create more focused goals, such that they develop a better task model and a means to meet their goal for reading. Thus, we anticipated an additive effect, such that participants who received the self-explanation instructions and purpose instructions would perform best on the post-reading measures.

Method

Participants

Participants ($n=88$) were undergraduates from two universities in the United States. The mean age was 19.19 years ($SD=0.98$). One university was in the northeastern US ($n=46$) and the other was in the upper Midwest ($n=42$). Analyses indicated participant scores did not differ by university (see Results). Participants received extra credit for participation. Self-identified gender was: 71 women (80.68%) and 17 men (19.31%). Self-identified racial category was: White (88.7%, $n=78$), Hispanic/Latino (5.68%, $n=5$), biracial/mixed race (1.5%, $n=2$), and Asian (0.76%, $n=1$). Two participants (1.5%) did not report their race. An a-priori power analysis using G* Power for an ANOVA with four groups, one numerator degrees of freedom, with an alpha level of 0.05, power equal to 0.0.80, and a medium-to-large effect size ($f=0.30$, corresponding to prior research which demonstrated a medium to large effect size of self-explanation and purpose instructions on reading) were run to decide the sample size. Total recommended sample size was 90, which closely approximated our sample size.

Materials

Text

Participants were asked to read an introductory level (Flesch-Kincaid grade level of 6.0) and highly cohesive text about natural selection (see referential cohesive indices on Table 1, at least 50% of the sentence pairs in the text contained an overlapping noun, adjective, and pronouns when comparing all the sentences). The text, adapted from Kelemen (2018), described how a fictitious species (dormacks) with shorter backs evolved longer backs. It described five principles of natural selection (i.e., variation, differential survival, differential reproduction, inheritance, population change), although the names of the principles were not explicitly stated. The text (974 words, 61 sentences) was separated into 23 sections. A blank box was provided after each section of text for participants to type their constructed responses. Each of the sections corresponded to a complete idea. For instance, sentence 15 (“Because they were so busy, they felt hungry and thirsty a lot”) and sentence 16 (“They had to spend a lot of time looking for food to eat and water to drink”) were in the same section and the blank box appeared after sentence 16.

Prior knowledge test

The prior knowledge test consisted of seven multiple-choice items from the Conceptual Inventory of Natural Selection (CINS, Anderson et al., 2002). Participants were provided descriptive scenarios about two animals (i.e., Galapagos Finches, Canary Island Lizards). After each scenario, participants answered multiple-choice questions about concepts of natural selections (3 questions about Galapagos Finches; 4 questions about Canary Island Lizards). Responses were scored as correct or incorrect; thus, total scores could range from 0 to 7. The average score on the prior knowledge test was 3.33 ($SD=1.49$). Cronbach’s alpha reliability of the pretest was 0.45. A two-way ANOVA indicated no significant difference in prior knowledge among groups, $ps>0.18$. Given the low reliability of the prior knowledge test and the lack of differences in scores across groups, the prior knowledge test was excluded from further analysis.

Table 1 Referential cohesion indices for the text

Referential cohesive indices	Value
Noun overlaps between adjacent sentences	0.607
Argument overlaps between adjacent sentences	0.738
Stem overlaps between adjacent sentences	0.689
Noun overlaps in all sentences	0.506
Argument overlaps in all sentences	0.607
Stem overlaps in all sentences	0.566

Comprehension test

Comprehension was measured via four open-ended questions tapping the process of how longer-back dormacks evolved from shorter-back dormacks and the reasons why it happened. For example, students were asked: *Did it take a short time or a long time for dormacks to go from having mostly shorter backs in the past to having mostly longer backs now? Why? Please provide a detailed explanation.* Responses to the four items were collapsed into one composite score.

Transfer test

Three items were developed based on materials from Shtulman et al. (2016) to assess participants' ability to apply the four principles of natural selection in the text to three new animals (i.e., cheetahs, seals, polar bears). Specifically, the items asked participants to explain why a species changed over time (e.g., *Cheetahs are able to run faster than 60 miles per hour when chasing prey. How would a biologist explain how the ability to run fast evolved in cheetahs, assuming their ancestors could only run 20 miles per hour?*).

Procedure

The study was conducted via Qualtrics, and students provided informed consent before beginning the study. There were five main steps in the procedure. First, students received the prior knowledge test. Second, students were randomly assigned to one of four conditions (i.e., control, self-explanation only, purpose instructions only, and self-explanation and purpose instructions) and received their respective instructions. Participants completed a manipulation check to indicate they understood their instructions, followed by a summary of their respective task instructions (see Table 2). Specifically, participants were asked to read the text section at a time and to type their constructed responses into the blank box directly below the text section. Third, participants read the text and typed their constructed responses. Fourth, participants completed the comprehension and transfer tests. Finally, participants were asked to provide their demographic information.

Data coding

Constructed responses

We coded each constructed response holistically for quantity and quality (see Tables 3 and 4) using a scheme adapted from McNamara (2004). For quantity scores, we coded for the presence of four non-mutually exclusive general cognitive processes (paraphrases, text-based bridging inferences, elaborations, and predictions) in each constructed response. The first rater coded all responses and a second trained rater coded 28.41% ($n=25$) of the responses to establish interrater reliability. Each constructed response was coded by each rater for each of the four cognitive processes to determine the respective quantity scores. Interrater agreement was 93.57% (Cohen's

Table 2 Summary of task instruction for each group

Group	Summary of task instructions
Control	You will now be asked to read a text about how dormacks evolved longer backs. For each text section, please read the text, and then write the thoughts that immediately come to mind in the space provided below the text section. Please note that there are no "right" or "wrong" thoughts. Please respond to the text segments in the order in which they are presented, and do not go back and change any responses.
Self-explanation instructions only	You will now be asked to read a text about how dormacks evolved longer backs. For each text section, please read the text, and then provide your own self-explanation of that text section in the space provided below the text section (i.e., self-explain how dormacks evolved longer backs.) Remember that an explanation doesn't just restate the passage. It explains what the passage means. You can use anything you know about the text to explain it.
Purpose instructions only	You will now be asked to read a text about how dormacks evolved longer backs. For each text section, please read the text, and then write the thoughts that immediately come to mind in the space provided below the text section. Please note that there are no "right" or "wrong" thoughts. Please respond to the text segments in the order in which they are presented, and do not go back and change any responses. After you read, we will assess your understanding of the text. Specifically, we will ask you to explain the reasons why dormacks have evolved longer backs.
Self-explanation and purpose instructions	You will now be asked to read a text about how dormacks evolved longer backs. For each text section, please read the text, and then provide your own self-explanation of that text section in the space provided below the text section (i.e., self-explain how dormacks evolved longer backs.) Remember that an explanation doesn't just restate the passage. It explains what the passage means. You can use anything you know about the text to explain it. After you read, we will assess your understanding of the text. Specifically, we will ask you to explain the reasons why dormacks have evolved longer backs.

$K=0.82$) for paraphrases, 96.35% (Cohen's $K=0.79$) for bridging inferences, 97.73% (Cohen's $K=0.90$) for elaborations, and 95.31% (Cohen's $K=0.80$) for predictions. These were calculated by comparing the number of times the two raters agreed on the coding of constructed response.

For quality scores, we coded the quality of each of these four general cognitive processes. Each paraphrase, bridge, and elaboration was coded separately via three indices (i.e., contribution, accuracy, level). Each index ranged from 1 to 2, or 1 to 3, based on type of cognitive process. Participants could get a maximum score of 9 for each paraphrase, 7 for each bridge, and 7 for each elaboration. We summed the three quality indices of each cognitive process individually (paraphrases, bridges, and elaborations) and divided by the total scores of the three indices (i.e., 9 for paraphrase, 7 for bridging inference, and 7 for elaboration) to get the quality of each cognitive, ranging from 0 to 1. For instance, if a participant generated three paraphrases, each paraphrase would be scored for contribution (1–3), accuracy (1–3), and level (1–3). For each paraphrase, the indices would be summed (e.g., $3+2+2=7$) and divided by 9 ($7/9=0.78$). Then the scores for each paraphrase would be summed (e.g., $0.78+0.89+0.78=2.45$) and divided by the total number of paraphrases (e.g., $2.45/3=0.82$). Thus, the overall quality score for each cognitive process for each participant could range from 0 to 1. Each prediction was coded via one index (quality), which ranged from 1 to 3, then divided by the total score of 3 to get the quality of

Table 3 Coding scheme for quantity of cognitive processes

Cognitive process	Definition	Scoring	Text excerpt	Sample participant response
Paraphrase	Restatement of the current sentence in different words	0 = no 1 = yes	Many hundreds of years ago, dormacks wandered all through the woods with their children. They had a busy life.	*A long time ago, dormacks and their children would journey through the woods together, having a very active lifestyle.*
Bridging inferences	Backward inference to previous sentences	0 = no 1 = yes	*Earlier sentences*: Here are some different fully-grown adult dormacks. These are the dormacks that live nowadays, and this is what the group looks like now. Dormacks nowadays mostly all have longer backs. Why were there so many dormacks with shorter backs in the group a long time ago but nowadays there are mostly dormacks with longer backs in the group? Why do dormacks mostly have longer backs now? *Current sentences*: Dormacks with shorter backs had trouble getting food. They could only reach the bottom branches where there were hardly any nuts. Some dormacks with shorter backs got to eat when they found nuts hanging from the bottom branches. But other dormacks with shorter backs did not eat anything at all.	*The shorter dormacks had a lack of food and died overtime for being malnourished. The long backs survived, which is why mainly the dormacks now have longer backs.*
Elaboration	Connecting the current sentence with background knowledge	0 = no 1 = yes	Here are some different fully-grown adult dormacks. These are the dormacks that live nowadays, and this is what the group looks like now. Dormacks nowadays mostly all have longer backs. Why were there so many dormacks with shorter backs in the group a long time ago but nowadays there are mostly dormacks with longer backs in the group? Why do dormacks mostly have longer backs now?	*This seems like a simple case of evolution. I have learned about evolution many times in psychology and biology classes. The taller dormacks probably have an advantage when it comes to getting food and that is why dormacks today are mostly taller. Taller dormacks are able to reproduce more frequently passing along those genes.*

Table 3 (continued)

Cognitive process	Definition	Scoring	Text excerpt	Sample participant response
Prediction	Thinking about what might happen next in the text and/or what might be the reason of specific event	0 = no 1 = yes	Because of the cold, the nuts went from hanging from the bottom branches to only hanging from the top branches that didn't break from the frost. Most of the nuts hung from the very top branches	*Only tall dormacks can reach those nuts*

prediction, which could range from 0 to 1. Two raters independently coded 28.41% ($n=25$) of the protocols for quality of cognitive processes. Each rater coded each paraphrase, text-based bridging inference, and elaboration for each of the quality indices (i.e., contribution, accuracy, and level). Specifically, if a constructed response was identified as a paraphrase, text-based bridge inference, or elaboration, each rater read this constructed response to code its contribution, then read the same constructed response again to code its accuracy, and finally its level. If the constructed response was coded as prediction, each rater read the response to code its quality. The inter-rater reliability was 88.35% (Cohen's $K=0.84$) for paraphrase contribution, 89.74% (Cohen's $K=0.75$) for paraphrase accuracy, 85.57% (Cohen's $K=0.74$) for paraphrase level, 96.52% (Cohen's $K=0.80$) for bridging inference contribution, 96.52%(Cohen's $K=0.80$) for bridging inference accuracy, 96.35% (Cohen's $K=0.79$) for bridging inference level, 97.21% (Cohen's $K=0.88$) for elaboration contribution, 97.04% (Cohen's $K=0.87$) for elaboration accuracy, 97.57% (Cohen's $K=0.89$) for elaboration level, and 95.31% (Cohen's $K=0.81$) for prediction quality. The quantity and quality codes from the first rater we used for the analyses.

Comprehension and transfer tests

Responses to the post-reading comprehension and transfer items were coded for the use of four principles of natural selection demonstrated in the text (i.e., differential survival, differential reproduction, inheritance, population change). Variation (a fifth principle) was not scored because item directions explicitly referenced variation between short- and long-backed dormacks. For example, the item "*Did it take a short time or a long time for dormacks to go from having mostly shorter backs in the past to having mostly longer backs now?*" signals the principle of variation (i.e., existence of shorter-back dormacks and longer-back dormacks). Correct use of each of the four principles was worth one point, so scores on the post-reading comprehension test could range from 0 to 4, scores on the transfer measure could range from 0 to 12 (i.e., each transfer item was worth up to 4 points). See Table 5 for examples of students' responses. The first rater coded all responses, and the second rater coded 45% ($n=40$) of the responses. Interrater agreement was 81.25% for comprehension responses, and 89.58% for transfer responses ($\alpha=0.90$).

Table 4 Coding scheme for quality of cognitive processes

Cognitive process	Quality index	Definition	Scoring method
Paraphrases	Contribution	How many main ideas the paraphrase captures from the current sentence *(only code if paraphrase is present)*	1 = missing 50% or more main ideas 2 = contains more than 50% of main ideas 3 = contains all main ideas
	Accuracy	Whether the paraphrase correctly expresses the meaning of the current sentence *(only code if paraphrase is present)*	1 = incorrect 2 = partially correct 3 = correct
	Level	The degree of using different words to restate the sentences *(only code if paraphrase is present)*	1 = repetition lexically similar (1–2 differences) 2 = paraphrase with some different words but still similar (~ 50% different) 3 = paraphrase that is a restatement but using different words (> 50% different)
Bridging inferences	Contribution	Whether the bridging inference facilitates understanding at a local or global level *(only code if bridging inferences is present)*	1 = local (inference facilitate the understanding of the current sentence) 2 = global (inference facilitate the understanding the ideas beyond the current sentence)
	Accuracy	Whether the bridging inference is correct *(only code if bridging inferences is present)*	1 = incorrect 2 = partially correct 3 = correct
	Level	How clearly and apparent the bridging inference is *(only code if bridging inferences is present)*	1 = weak connection of ideas 2 = relationships between ideas are clearly evidenced
Elaborations	Contribution	Whether the elaboration facilitates understanding at a local or global level *(only code if elaboration is present)*	1 = local (elaboration facilitates the understanding of the current sentence) 2 = global (elaboration facilitates the understanding the ideas beyond the current sentence)
	Accuracy	Whether the elaboration is correct *(only code if elaboration is present)*	1 = incorrect 2 = partially correct 3 = correct
	Level	How clearly and apparent the elaboration is *(only code if elaboration is present)*	1 = weak connection of ideas 2 = relationships between ideas are clearly evidenced
Predictions	Depth	How much cognitive effort is need when generate the prediction and/or whether the prediction is relevant to the text (*only code if prediction is present*)	1 = no cognitive effort or not relevant to the text 2 = make predictions based on understanding of the current sentences 3 = make predictions based on connections of text information or connection between text information with prior knowledge

Table 5 Participant sample responses to comprehension and transfer items

Post-reading measure	Sample responses
Comprehension	Dormacks used to have shorter backs until the weather and food source became an issue. Nuts started growing on the top branches and the shorter back dormacks could not reach the food. This caused them to have little energy, strength and poor health. Hence, the longer back dormacks survived more (*differential survival*). The dormacks with longer backs had many children since they were healthy (*differential reproduction*). This happened because they had access to the nuts and their children also had longer backs (*inheritance*). Dormacks with shorter backs were unhealthy and as a result had less children. This caused longer back dormacks to be the majority of the population. It took time for the majority of dormacks to have longer backs now (*population change*). The dormacks started a cycle that allowed longer back dormacks to stay healthy whereas shorter back dormacks did not survive.
Transfer	The polar bear's environment shifted from a dark background to a white background, due to snow. White polar bears were more likely to survive since they could camouflage in the snow and hide from potential predators (*differential survival*). The white polar bears had a survival advantage over the dark bears, and they survived, reproduced (*differential reproduction*) and passed this gene on to their offspring (*inheritance*). This changed the population over time, and eventually polar bears evolved to have white fur (*population change)*.

Results

Correlations between reading processes and products appear in Table 6. We conducted a series of preliminary analyses to examine whether there were differences between participants based on location. We ran two separate MANOVAs using location as the independent variable and quantity of cognitive process and quality of cognitive process, and two ANOVAs using comprehension and transfer as the dependent variables. No significant effects were found. Thus, the samples were combined.

Quantity of general cognitive processes

We ran a two-way MANOVA with purpose instructions and self-explanation instructions as between-subject variables and the frequency of each cognitive process (paraphrases, bridges, elaborations, and predictions) as the dependent variables (see Table 7 for descriptive statistics). We used Pillai's Trace test because there was a violation of equality of covariance matrices. The main effect for self-explanation instructions was significant, Pillai's Trace = 0.68, F (4, 81) = 43.20, $p < .001$, $\eta^2 = 0.68$. Participants who received the self-explanation instructions used the cognitive processes more frequently than participants who did not receive self-explanation instructions. Neither the main effect for purpose instructions ($p = .93$), nor the interaction effect ($p = .50$), were significant.

The main effects for self-explanation instructions on paraphrases, $F(1, 84) = 137.58$, $p < .001$, $\eta^2 = 0.62$, and bridging inferences, $F(1, 84) = 8.00$, $p < .01$, $\eta^2 = 0.09$, were significant. Participants who received the self-explanation instructions generated more paraphrases ($M = 19.6$ vs. $M = 3.7$) and bridging inferences ($M = 3.83$ vs. $M = 2.15$) than participants who did not receive self-explanation instructions. The main effects for elaborations and predictions were not statistically significant ($p > 0.40$).

Table 6 Descriptive statistics and correlations for process and products

	M	*SD*	1	2	3	4	5	6	7	8	9
1.Quantity of Prediction	4.98	3.77	1								
2.Quantity of Bridge	2.93	2.93	0.43**	1							
3.Quantity of Elaboration	4.86	3.78	0.48**	0.29**	1						
4.Quantity of Paraphrase	12.60	8.29	−0.25*	0.10	−0.31**	1					
5.Quality of Prediction	0.87	0.12	0.15	0.22	0.27*	0.08	1				
6.Quality of Bridge	0.67	0.11	0.03	0.16	−0.12	0.02	0.08	1			
7. Quality of Elaboration	0.71	0.07	0.03	0.10	−0.18	0.08	−0.02	0.09	1		
8. Quality of Paraphrase	0.82	0.08	−0.03	0.42**	0.05	0.43**	−0.04	0.04	0.10	1	
9. Comprehension	3.02	0.87	−0.08	0.14	0.05	0.25*	0.24*	−0.25*	−0.05	0.27*	1
10. Transfer	4.30	2.51	0.14	0.16	0.32**	−0.08	0.33**	−0.10	0.05	−0.01	0.30**

*$p < .05$. **$p < .01$

Quality of cognitive processes

The quality of cognitive process could be coded only when participants used a respective process. As a result, the number of constructed responses that were coded for the quality of each cognitive processes varied. We ran four separate two-way ANOVAs with purpose instructions and self-explanation instructions as between-subject variables and the quality of each of the four cognitive processes as the dependent variables, respectively (see Table 8 for descriptive statistics).

The main effect for self-explanation instructions on quality of paraphrases was significant, F (1, 81) = 28.12, $p < .001$, $\eta^2 = 0.26$. Participants who received self-explanation instructions had higher quality paraphrases than participants who did not receive the self-explanation instructions ($M = 0.86$ vs. $M = 0.79$). The main effect for purpose instructions on quality of paraphrases was significant, F (1, 81) = 7.22, $p < .01$, $\eta^2 = 0.08$. Participants who received purpose instructions had *lower* quality of paraphrases than participants who did *not* receive purpose instructions ($M = 0.80$ vs. $M = 0.84$). No other main effects were significant.

The interaction between self-explanation instructions and purpose instructions on the quality of predictions, F (1, 74) = 5.43, $p < .05$, $\eta^2 = 0.07$, was significant. Independent t-tests were conducted to better understand the interaction. The results indicated that participants who received both the self-explanation and purpose instructions generated higher-quality predictions ($M = 0.95$, $SE = 0.01$) than participants who received only purpose instructions ($M = 0.86$, $SE = 0.03$), t (36) = 2.31, $p < .05$; and participants who received only self-explanation instructions ($M = 0.83$, $SE = 0.03$), t (33) = 3.74, $p < .001$, with equal variance assumed for the two tests. In addition, participants who received both the self-explanation and purpose instructions also made higher-quality predictions ($M = 0.95$, $SE = 0.01$) than participants in the control group ($M = 0.86$, $SE = 0.12$), t (32.77) = 2.80, $p < .01$, with degrees of freedom adjusted based on a violation of the equal variance assumption ($F = 6.97$, $p > .05$). The other comparisons were not significant. Further, no other interactions were statistically significant (ps > 0.05).

Comprehension and transfer

We ran two separate ANOVAs with purpose instructions and self-explanation instructions as the between-subject variables and comprehension and transfer scores as the dependent variables, respectively (see Table 9 for descriptive statistics). For comprehension, the main effects for self-explanation instructions ($p = .07$) and purpose instructions ($p = .68$) were not significant. However, the interaction was significant, F (1, 84) = 5.48, $p < .05$, $\eta^2 = 0.06$. We conducted independent t-tests to follow-up the interaction. Participants who received both the self-explanation instructions and purpose instructions had higher comprehension scores ($M = 3.45$, $SE = 0.11$) than participants who only received self-explanation instructions ($M = 2.95$, $SE = 0.21$), t (39) = 2.03, $p < .05$, with equal variance assumed; and participants who only received purpose instructions ($M = 2.70$, $SE = 0.20$), t (34.15) = 3.24, $p < .01$, with degrees of freedom adjusted based on a violation of the equal variance assumption ($F = 7.03$, $p > .05$). No other comparisons were significant.

Table 7 Descriptive statistics for frequency of cognitive processes by condition

Cognitive process	Self-explanation		Think-aloud	
	Purpose instruction *M(SD)*	Control instructions *M(SD)*	Purpose instruction *M(SD)*	Control instructions *M(SD)*
Paraphrases	19.40 (4.26)	19.71 (3.13)	6.61 (6.24)	6.46 (6.14)
Bridging inferences	4.40 (3.68)	3.29 (3.35)	1.78 (1.76)	2.50 (2.25)
Elaborations	5.05 (4.50)	4.05 (3.44)	4.87 (3.68)	5.42 (3.60)
Predictions	5.05 (3.93)	4.19 (3.37)	5.61 (4.06)	5.00 (3.80)

Table 8 Descriptive statistics for quality of cognitive process by condition

Cognitive process	*N*	Self-explanation		Think-aloud	
		Purpose instructions *M(SD)*	Control instructions *M(SD)*	Purpose instructions *M(SD)*	Control instructions *M(SD)*
Paraphrase	85	0.85 (0.08)	0.88 (0.04)	0.77(0.07)	0.80 (0.06)
Bridging Inferences	70	0.70 (0.05)	0.68 (0.09)	0.63 (0.16)	0.68 (0.10)
Elaborations	81	0.72 (0.05)	0.72 (0.09)	0.71 (0.08)	0.69 (0.05)
Prediction	78	0.95 (0.06)	0.83 (0.11)	0.86 (0.15)	0.87 (0.12)

Table 9 Descriptive statistics for the reading products

Reading products	Self-explanation instructions		Think-aloud instructions	
	Purpose instructions *M(SD)*	Control instructions *M(SD)*	Purpose instructions *M(SD)*	Control instructions *M(SD)*
Comprehension	3.45 (0.51)	2.95 (0.97)	2.70 (0.97)	3.04 (0.81)
Transfer	5.25 (2.10)	3.81 (2.32)	3.96 (2.38)	4.25 (2.98)

For transfer, neither main effect ($p=.43$ for self-explanation instructions, $p=.28$ for purpose instructions) nor their interaction ($p=.11$) were significant. We conducted a series of independent t-tests to explore whether self-explanation and purpose instructions interactively affected transfer. The results indicated that participants who received both self-explanation instructions and purpose instructions had higher transfer scores ($M=5.25$, $SE=0.47$) than participants who only received self-explanation instructions ($M=3.81$, $SE=0.51$), t (39)$=2.08$, $p<.05$, with equal variance assumed. No other comparisons were significant.

Discussion

We examined the effect of purpose instructions and strategy-focused instructions on reading processes and learning. There were three main findings. First, purpose instructions did not affect the quantity of reading processes or products individually, which differs from previous research on purpose instructions (Bohn-Gettler & Kendeou, 2014; van den Broek et al., 2001). One explanation for the difference between findings from the previous research and the present findings may be based on differences in the manipulation of the purpose instructions. In previous research, participants were asked to read for study or entertainment purposes (Geiger & Millis, 2004; Linderholm & van den Broek, 2002; van den Broek et al., 2001). In the present research, readers were asked to read for a study purpose or just to read. The contrast between read-for-study versus read-for-entertainment may be sharper than the contrast between read-for-study versus simply to read. Reading is a goal-directed activity and participants who were asked simply to read may have sought to read for understanding, which would be similar to reading for study. Moreover, the text might have influenced the findings. The text was highly cohesive and may not have required effortful processing to comprehend.

Our second finding was that self-explanation instructions affected the quantity and quality of reading processes. Readers who received self-explanation instructions generated more paraphrases and bridging inferences than readers who did not receive self-explanation instructions. Further, participants who were prompted to self-explain made higher quality paraphrases than those who were not prompted to self-explain. This is consistent with prior work which has shown that self-explanation instructions promote the quantity and quality of cognitive processing during reading (Allen et al., 2016; Creer et al., 2020; McNamara, 2004, McNamara et al., in press). For example, McNamara et al. (in press) investigated the combinations and patterns of strategies that readers use during reading. They found that readers primarily generated paraphrases and combined paraphrases and bridge inferences while self-explaining, which is consistent with our results that readers conducting self-explanations were more likely to engage in paraphrases and bridge inferences than readers conducting think-alouds during reading. Self-explanation requires students to go beyond the words explicitly stated in the text to construct meaning. Participants who are prompted to self-explain are perhaps more likely to engage in coherence-based processes (e.g., bridge inferences, paraphrases) to understand text information than readers who are not prompted to self-explain (Bohn-Gettler & Kendeou, 2014; Kendeou et al., 2011; McNamara, 2004). These results also align with the TRACE and RESOLV models (Britt et al., 2018; Rouet, 2006; Rouet et al., 2017). Self-explanation instructions encourage readers to use a self-explanation strategy while reading, which leads readers to update their task model in terms of designing a plan to use the self-explanation strategy to complete their reading goals.

Third, there was a significant interaction between purpose instructions and self-explanation instructions on comprehension. Participants who received both purpose instructions and self-explanation instructions performed better on post-reading comprehension measures than participants who only received purpose instructions or only self-explanation instructions. Our expectation that participants who received purpose instructions and/or self-explanation instructions would learn better than participants in the control group was not met. We hypothesized that purpose instructions would influence reading goals, while self-explanation instructions would influence the strategies readers would use to complete such goals. The results showed that providing self-explanation instructions and purpose instructions together enhanced comprehension, whereas providing only purpose instructions or self-explanation instructions did not. That is, self-explanation instructions facilitated comprehension only when readers had an explicit reading purpose. This finding suggests when task instructions are most effective when readers have a clear task and guidance on how to effectively complete those tasks. These findings are in line with the TRACE and the RESOLV models, such that readers construct a task model that includes both reading goals and ways to compete the goals (Britt et al., 2018; Rouet, 2006; Rouet & Britt, 2011; Rouet et al., 2017).

However, we did not find a significant effect of task instructions on the transfer test. We noted overall performance on the transfer test was low (i.e., $M = 4.30$ out of 12 points). We provide three explanations for this finding, which are not mutually exclusive. First, the text did not explicitly state the principles of natural selection, which may have increased the difficulty of the transfer test. The transfer test required students to apply the principles of natural selection to explain why three new animals changed over time. Since the text did not explicitly mention the principle of natural selection, students needed to infer the principles of natural selection based on their reading, and then apply the principles they inferred to the new context, which may have influenced performance. Second, transfer may be difficult when reading a single text. Prior work has argued that learners need practice with different materials to achieve transfer (Perkins & Salomon, 1992). Future research is needed to explore the effect of task instructions on transfer using multiple texts as materials or incorporating practice activities during reading. Third, there could have been a fatigue effect. For example, the transfer test was at the end of the procedure. Perhaps participants wrote less because they had already written similar information on the comprehension test.

Even though task instructions did not have a significant effect on transfer, when we explored the interaction between purpose instructions and self-explanation instructions, we found that their combination improved transfer more than self-explanation instructions alone. This result is consistent with our findings on comprehension, and with the TRACE and RESOLV models, which suggest that reading strategies facilitate learning from texts better when readers have a clear reading goal (Britt et al., 2018; Rouet, 2006; Rouet & Britt, 2011; Rouet et al., 2017). Although we did not find significant individual effects of self-explanation and purpose instructions on learning from texts in this study, the combined effect of the two instructions still replicate the positive effect of the two instructions on learning from texts in previous research (Magliano et al., 1999; Trabasso & Magliano, 1996; Linderholm et al., 2014a, b; Linderholm & van den Broek, 2002; van den Broek et al., 2001).To improve reading comprehension and transfer, researchers and instructors should consider the value of task instructions that combine reading strategies and reading purpose.

Contributions

This study makes two main contributions to the literature. First, to our knowledge, this study represented a first attempt to examine the individual and combined effects of purpose instructions and self-explanation instructions on reading processes and products. Importantly, the findings indicated that purpose and self-explanation instructions affect reading processes in different ways. From a theoretical perspective, more research is needed to evaluate the individual and combined effect of purpose instructions and strategy-focused instructions on reading processes and products and how these influence a reader's task model. From a practical perspective, these findings suggest that instructors should provide students with information about expected outcomes from reading and guidance on ways to process text to effectively achieve these outcomes. Second, we investigated the quantity and quality of cognitive processes during reading. Prior research on task instruction have often measured cognitive processes by coding readers' think-aloud data given the frequency of each cognitive process (Anmarkrud et al., 2013; Bohn-Gettler & McCrudden, 2018; Kaakinen & Hyona, 2005, 2007; Tilstra and McMaster, 2013). In the current study, we also coded the quality of each cognitive process and provided empirical evidence for the impact of task instructions on the quality of reading cognitive processes.

Limitations and future directions

There are three main limitations in this study. First, we used think-alouds to capture readers' cognitive processes, which may influence how people normally read (i.e., silent reading). However, as compared to other less intrusive methodologies (e.g., reading time, notes, eye movements), think-aloud protocols can provide richer data and evidence about readers' cognitive processes. Future research could explore the individual effect and interaction between purpose instructions and self-explanation instructions on online reading processes using less intrusive methodologies. Second, this study used a single text as the reading material. It is unclear how purpose instructions and self-explanation instructions would individually and collectively influence learning from different texts or from multiple texts. Future research should examine whether the results of this study can be replicated (or not) with different materials. Third, we assumed task instructions affected reading processes and products through readers' construction of their task model. However, readers' construction of task models was not examined in this study. In future studies, exploring the effects of task instructions on the formation of task models and the association between task models with reading processes and products might provide information for how task instructions influence reading.

Conclusion

This study investigated the influence of purpose instructions and self-explanation instructions on online cognitive processes and offline products. In line with prior work, self-explanation instructions positively affected cognitive processes and reading outcomes. Also, there were significant interactions between purpose instructions and self-explanation instructions on quality of cognitive processes and post-reading comprehension. The present study adds to literature by demonstrating purpose instructions and self-explanation instructions can make independent and combined effects on moment-by-moment processing and learning and that the pair of the purpose instructions and strategy instructions may facilitate learning from text to a larger extent than strategy instructions or purpose instructions individually.

Declarations

Conflict of interest The authors declare that there are not conflicts of interest with respect to this manuscript.

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