Learning to Write Synthesis Texts: A Review of Intervention Studies

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Abstract: This study aims to explore effective ways in which students can learn to write synthesis texts. First, through a systematic literature search we found 16 (quasi-)experimental studies from 6th grade to undergraduate level in the field of learning to write source-based synthesis texts, that met our inclusion criteria. Second, we formulated a general instructional design principle, that included three main processes: (a) selecting relevant/important information from sources, (b) organizing, and (c) connecting that information. Bottom-up analyses of the six most effective studies yielded a set of learning activities that contribute to the improvement of students' performance on writing synthesis texts. Subsequently, we supplemented our general design principle with relevant learning activities obtained from these effective interventions. One effective intervention differed considerably from the others due to its divergent nature, but its content was considered valuable enough to warrant the inclusion of an additional design principle. The design principles formulated in this study can be used as guidelines for future interventions in synthesis writing or as a means of support for teachers who want to develop educational materials for teaching synthesis writing.

Keywords: synthesis writing, learning activities, design principles, review study

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1. Introduction

1.1 The synthesis writing task

Thanks to modern media, information sources are becoming more numerous and more accessible. One of the greatest challenges educators currently face is teaching students how to find reliable sources, and then analyze and process them. These are essential, but cognitively demanding skills for students to acquire. To be successful in academic education, as well as in today's society, people must be able to initiate and direct their own learning, and to make decisions independently, based on reliable information and directed toward a self-determined learning goal.

The synthesis writing task is a task in which all these skills come together and can be practiced. A synthesis text is a text that integrates different information sources. The sources can complement, but also contradict each other. Drafting such a text calls for a combination of reading and writing skills: the exploratory reading and understanding of the sources, selecting sensible information from them, arranging selected information in a logical way and formulating a new text (Klein & Boscolo, 2016). The final text should be a representative and at the same time well-integrated reflection of the information selected from the sources.

The synthesis task is very suitable for educational purposes because previous research has established that although writing alone can lead to the transformation of knowledge (Scardamalia & Bereiter, 1987), the epistemic potential of writing can be increased by the integrated use of both reading and writing. This triggers an internal dialogue, which plays a role in both good reading and good writing (Martínez, Mateos, Martín, & Rijlaarsdam, 2015; Mateos et al., 2014). Furthermore, the choices writers make during synthesizing, depend on rhetorical considerations including the writing purpose and the audience for which they write, and are supported by deploying strategies for understanding and composing (Spivey, 1997). Teaching synthesis strategies to students can improve both their writing skills and conceptual learning (Mateos et al., 2014). Thus, writing-to-learn and learning-to-write may be connected in synthesis tasks.

For this reason, the synthesis task can be used as a tool to promote content learning in education: reading-and-writing-to-learn. Subject teachers give students synthesizing assignments to help them acquire content knowledge, to organize their thoughts, and to improve their retention of content. Synthesis writing tasks are well suited for this purpose.

1.2 Synthesizing processes

Spivey (1997) considered synthesis tasks to be 'hybrid' tasks, which cannot be performed successfully by first reading and then writing. Instead, they call for a recursive process in which three interrelated processes contribute to the final quality of the synthesis text: selecting, organizing, and connecting.

When students read a source text, they cannot, or may not want to, retain all the information. They must consider what information is relevant for their purpose and is important enough to include in their synthesis text. Therefore, it is necessary that they thoroughly understand the source texts' content. Flower (1989) emphasized the importance of the comprehension process as a part of synthesizing, since students do much of the cognitive work normally associated with the writing process while reading, including reading a source text and creating a mental summary. In their model, Kintsch and Van Dijk (1978) hypothesized that readers can create such a mental summary, or "gist", of the text by deleting redundant propositions. Thus, students must generalize each sequence of propositions, and construct a macro proposition when one is not explicitly stated in the text.

At the same time, they must try to combine the selected information into a new, meaningful content structure. In a synthesis task, this process is complicated because readers need to process and compare the information from different sources, and ultimately create a "super proposition" (Segev-Miller, 2004), in which they also account for their own rhetorical goal. Thus, students organize, as well as select, content as they construct a mental representation of a text. While reading the source texts, they use their prior knowledge and knowledge of text structure to guide their understanding. Simultaneously, they must decide which macrostructure they will apply in their own text and, in the words of Boscolo, Arfé and Quarisa (2007), create an 'intertext': a new, integrated text that connects all sources.

Although this organizing process helps to add global coherence to a text and to the mental representation, students must also connect the content at the level of propositions, clauses, and sentences. Such local-level connections are supplied in the source texts, but readers also generate their own connections while reading source texts in the form of inferences, which become part of their mental representation. Subsequently, when students write their syntheses, they must connect the relevant content elements they have selected from the source texts by providing explicit links between related ideas.

Time and time again, the synthesis task has proved to be difficult for students, even in the highest educational grades. The difficulties in writing a synthesis text result, among other things, from an incorrect task representation. In their study, Mateos and Solé (2009) found that the students considered synthesizing to entail making a summary organized around the main ideas drawn from each of the source texts. Only a very small minority of the students tried to find an integrating idea or concept on which to base their text. The approaches employed by the students, especially secondary school students, seemed to reveal a recently learned sequence, of which the students saw the steps as separate tasks that they had to perform without an adequate representation of what the synthesis task really requires (Mateos & Solé, 2009).

Mateos, Martín, Villalon, and Luna (2008) found indications that the best syntheses were generated by students whose writing processes showed high degrees of flexibility

and recursivity. They alternated between reading the source texts, writing while rereading the sources, and revising the text produced so far. However, Mateos et al. (2008) also found that in general secondary school students did not appear to use the cognitive and metacognitive processes that would enable them to make strategic use of reading and writing. In fact, synthesizing appears to be a difficult task even for university students, who are generally highly competent readers and writers (Mateos & Solé, 2009).

1.3 Synthesizing strategies

The complex and hybrid nature of synthesis tasks makes the design of effective instructions challenging. Nevertheless, successful interventions have been carried out at all educational levels.

In primary education successful interventions have been developed by Martínez, Martín, and Mateos (2011), and Martínez et al. (2015). In the first study, the authors designed and implemented an intervention program that taught 6th grade students to write a synthesis text using source texts on the subject of Environmental Knowledge. The intervention included: task representation, knowledge of the content to be included (the Climate, population and rivers of Spain), source text comprehension, both intratextual and intertextual integration of source information, generating ideas for the final thesis, structuring, and writing of the synthesis, revision of the synthesis and the construction of a step-by-step guide for synthesizing. The results indicated that the intervention had a positive impact on the quality of the syntheses students wrote, as well as on their content knowledge. The second study is described in detail in section 3.2 of this paper, as it is part of our review.

Various successful interventions in learning to write synthesis texts have also taken place in secondary education. For example, Hammann and Stevens (2003) designed an intervention to teach 8th graders how to write compare-contrast texts based on two expository source texts. In doing so, they compared the effectiveness of different treatments: in one group they focused on summarization skills, in a second group on text structure, while a third group focused on a combination of those two treatments. The outcomes of these three groups were compared with the outcomes of a control group. When differences in prior knowledge were considered, the results seemed to indicate that students who received text structure instruction had significantly higher scores on compare-contrast structure but lower ones on content than those in the other groups. Students who received summarization skills instruction had significantly lower scores on structure than students in the other groups. Surprisingly, the combination of the two treatments in the third group did not yield any significant improvements. The researchers attribute this finding to the short duration of the intervention and participants' relatively young age. Another example of an intervention on writing compare-contrast texts from sources is a study carried out by Kirkpatrick and Klein (2009) with 7th and 8th grade students. This study is described in more detail in section 3.2 of this paper, as it is included in our review as well.

Finally, successful interventions have been carried out in higher education. A well-known example is an intervention carried out by Boscolo et al. (2007), a one group pre-posttest study, in which undergraduate students wrote syntheses. They practiced by composing synthesis texts which were revised by the teacher and by analyzing and discussing examples of good and weak texts. After the intervention the students seemed to have progressed on all the content related criteria, but not on any related to integration. In addition, it seems that undergraduates are not the only ones who can learn from synthesis writing instruction. In-service teachers who enrolled in a course on "Reading and writing to learn" as part of Segev-Miller's (2004) study, benefitted from explicit instruction of relevant strategies and assessment criteria on discourse synthesis processes and products, as the results indicated significant improvements on both counts.

1.4 Designing an effective synthesis writing intervention

Based on their systematic synthesis of 69 studies on writing from sources, Cumming, Lai, and Cho (2016) confirm that instruction can help students improve their use of sources in writing. With this in mind, we looked for a way to facilitate the design of an effective instruction as much as possible. As a first step we formulated design principles. These are course parameters: the boundaries which define it (Merrill, 2002; Reigeluth, 1999; Van den Akker, 1999). Design principles are heuristic statements that describe the conditional (if/then) relationship between the desired outcome of an intervention and each instructional component. For example: '*if* we want our students to achieve learning outcome X, *then* we should involve them in strategy, activity, approach… Y'.

These principles are then operationalized in various intended learning activities. Rijlaarsdam, Janssen, Rietdijk, & Van Weijen (2017, p. 286) define learning activities as: *any cognitive or meta-cognitive activity of an individual organized with the intention to improve his/her knowledge, skills and competence*. A learning activity deals with a certain content or object on which the thinking activity is based, which implies that a learning activity is characterized by unity of method and content. Therefore, interventions are complex constructs of various learning activities.

In an intervention, a learning activity is a mediating variable between the instruction and the desired learning outcome. Therefore, if one wants to stimulate certain learning outcomes when designing an intervention, one must choose the learning activities that increase the likelihood of realizing those outcomes. Designers often choose theory-based learning activities which they believe to be effective in achieving the desired learning outcome. Theoretically, learning activities in synthesis writing interventions support the different transformations writers must make when synthesizing: selecting, organizing, and connecting source information (Spivey & King, 1989). However, whether theory-based activities work in practice and how effective they are often remains unclear. Thus, the learning activities designers choose may not always be the most effective ones for achieving those desired learning outcomes.

Therefore, identifying essential learning activities which have been tried and tested in effective interventions could be a good starting point for the design of new, evidence-based interventions.

1.5 Present Study

The aim of this study was to create an overview of the (often implicit) knowledge about the design of synthesis writing interventions and, in this way, contribute to the effectiveness of future interventions. Therefore, we carried out a systematic review of the literature. Subsequently, we formulated instructional design principles as a starting point for the design of evidence-based modules for learning to write synthesis texts. We based these on the literature on source-based writing and a bottom-up analysis of the interventions in these studies. Finally, we wanted to determine which learning activities contribute effectively to the improvement of students' synthesis writing performance. To this end, we aimed to create an overview of crucial synthesis learning activities in effective interventions.

2. Method

2.1 Review

At the start of the literature review it was unclear whether we would find sufficient studies in the field of learning to write synthesis texts. For this reason, we carried out a broad literature review and searched not only for studies on synthesis writing, but also on source-based writing. Because the research on synthesizing overlaps with other research in which students integrate multiple sources to create a text (Klein & Boscolo, 2016), we assumed that learning activities carried out by students learning to write source-based texts might be effective to some extent for students who learn to write synthesis texts as well.

Inclusion criteria

We conducted a systematic literature review to collect all relevant literature on learning how to write synthesis texts. Studies had to meet four criteria to be included in the present review (see Table 1).

Search Procedures and Selection of Studies

We applied four strategies to identify possible studies for this review (see the schematic overview provided in Figure 1).

Strategy 1*: Collecting.* First, electronic searches were conducted in six databases: PsychINFO, ERIC, LLBA, Web of Science, Scopus, and Google Scholar (September 2016). In the academic literature, a synthesis text is sometimes also called a *discourse synthesis* (Spivey,1997) or *writing from sources* (Segev-Miller, 2004). So, for the electro-

Table 1. Overview of four inclusion criteria

1	Aim	The research aimed to test instructional arrangements on learning how to write synthesis texts and/or learning how to write from sources.
2	Participants	The study involved students in the highest grades of elementary, secondary, or higher education (aged between 10.5 and 22.5 years). Studies conducted in special education or which only involved struggling writers were excluded from the analysis.
3	Research design	The research design was experimental or quasi-experimental and compared at least two instructional conditions: an experimental condition and a control condition. This could either be a 'pure' control condition, in which no extra instruction was given, or a comparison condition in which an alternative treatment was provided.
4	Performance assessment	The study required students to write a text as a posttest measure, as an indication of the impact of the intervention, possibly in addition to other measures. Impact could be operationalized in various ways, for example a measure of information integration, selection, or structure, as long as the scores were based on a written text. Studies could provide a holistic assessment of the effect, or a combination of the aforementioned methods.

nic search, we used the following keywords *writing/written* in combination with *synthesis, synthesis* or *synthesizing task, synthesis text, information synthesis, synthesizing information, integrating information* or *multiple sources, synthesis skills, hybrid tasks* in combination with *writing, writing* or *composing from sources, writing-to-learn* in combination with *sources* or *documents*. These keywords were combined with keywords indicating the domain, for example: *writing skills* or *written communication,* in combination with *education* or *student* or *teaching etc.* Keywords indicating the educational level we were interested in, such as: *pre-university, ninth-grade, tenth-grade, eleventh-grade* or *twelfth-grade, junior high* or *high school,* were also added.
This search resulted in 655 hits which we screened, by examining titles and abstracts to determine whether the hits addressed the topic of *source-based writing*. If an item was considered promising based on its abstract or title, the full text of the article was obtained. Subsequently, in line with our inclusion criteria (see Table 1) research conducted in the lower grades of primary education, literature unrelated to the subject, and documents which mentioned synthesis writing as part of a national or local educational policy, were excluded from the sample.

Strategy 2*: Reference tracking*. Second, a further search was conducted based on the selected studies. The reference list of each paper was scanned to identify other relevant studies, and the full texts of promising studies were obtained.

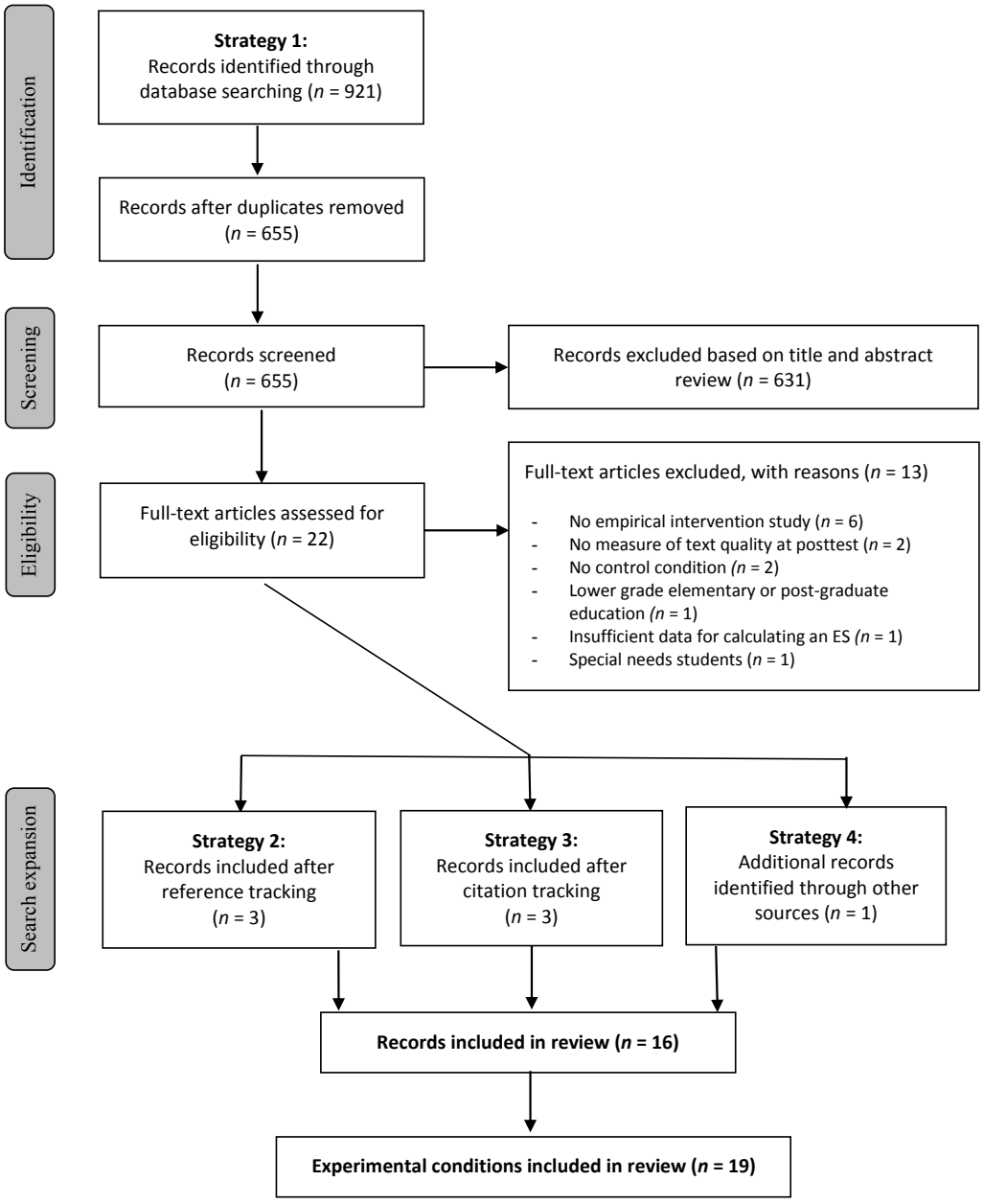

Figure 1. Flow chart of the literature selection procedure.

Strategy 3*: Citation tracking.* Third, a Google Scholar search of all studies included in the review was conducted to examine the articles referencing any of these papers. Again, the abstracts of promising titles were scanned to check their relevance for the review.

Strategy 4*: Grey Literature search.* Finally, databases of theses, dissertations, and conference proceedings were searched for unpublished studies on the topic.

Of the 22 papers that were reviewed in full, nine papers met the inclusion criteria. The reasons for excluding the other 13 studies are shown in Figure 1. Furthermore, three studies were identified and included through reference tracking (strategy 2), another three through citation tracking (strategy 3) and one additional study through the grey literature search (strategy 4). So, in total the review includes 16 papers, two of which include multiple experimental conditions (Hammann & Stevens, 2003 (three experimental conditions); Reynolds & Perin, 2009 (two experimental conditions)). Thus, 19 experimental conditions were included in all.

Coding procedure

The first author coded the 16 studies included in the data set in two phases. First, several general aspects were coded, including reference, grade, number of participants, research design (experimental, quasi-experimental), short description of experimental and control condition, and effect size. Second, variables which could account for heterogeneity of effect sizes were coded, such as goal (writing-to-learn or learning-to-write), number of sessions, and intensity (in minutes) of the intervention, and assessment method at posttest (analytically, holistically, a combination of both) (see Appendix A). Subsequently, to establish reliability of the coding procedure used in this review, a teacher educator who is familiar with the subject of teaching synthesis writing was invited to independently code the five articles which scored highest on effect size as well. The interrater reliability between the coders was calculated based on the percentage of agreement, which was 83% over all. Furthermore, Cohen's Kappa was calculated for each aspect as well (mean Kappa = 0.72, range = .41 – 1.0). Differences in coding were minor, but resulted in two low Kappa values, due to the small number of studies included (N = 5). All remaining differences in outcome were discussed until full agreement was obtained.

Effect sizes and statistical analysis

For each selected study, we calculated the effect size based on scores reported for text quality at posttest. If available, we used a holistic text quality score to calculate the study's effect size. Some studies reported various quality scores, representing different aspects of text quality, such as accuracy of selection, the level of integration, and the

quality of the text's structure. For these studies, we calculated the effect size for each individual aspect and then averaged them.

Effect sizes were computed by calculating the difference between the writing performance of the experimental condition and the control condition at posttest, divided by the pooled and weighted standard deviation for both groups. Using this approach, a negative effect size indicated that students in the control condition outperformed students in the experimental condition on that specific outcome measure. To account for small sample bias, we used Hedge's *g*, which includes weighted standard deviations, to calculate effect sizes instead of Cohen's *d*.

2.2 Analysis of learning activities as elements of effective interventions

Design principles

As a first step in the analysis of effective interventions, we determined which studies were eligible for analysis. We selected the studies with an effect size of 0.80 or more, because an ES of 0.80 is usually interpreted as a large effect (Cohen, 1988). A large effect size (ES) can be an indicator that the intervention was effective, although the ES must be interpreted with caution, because factors such as the study's quality must always be taken into account as well. This set of interventions with an ES larger than 0.80 was then analyzed to extract each intervention's instructional practices. Finally, we formulated design principles based on the outcome of this analysis.

Learning activities in synthesis writing instruction

The next step was to supplement the design principles with effective learning activities, obtained from a bottom-up analysis of the effective interventions. However, it is not always easy to determine which learning activities an intervention includes. That is why we analyzed the interventions in stages, during which groups of experts assessed the learning activities that had been found up until that point, at three different points in time. First, the learning activities were assessed by Dutch and Flemish writing proficiency researchers during a seminar on synthesis texts at the University of Amsterdam. Subsequently, an adjusted set of learning activities was assessed by students of the teacher education program at the University of Amsterdam during a group meeting, and finally a revised set was presented to an international group of writing proficiency researchers during a roundtable at the ARLE conference in 2017. Based on their comments, we made some final adjustments to our analysis.

While analyzing the effective interventions, we focused on identifying essential learning activities that supported the three transformational processes: selecting, organizing, and connecting (Spivey & King, 1989). Other learning activities that are indispensable in a complete instructional cycle, such as building a task representation, activating prior knowledge, and providing sufficient opportunities to practice (Merrill, 2002), were excluded from the analyses if they were not directly connected to one of

the three transformational processes. As a result, the outcome of the expert analyses was an overview of activities we considered to be essential for learning to write synthesis texts.

In the next step, a Delphi-style method was used to facilitate the assignment of these essential learning activities to the transformational processes. We asked seven writing proficiency researchers and teachers to estimate the suitability of the various learning activities for practicing each of the transformational processes mentioned above. The experts first discussed the learning activities and then each completed an online questionnaire, in which they assessed all activities on a scale from 1 (not suitable for learning this process), to 4 (suitable for learning this process). If participants unanimously indicated that a learning activity was suitable or reasonably suitable for learning a certain process, it was provisionally assigned to that process. This proposed categorization was then returned to the participants for further comments or additions to this classification. We received extensive responses from one researcher and one teacher and adjusted the provisional classification based on their feedback, before the final categorization was achieved.

3. Results

3.1 Analysis of reviewed studies

The review revealed that six interventions had an effect size of > 0.80. These interventions, ranked by effect size, formed the basis for further analysis: Martínez et al. (2015), Kirkpatrick and Klein (2009), Britt and Aglinskas (2002), Barzilai and Ka'adan (2017), Zhang (2013), and Robledo-Ramón (2016). Based on this analysis we propose a general design principle for acquiring synthesizing skills, and three sub-principles, one for each transformational process. In addition, we propose an additional design principle based on Robledo-Ramón's (2016) intervention. This intervention differed considerably from the other five: instead of providing students with a general strategy for synthesis writing, as was the case in the other five interventions, the aim was to enable students to develop their own personal strategy. Finally, it is important to note that all selected interventions focused on L1 synthesis writing, except for Zhang (2013) who worked with students of English as a second language.

3.2 Description of effective interventions

In the most effective intervention, Martínez et al. (2015) aimed to improve learning from texts via strategies that train students to create syntheses. They offered 62 6th grade students 12 60-minute sessions each, grouped in three blocks of four lessons. In the first block the focus was on modeling, in the second block on collaborative learning, and in the final block on individual activities. In each block the students were taught the same five strategies for: (1) selecting important ideas from the source texts, (2) elaborating on the information, (3) organizing the content, (4) integrating prior knowledge with new

knowledge, and (5) integrating information from both source texts. We used additional information from Martínez, Mateos, and Martín (2017) to determine what learning activities were offered to the students to practice these processes.

The second intervention, carried out by Kirkpatrick and Klein (2009), aimed to teach students how to write compare-contrast reports when writing from sources. They offered 83 7th and 8th grade students six 60-minute sessions on how to write compare-contrast syntheses, based on two source texts. The sessions focused on teaching students to plan their texts, using an IAPN-table. The table contained five columns, of which the first two with the headings: Information (first source text), Information (second source text). Then the column Aspect followed, in which information is overarched based on equal sub-topics. Finally, the columns Paragraph, in which the subtopics are combined into full passages, and Number, in which the position of the paragraph in the text is indicated, followed. After this extensive preparation the students wrote their text.

Third, Britt and Aglinskas (2002) examined students' historical document sourcing skills proficiency in a series of experiments, of which the third was relevant for this study. They offered 23 11th grade students a 35-minute session in which students worked in an online environment, *The Sourcer's Apprentice*, a computer-based tutorial and practice environment for teaching students to analyze source features and corroborate source information while reading historical source texts.

Fourth, Barzilai and Ka'adan (2017) examined the role of epistemic integrative strategy training in learning to integrate divergent information sources. They offered 99 9th grade students two similar 50-minute sessions on learning how to analyze source features (e.g. name, expertise and purpose of author), how to evaluate the reliability of sources, and how to link ideas from the source texts. Additionally, in a third session a meta-strategic scaffold was offered to a selection of the students to help articulate, develop, and generalize their understanding of the integration strategy by answering questions about when, why, and how to use the strategy.

The fifth intervention we included, by Zhang (2013), examined the effect of synthesis writing instruction on students with English as a second language. He offered his 29 undergraduate ESL students five sessions, in each of which they completed five identical cycles of synthesis writing. In such a cycle students focused on: (1) analyzing source texts, (2) selecting important information from the sources, (3) linking different pieces of information, (4) drafting, (5) peer reviewing and receiving instructor's feedback, and finally (6) revising the synthesis text.

Finally, we included the intervention carried out by Robledo-Ramón (2016), who analyzed the effectiveness of strategic instruction in synthesizing, based on models and programs of strategy training and self-regulation. She offered 60 first year students eight 50-minute sessions in which students were stimulated and guided to develop and implement their own synthesis strategy in a self-regulated way.

General design principle

In a bottom-up analysis we found that, in line with the literature, effective interventions tend to focus on all three transformational processes: selecting, organizing, and connecting. So, in conclusion, the *general design principle* that we derived from the analysis of these effective interventions is:

If we want students to acquire synthesizing skills, then we should involve them in a set of learning activities that promote all three transformational processes:
(a) selecting information from sources,
(b) organizing, and
(c) connecting that information.

We will substantiate this general design principle by elaborating on the three sub-principles, one for each transformational process, complemented by the learning activities obtained from the effective interventions. Finally, we propose an additional design principle on personal strategy and self-regulation, based on an analysis of the intervention carried out by Robledo-Ramón (2016).

Sub-principle a: Selecting information

The first transformational process in synthesizing is selecting information from the obtained sources. However, to be able to select the important and relevant source information, students must first fully comprehend each source's content. Since students are not inclined to deepen their text comprehension by themselves, and tend to read texts superficially (Beck, McKeown, Sandora, Kucan, & Worthy, 1996), both text comprehension and selection strategies should be actively promoted in source-based writing interventions. Learning activities which support the selection process, result in a representative selection of source content. Such activities should stimulate students to think evaluatively: to determine the level of importance of the informational units in the source texts in relation to each other and to their own rhetorical goal, and then to decide which units they want to include in the synthesis.

In effective interventions students were involved in learning activities that stimulated them to select relevant/important information from sources**,** such as:

- answering questions on the main ideas and organization of each text (Zhang, 2013),
- comparing-contrasting sample texts by ranking the samples based on an (un)balanced input of source information (Kirkpatrick & Klein, 2009),
- comparing-contrasting source features and content to contextualize the information, for example by answering questions, such as: "Which document was written first?" (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002),
- linking different pieces of information to fulfill the requirement of the type of synthesis essay, for example finding common ideas and/or important complementary ideas and integrating them, or matching problems to solutions (Zhang, 2013), and

- underlining/schematizing source content (documents mentioned, main point, comments) (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002; Kirkpatrick & Klein, 2009; Martínez et al., 2015).

Sub-principle b: Organizing information

The second transformational process in synthesizing is building a mental representation of the source information by re-organizing the selected information. Analysis of the effective interventions revealed that there are two groups of learning activities related to organizing present in the studies, distinguished by the object of the activity: (1) comparing source *features* (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002) and (2) analyzing source *content* (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002; Kirkpatrick & Klein, 2009; Martínez et al., 2015; Zhang, 2013).

Comparing source features may help students interpret and organize source information, which formed the basis for Britt and Aglinskas' (2002) intervention. They based their intervention on the heuristics Wineburg (1991) found when he compared how historians and students interpreted source information. He found that unlike high school students, historians investigated and evaluated the source of a document and used this source information to interpret the document's content (sourcing heuristic). Wineburg noted that experts also compared content across documents systematically and were therefore able to identify discrepancies between them. All the selected studies paid attention to analyzing and comparing source content to re-organize selected source information, which is not surprising, since integration is seen as the core component of the synthesis task (Flower, 1989; Mateos et al., 2008; Segev-Miller, 2004; Spivey & King, 1989).

Learning activities which support the content organizing process, result in a mental representation of the combined sources and possibly an idea for the macro-structure of the final draft of a writer's synthesis text. These activities might focus on an analysis of source features, and the global and local organization of source texts. They should help students find a way to represent information by identifying source features which are important for understanding the content, and by searching for key concepts to determine how ideas are related.

In effective interventions students were involved in learning activities which required them to organize information from sources, by:

(a) comparing source *features*, such as:

- answering questions on the author and title of each text (Zhang, 2013),
- grouping/schematizing source features, for example into categories: 1. author (who, position, how does the author know of the situation, and author motives), and 2. document (when, type) (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002)

- comparing-contrasting source features and content to contextualize the information, for example by answering questions, such as: "Which document was written first?" (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002), and
- evaluating source reliability, for example by rating the reliability of each source, and explaining why each source text is given its rating (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002),

and

(b) analyzing source *content*, such as:

- answering questions on the main ideas and organization of each text (Zhang, 2013),
- comparing-contrasting sample texts by ranking the samples based on an (un)balanced input of source information (Kirkpatrick & Klein, 2009),
- comparing-contrasting source content (Britt & Aglinskas, 2002),
- linking different pieces of information to fulfill the requirement of the type of synthesis essay, for example finding common ideas and/or important complementary ideas and integrating them, or matching problems to solutions (Zhang, 2013), and
- schematizing source content, using tables, concept maps, or graphic organizers, and identifying overarching aspects (Barzilai & Ka'adan, 2017; Kirkpatrick & Klein, 2009; Martínez et al., 2015).

Sub-principle c: Connecting information

The third transformational process synthesizing requires is connecting information in the final draft. Learning activities which support this connection process, help students to create a verbally structured and integrated representation of the selected source content. They should encourage students to structure their text by explicitly connecting informational units from different sources, and to link the newly structured information properly, for example by using appropriate words or phrases for linking ideas, to create a coherent, reader-based text.

In effective interventions students were involved in learning activities which required them to connect information from source texts**,** such as:

- comparing-contrasting sample texts by ranking the samples based on their (dis)organization (Kirkpatrick & Klein, 2009),
- comparing-contrasting source features and content to contextualize the information, for example by answering questions, such as: "Which document was written first?" (Barzilai & Ka'adan, 2017; Britt & Aglinskas, 2002),
- linking different pieces of information to fulfill the requirement of the type of synthesis essay, for example finding common ideas and/or important complementary ideas and integrating them, or matching problems to solutions (Zhang, 2013), and

- schematizing source content, using tables, concept maps, or graphic organizers, for instance to organize the informational units in paragraphs, deciding in which order to present them, and how to link them (Barzilai & Ka'adan, 2017; Kirkpatrick & Klein, 2009; Martínez et al., 2015).

Table 2 provides an overview of crucial learning activities that stimulate students to practice the various transformational processes. This overview shows that various learning activities are suitable for practicing multiple transformational processes. Comparing-contrasting source features and content is an example of such a learning activity suitable for practicing all three transformational processes. Three other crucial learning activities, comparing-contrasting sample texts, schematizing source content,

Table 2. Overview of the suitability of different learning activities for learning synthesis writing. Suitability of an activity is indicated by a plus sign

	Transformational process			
Learning activity	Selecting	Organizing		Connecting
		by analyzing source features	by analyzing source content	
Comparing-contrasting sample synthesis texts by ranking the samples	+		+	+
Grouping/schematizing source features		+		
Comparing-contrasting source features and content	+	+	+	+
Evaluating source reliability		+		
Schematizing source content, using tables, concept maps, or graphic organizers	+		+	+
Answering questions on main ideas and organization of each source text	+		+	
Answering questions on author and title of each text		+	+	
Linking exercises	+		+	+

and linking exercises, address all the transformational processes as well, but focus more on analyzing source content than on source features.

Additional design principle: Personal strategy and self-regulation

As mentioned above, we based an additional design principle on our analysis of Robledo-Ramón's (2016) study, which differs considerably from the other effective interventions due to its divergent nature, as opposed to the convergence of the other interventions. Instead of providing students with a general strategy for synthesis writing, she introduced a program aimed at developing a personal writing strategy and personal writing goals for each student, based on the Strategic Content Learning (SCL) approach to promote self-regulated learning (Butler, 1998).

The SCL approach is based on the recognition of the essential role of motivation in leading theories of writing (e.g. Hayes, 1996). Graham and Harris (2006) found that motivation is related to students' writing performance, and that motivation influences writers' engagement, persistence, and their use of writing strategies, knowledge, and skills. Writing motivation can be increased by self-regulation, because self-regulated learners are able to manage their cognitive, motivational, and volitional processes during learning to keep themselves on task when they become discouraged or encounter an obstacle (Butler, 1998). Thus, a first goal of strategy intervention models is to support students' self-regulated engagement in tasks.

The SCL-approach consists of a recursive cycle of cognitive activities during which teachers support students in a) task analysis and goal setting; b) selection, development or adaptation of appropriate strategies to achieve goals; c) implementation of strategy and monitoring, feedback, and necessary changes, until independent and self-regulated performance is achieved (Robledo-Ramón & García, 2017).

Based on the effect size of Robledo-Ramón's (2016) study (0.88) we can conclude that the freedom to adapt strategies to personal preference or the possibility to develop one's own strategy can contribute to students' writing motivation, and thereby to the effectiveness of an intervention. Our additional design principle therefore states:

If we want to increase the effectiveness of educational interventions, then we need to provide students with the freedom to adapt strategies to their personal preferences, or with the possibility to develop their own strategies.

4. Discussion

In this study we investigated which instructional practices contribute effectively to the improvement of students' performance on writing synthesis texts. The studies we found addressed many different education levels: from 6th grade up to undergraduates. On the one hand, research shows that writing synthesis texts is difficult for students in all grades, even for university students (Mateos & Solé, 2009). It is therefore not surprising that many interventions take place in higher education. In addition, the synthesis task,

often in the form of a literature review, is much more common in higher education. Yet pupils in primary education already work on tasks where they must connect information from different source texts as well. Various studies have shown that interventions can be effective for younger pupils (Martínez et al., 2011; Martínez et al., 2015), older students (Boscolo et al., 2007) and even adults (Segev-Miller, 2004). Despite the complexity of the synthesis task it is therefore desirable to also help younger pupils to learn the basics of this task, and then gradually expand the task requirements as the students' age increases and they have greater cognitive capacity to handle the complexity of the synthesizing processes. For instance, the number of source texts, their level of difficulty and the extent to which sources contradict each other can all be tailored to students' age and achievement levels.

Research has shown that instruction can help students improve their use of sources in writing (Cumming et al., 2016). However, knowledge about synthesizing processes is indispensable, but not sufficient. In education, students often focus on the final product and pay insufficient attention to the complex, recursive processes that are necessary for creating a good synthesis. Metacognitive knowledge about why it may be better to base yourself on multiple sources instead of on a single source, can help students appreciate the importance of the synthesis task and enable them to make the effort needed to really engage in the complex synthesis processes (Barzilai & Ka'adan, 2017). The importance of the synthesis task could also be emphasized by having students perform the task more often, for example in different subjects and in different grades.

Nevertheless, even though knowledge of the importance of the synthesis task and the synthesizing processes is essential, successful interventions must also contain strategies that can be taught and learned (Solé, Miras, Castells, Espino, & Minguela, 2013). With this in mind, it was our goal to determine how students can learn to write better synthesis texts by analyzing the six most effective synthesis writing interventions in our review. We aimed to create an overview of crucial synthesis learning activities (table 2). This overview shows that various learning activities appear to promote multiple synthesizing processes. Comparing-contrasting source features and content is an example of such a learning activity. Three other crucial learning activities, comparing-contrasting sample texts, schematizing source content, and linking exercises, appear to promote multiple synthesizing processes as well.

Of course, these crucial synthesis learning activities must be embedded in a coherent and complete instructional cycle together with other indispensable learning activities, such as building a task representation, activating prior knowledge, and providing sufficient opportunities to practice (Merrill, 2002). But no matter how well thought-out and complete an intervention is, if students are unmotivated, the intervention will be less effective. Based on our analysis we concluded that the freedom to adapt the strategies offered to one's personal preferences or the possibility to develop one's own strategy can contribute to students' writing motivation, and thereby to an intervention's effectiveness.

4.1 Limitations

We based our research on a systematic review of (quasi-)experimental studies on source-based writing. Although source-based writing and synthesizing are not synonymous, there is such a great overlap in research into both forms of writing (Klein & Boscolo, 2016) that we can assume that learning activities that are effective for practicing the one will also be effective for the other. Furthermore, we determined that studies with an effect size of 0.80 or greater were eligible for analysis, and therefore used the average effect size of each study as a selection criterion for effect. This chosen procedure raises four issues.

The first issue is that working with an average effect size can cause nuances to be lost. For example, an intervention might have had a large positive effect on a particular aspect of synthesizing, such as the quality of integration in the text, but that effect will no longer be visible in the final effect size if there was a negative effect, or none, on other aspects. To overcome this problem, we examined whether the final average effect size was an accurate reflection of the partial results on the various aspects in an analytical assessment scheme. We found that the average effect size adequately represented the partial effects in all the studies included, except for those with an emphasis on note taking (Gil, VidalAbarca, & Martínez, 2008; Hilbig & Proske, 2014). The effect on acquisition of ideas from sources in these studies was large, but at the same time the effect on writing quality and making inferences was negative. Because these last two aspects are at least as important for a good synthesis as the selection of source ideas, we nevertheless decided to use the average effect size for these studies and as a result they were excluded from further analysis.

Secondly, we recognize that the group of six interventions that formed the basis of our analysis is not all-encompassing: there are other important studies which did not meet our > 0.80 threshold. One study, by Gonzalez-Lamas, Cuevas, and Mateos (2016), was excluded because the experiment compared two experimental conditions, without a control condition. This then led to a seemingly small effect size, which would probably have been many times larger when compared to a control condition. In addition, it is conceivable that the less effective interventions, which did not make the cut, contain effective learning activities as well. For this reason, we analyzed all the interventions which emerged in our review as potentially relevant, but which did not meet our > 0.80 cut off point and checked for relevant learning activities within them. This analysis yielded only one additional learning activity, that seemed especially suitable for the integration of source information: the color-coding method (Darowski, Patson, & Helder, 2016; Lundstrom, Diekema, Leary, Haderlie, & Holliday, 2015). We did not find this activity in the selection of effective interventions, but we propose this could be a valuable addition to our list of learning activities since the experimental groups in the studies in which this method was used, scored significantly higher on citation integration than the control groups. As integration is seen as an important aspect of synthesizing, these outcomes are important, even though the overall effect sizes of these interventions were not substantial enough to be considered effective.

Thirdly, one study with a large effect size (Barzilai & Ka'adan, 2017) that is part of our selection of most effective interventions, proved especially effective in the delayed posttest, administered four weeks after the posttest. The authors suggest that providing students with repeated opportunities to engage in strategies appears to be a better approach for robust acquisition of these strategies. In the experimental condition there was a strategic group and a meta-strategic group, of which the last group had an ES of 0.55 at posttest. Eventually, both groups reached the same level of performance in the delayed posttest. The strategic group seemed to acquire the strategy more gradually, and after four weeks the intervention turned out to be equally effective for both groups. That is why we decided to include this study, the only one with a delayed posttest, in the analysis.

Fourthly, there is a group of interventions of which it is reasonable to assume that they were effective, but which did not appear in the review as they were based on one group pre-post-test designs without a control condition, such as Boscolo et al. (2007), Knudson (1998), and Nadal, Castells, and Miras (2015). Both Boscolo et al. (2007) and Nadal et al. (2017) described the content of their interventions in detail, which enabled us to establish that they have many elements in common with the interventions we analyzed, but did not provide new learning activities or additional insights.

In addition to these four issues, it is important to mention that the analysis of effective interventions, specifically identifying learning activities that support the three transformational processes, was not as straightforward as might be expected. That it is hard to identify and label learning activities, was previously shown in a study by Rijlaarsdam et al. (2017). In a seminar on effective ingredients of strategy-oriented writing interventions in Amsterdam (May 2012) Rijlaarsdam et al. (2017) experienced that it was difficult to come to a unanimous categorization, because an intervention which usually consists of several learning activities and contextual factors, is compared as a whole to a control condition. Moreover, not all studies provided a full description of all learning activities included. This makes it both difficult to distil learning activities from the intervention as well as replicate it. However, in the present study, after discussions in different expert groups we were able to pinpoint activities essential for learning synthesizing. Subsequently, with the help of writing proficiency researchers and teachers, we were able to assign essential learning activities to each transformational process, using a Delphi procedure.

Furthermore, when interpreting the results of this review, we must consider the broad age range of the students in the studies we analyzed. We included these in our review, because in the late elementary and early secondary grades students will have automated the formulation and transcription processes to such an extent that they can begin to devote some cognitive capacity to planning and revision activities (McCutchen, 2006). Therefore, these writers are no longer limited to only 'knowledge telling' as a strategy for dealing with cognitive overload (Scardamalia & Bereiter, 1987), even though 'knowledge-telling' at this age is the default strategy that students tend to apply. The transition to real knowledge transforming strategies, which require highly recurrent processes and extensive revision activities, emerges at a later stage of

development. Nevertheless, based on previous studies (Martínez et al., 2011, 2015), we believe that young writers for whom knowledge telling is the default strategy can also benefit from instruction in selecting, organizing, and connecting information from sources.

Finally, we decided to include studies in first (L1) as well as in second language writing (L2), because earlier research on source-based writing indicated that it is difficult to clearly distinguish between L1 and L2 writing in this genre (Cumming et al., 2016, p. 52). In addition, research by Van Weijen, Rijlaarsdam and Van den Bergh (2018) provides support for a common underlying source of writing related knowledge and practices, such as source use and argumentation behavior, which they can apply in multiple languages. Therefore, we assumed that learning activities that are effective for students who learn to write in a second language can be effective for first language students, as well.

4.2 Future research

Now that we have determined that effective interventions tend to pay attention to all three transformational processes of the synthesizing process, it might also be interesting to determine what each individual process contributes to the quality of synthesis texts. This should be considered when designing an intervention. In addition, it could be useful to study the influence of language proficiency and multilingualism on learning to write synthesis texts. Cumming et al. (2016) noted that little research has been done in this area and that is surprising given the fact that there are frequent discussions about the problems students experience when they learn to write in a second language.

Furthermore, we found that different synthesis learning activities are suitable for promoting the same processes. In interventions learning activities are usually employed in conjunction with other practices, limiting the ability to estimate their individual effect on the outcomes. Therefore, analysis of the effectiveness of the individual learning activities could be an interesting topic for further research.

Further research is also needed to find out more about the interaction between synthesis learning activities and writing preferences. What influences the execution of the writing task, amongst many other things, are individual writers' preferred writing process styles. Not everyone tackles a writing task the same way. Differences in writing preferences can be described along three dimensions: preferences related to planning, revising and formulation (Kieft, Rijlaarsdam, Galbraith, & Van den Bergh, 2007). Kieft et al. (2007) found an effect of adapting writing tasks to students' writing preferences on knowledge acquisition and the improvement of their writing skills. This raises the question: do students' writing preferences also influence their preference for certain learning activities when learning to synthesize? And subsequently, does this writing preference affect the effectiveness of the intervention?

Recently, Van der Loo, Krahmer, and Van Amelsvoort (2018) compared learning-by-doing with observational learning and studied the effects of writing preference (planning versus revision) on academic writing quality when writing an introduction to

an empirical research report based on summaries of scientific articles. They found no main effects for instruction method and writing preference, but simple effect analyses showed that revisers benefited slightly more from the observational learning method than planners. Planners did equally well in both conditions, but planners who learned by doing performed better than revisers who learned by doing. Additional research on this topic would be both an important educational objective and an interesting perspective for research on child development, because we already know quite a lot about writing processes in general, but much less about the interaction between personal writing preferences and their influence on the effectiveness of educational writing interventions.

5. Conclusion and implications for practice

In this review, we have taken the content of effective interventions as a basis for formulating design principles for future interventions. We assumed that we could learn from the experience gained in earlier interventions and that it was not necessary to re-invent the wheel time and again when designing interventions or educational material. We regarded the learning activities in these effective interventions as valuable input for the development of a set of instructional design principles, that can be used as guidelines for future interventions in synthesis writing or as a means of support for teachers who want to develop educational material on synthesis writing.

The results of our analysis seem to indicate that effective synthesis writing instruction should stimulate all three transformational processes, selecting, organizing, and connecting, during the intervention or learning process. Students can practice these processes by performing specific learning activities as shown in Table 2, but if we want to increase the effectiveness of an intervention even further, then we need to provide students with freedom of choice, so they can adapt the available strategies to their personal preferences or develop their own strategies. The challenge now is to design interventions and educational materials that offer an evidence-based selection of different learning activities to practice the synthesizing process, while providing students with some freedom to choose the learning activities that suit them best.

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Appendix A: Studies reviewed

Table A1 contains a description of all the studies reviewed and their effect sizes. Studies are arranged in alphabetical order. For each study the following information is given: reference, grade, number of participants, genre of text written at posttest, if the students wrote in their first (1) or a second (2) language, a short description of the intervention and control conditions, and the effect size. Variables which could account for heterogeneity of effect sizes such as: goal of the intervention, number of sessions and intensity (in minutes per session) of the intervention, and assessment method were also coded.

Table A1. Description of included studies

	Study	Gr.	N	Genre		L	Treatment	ES	Goal		Sessions	Min.	Assessment posttest	
				A	E				WTL	LTW			A	H
1.	Barzilai & Ka'adan (2017)	9	99		+	1	(Meta-)strategic scaffold vs. normal curriculum	1.17*	+		3	60	+	
2.	Britt & Aglinskas (2002)	11	23		+	1	Webbased interactive tutoring (instruction program) vs. normal curriculum	1.53	+		1	35	+	+
3.	Darowski et al. (2016)	UG	53		+	1	Integrating sources vs. normal curriculum	0.22		+	1	10	+	
4.	De la Paz & Felton (2010)	11	160	+		1	Historical reasoning strategy instruction vs. normal curriculum	0.33	+		4	50	+	
5.	Gil et al. (2008)	UG	59		+	1	Taking notes vs. no treatment	-0.04	+		2	50	+	
6.	Gonzalez-	9	74	+		1	Self-regulation strategies (SRS) vs. SRS +	0.25	+		8	50	+	+

	Lamas et al. (2016)						modeling and guide							
7.	Hammann & Stevens (2003) 1	8	63		+	1	Summarization Instruction + text structure instruction vs. no treatment	-0.1	+	+	6	45		+
8.	Hammann & Stevens (2003) 2	8	63		+	1	Summarization Instruction vs. no treatment	-0.34	+	+	6	45		+
9.	Hammann & Stevens (2003) 3	8	63		+	1	Text Structure Instruction vs. no treatment	0.33	+	+	6	45		+
10.	Hilbig & Proske (2014)	UG	48	+		1	Digital writing environment vs. no treatment	-0.86		+	1	180	+	
11.	Kirckpatrick & Klein (2009)	7/8	83		+	1	Text Structure Instruction vs. normal curriculum	1.64		+	6	60	+	+
12.	Klein & Rose (2010)	5/6	24	+	+	1	Cognitive strategy instruction vs. normal curriculum	0.28	+		11	?		+
13.	Lundstrom et al. (2015)	UG	176	+		1	Integrating sources vs. normal curriculum	0.65		+	1	75	+	
14.	Martínez et al. (2015)	6	62		+	1	Strategies for Writing Synthesis to Learn vs. normal curriculum	2.49	+		12	60	+	
15.	Raphael & Kirschner (1985)	6	45		+	1	Text Structure Instruction vs. normal curriculum	0.76		+	7	45		+

16.	Reynolds & Perin (2009) 1	7	121	+	1	Plan & Write strategy vs. Neutral Literacy (control)	0.55		+	5	45		+
17.	Reynolds & Perin (2009) 2	7	121	+	1	Text Structure Instruction vs. Neutral Literacy (control)	0.70		+	5	45		+
18.	Robledo-Ramón (2016)	UG	60	+	1	Strategy instruction vs. text product analysis (control)	0.88	+		8	50	+	
19.	Zhang (2013)	UG	29	+	2	Explicit discourse synthesis writing instruction vs. normal curriculum	1.10		+	5	?		+

Note: For each study, numbers behind the references indicate that effect sizes were calculated for a number of conditions or groups; these effect sizes are reported separately. For grade: as reported in the study. Grade systems may vary across countries, UG: undergraduate. For genre, A: argumentative, E: expository. For Language (L): 1: first language, 2: second language. For goal: LTW: learning-to-write, WTL: writing-to-learn. Assessment method: A: analytically, H: holistically.

* Mean ES of combined strategic and meta-strategic condition at delayed posttest