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Summary for educators



When and how to use visuals effectively: a meta-analysis of dual coding in the classroom

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Acknowledgements

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What is dual coding and why is it important?

Dual coding means using visuals, such as pictures or diagrams, alongside words in your teaching. The name comes from Dual Coding Theory (Paivio, 1990), which proposed that our long-term memory is formed through both language (words and phrases) and images (what we see around us). The theory predicts that pupils' learning will improve if they learn through both of these channels simultaneously (for example, if pupils read about Romans and see pictures of them, they will remember the facts better).

In reality, learning is far more complex. Mayer's Cognitive Theory of Multimedia Learning (2008, 2014) recognised that pupils have limited working memory and attention, which can affect how much they learn from dual coding. Pupils need to attend to, select and integrate the relevant information from both channels to form a coherent mental model. This means that teachers need to think carefully about how they use dual coding in the classroom. Neither theory suggests that certain pupils benefit from a more visual approach than others, and they are not related to previously debunked learning styles.

Why did we study dual coding?

Our study expands on the Education Endowment Foundation's review of cognitive science in the classroom (Perry et al., 2021). Their review found that, while dual coding is generally beneficial to pupil outcomes, several factors may affect how well it works, and sometimes it may not work at all. Our study aimed to better understand why the impact of dual coding varies.

In our study, we defined dual coding as using any kind of visual alongside verbal instruction or written text in teaching. There are many reasons why visuals might be used in the classroom. For example, to support pupils who cannot yet read, or as cues for routines and classroom organisation. In this research, we looked specifically at visuals used for dual coding to support pupils' learning, while acknowledging that visuals have many other functions.

Since teachers have many demands on their time, it is essential that they know how to apply dual coding effectively. The term dual coding has become popular in schools, and a range of strategies are being embedded within schools and trusts. This study therefore sought to bring clarity and practical suggestions for how and when to use dual coding to benefit pupils the most.

How did we research dual coding in this study?

We conducted a meta-analysis of 56 studies of dual coding, systematically searching for and combining the results of all existing research. Combining effect sizes (a standardised measure of how strong or meaningful a finding is) allows us to get a more precise overall estimate of impact by pooling results across many studies.

All the studies we reviewed took place in a school setting. This was important because much of the research on dual coding has been conducted in lab settings rather than schools. Our aim was to find out why the impact of dual coding on learning outcomes varies, and why it is sometimes not effective at all. We did this by analysing how visuals were designed and used, the characteristics of pupils in the study, and the design of the research itself.

Was dual coding effective in this study?

On average, dual coding had a positive and significant effect on pupils' learning. A 'positive' effect means pupils who were exposed to dual coding performed better than those who were not, while 'significant' means the result is unlikely to be due to chance.

However, the effect of dual coding varied considerably and in some cases had a negative effect on learning. We found several factors that influenced the impact of dual coding, including pupils' education phase, teaching group size, and the type of learning outcome being measured. In the next sections we discuss these in more detail.

When was dual coding effective?

Dual coding reliably helped pupils' retention of knowledge, particularly pupils in secondary and further education. It also had a positive impact on pupils' understanding, especially when content was segmented into meaningful units.

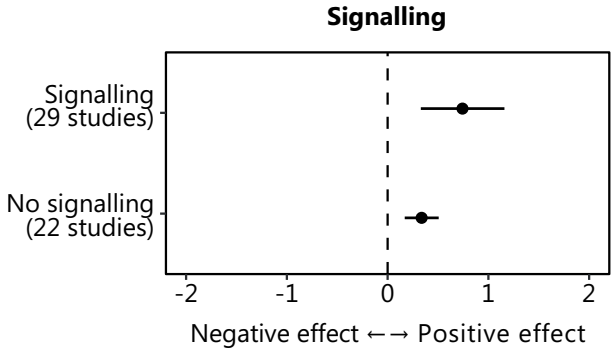
Dual coding had a less reliable impact on pupils' transfer of knowledge and sometimes had a negative impact on this outcome, particularly for primary-age pupils.

We found limited evidence that dual coding benefits long-term learning. In our sample, dual coding had no effect when outcomes were measured two or more weeks after the intervention, but more evidence is needed to confirm this finding.

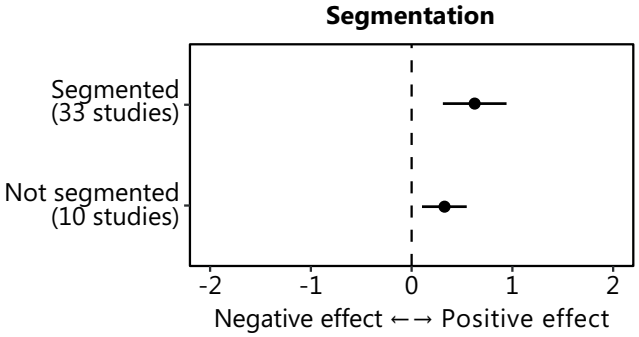
Dual coding was effective for teaching both factual and conceptual content. We found that it was reliably effective for science and technology, and for English and literacy (including reading comprehension). However, it has not been investigated to the same extent in all subjects (for example, there were very few studies of maths to review within our inclusion criteria). The impact on other subjects such as humanities and second languages was more variable and less clear, but this does not mean that dual coding is ineffective for these subjects.

We discovered that the way teaching resources and lessons are designed is important for ensuring that dual coding is effective. Three learning principles from the Cognitive Theory of Multimedia Learning resulted in better learning outcomes:

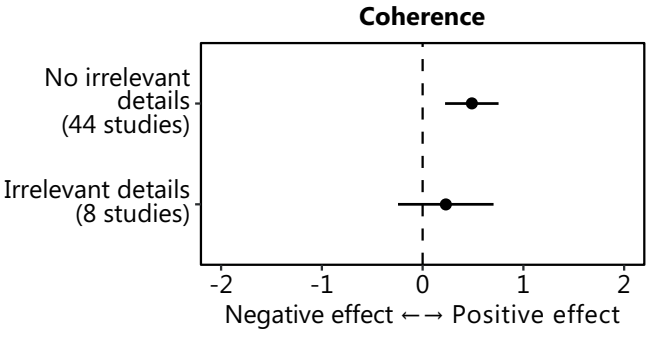
Signalling means directing learners' attention to relevant information to help them integrate visuals with verbal or written content. For example, a teacher might verbally refer to and point to a picture while explaining a concept, or a diagram might have annotations linking it to a written explanation. The graph on the right shows the average effect of dual coding (black circles) for studies that did and did not include signalling. The horizontal bars represent confidence intervals. The wider the bars, the less confident we can be in the average effect, and if they cross zero (the dotted line) we cannot be certain that effects will be positive. The graph shows that when signalling was applied, dual coding had a larger impact on pupils' learning.



Segmenting means breaking down content into meaningful segments, rather than one continuous unit, and is important to help pupils' understanding. For example, presenting written text and pictures as chunks of content with separate paragraphs or headers, or spacing verbal and visual content with pauses. The graph on the right shows that when teaching content was segmented, dual coding had a larger impact on pupils' learning.



Coherence means avoiding irrelevant details, for example not using decorative icons. This is important to help pupils focus their attention on the most important information and can prevent visuals having a negative impact on learning. The graph on the right shows that when learning resources included irrelevant details, dual coding had a smaller impact on pupils' learning. The confidence intervals cross the dotted line which means that we are less confident that dual coding would have a positive impact.



Note The number of studies is different in each graph as it depends on whether we could clearly identify the learning principle in each study.

Teachers are often advised to give pupils something specific to do with the visual when using dual coding (Carney & Levin, 2002; Caviglioli, 2019), such as copying out pictures or filling in a diagram. We found that this did not make dual coding more effective, and that more evidence is needed to understand when this strategy could benefit pupils' learning.

However, dual coding had a greater impact on pupils' learning when:

> The pacing of the lesson was set by the teacher or constrained by a time limit, rather than controlled by pupils themselves.

> Interventions were conducted in person rather than using computer software.

> The intervention was used with the whole class, rather than with small groups or individual pupils.

These findings suggest that dual coding may be more effective as part of the core teaching for all pupils, rather than as an additional resource provided only for some.

Which types of visual were effective?

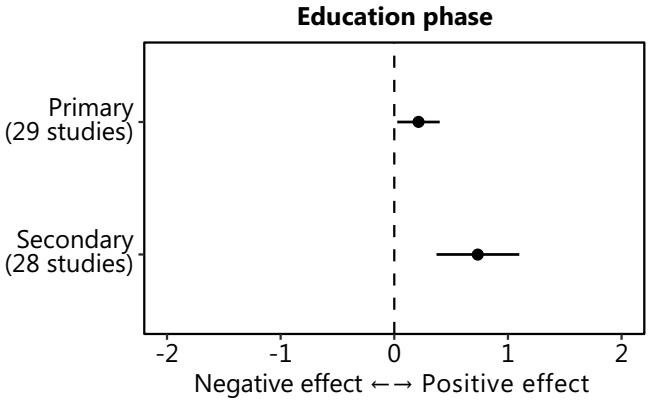
Different types and functions of visual all had a positive impact on pupil outcomes. This includes visuals that represent information accurately and literally (such as an illustration in a story book), visuals that organise content (such as a flow chart), or visuals that interpret a concept (such as a symbolic diagram). Pictures and diagrams had a positive impact, but the effect of animations was more variable. We did not find enough studies to analyse decorative or mnemonic visuals, graphic organisers or concept maps.

Which pupils benefitted most from dual coding?

Which pupils benefitted most from dual coding?

Secondary-age pupils benefitted more from dual coding than primary-age pupils. The graph on the right shows that on average, secondary-age pupils gained more than double the impact. We reviewed an equal number of studies from primary and secondary education, so the difference is not due to more research from one phase. The difference may be because older pupils are better able to mentally select, organise and integrate information from visuals to form coherent mental models from both channels.

There were insufficient studies to analyse effects in any other groups of pupils, or the impact of pupils' prior knowledge. More research is needed to explore which pupil populations will and will not benefit from dual coding. This is particularly important for pupils with special educational needs and disabilities, and pupils with English as an additional language, as it may form part of specialist support for these pupils.



How relevant are the results to everyday classroom practice?

The benefits of dual coding tended to be smaller and less reliable in studies that more closely reflected everyday classroom practice. This was the case when content was part of the curriculum (and not designed specifically for the research project), when interventions lasted more than one lesson, and when the intervention was carried out by a teacher rather than a researcher.

This suggests that teachers should have realistic expectations about the likely size of the benefit. Dual coding is not guaranteed to improve learning, but the recommendations in this summary can help teachers make informed choices about when and how to use visuals and words together, so that they support pupils to learn.

What could teachers do differently as a result of this study?

To get the most from dual coding, while using preparation time well, teachers should keep a few practical principles in mind:

Who to use dual coding with:

> All education phases and age groups.

> Consider using it more often for older pupils, particularly those aged 12-18.

> In primary settings, think carefully about when and how visuals are used, as dual coding could negatively impact younger pupils' transfer of knowledge.

When to use dual coding:

> To improve pupils' retention of knowledge and understanding in the short term.

> For in-person, whole-class teaching for all pupils.

> For teacher-paced or timed activities.

> For all subjects and types of content, but particularly for science, technology, English and literacy.

How to use dual coding effectively:

> Include signalling to help pupils integrate visuals with verbal or written content.

> Segment content into meaningful sections to improve pupils' understanding.

> Ensure resources with visuals do not include irrelevant details.

Use pictures and diagrams that:

> Interpret complex ideas or concepts.

> Accurately represent verbal or written information (for example, an accurate illustration).

> Organise information (for example, flow charts).

> Are tailored to individual lessons or activities.

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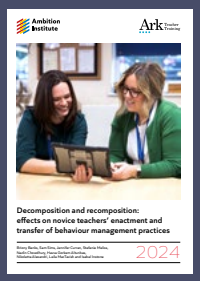
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