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Can structured practice improve science writing skills?

Why is it that Science students who can predict the outcomes of experiments, perform calculations and express their understanding in conversation often have difficulty expressing that understanding in writing in a sufficiently precise and unambiguous way to score marks in GCSE or A-level examinations?

The importance of this issue is clear. My survey of GCSE exam papers[1] showed that 61% of all available marks required a written answer of at least sentence-level complexity. The single command word *explain* accounts for 20% of all questions and 30% of all available marks.

Yet there are few readily available resources to help teachers develop students' science-specific writing skills. Common textbooks do not focus on this. Mark schemes for exam questions encode requirements for precise writing in brief descriptions of 'levels' of response (left to expert interpretation and adjudication), while far more space is given to content-centric 'indicative content'. It is difficult to blame teachers and students for concentrating on content knowledge feedback rather than sentence construction.

Analysing the problem

Linking my study of the examination requirements to my students' work, I identified common sentence structure errors that prevent students achieving full credit for their answers, exemplified in Table 1.

Type of sentence	Correct example	Common errors	Incorrect examples
Factual statement (*State…* or *Give…*)	Water boils at 100 °C.	Unclear referencing. Missing units when giving data.	It boils at 100.
Comparison (*Compare…*)	The water is hotter than the ice.	Unclear referencing. Making absolute rather than relative statements.	It is hotter. The water is very hot.

[1] The six papers of the 2018 AQA Combined Science (Trilogy) Higher Tier examinations.

Explanation (*Explain…* or *Why…?*)	The volume of the gas increased because it was heated.	Making statements without causal linking. Inverting cause and effect.	The volume of the gas increased. It was heated. The gas was heated because its volume increased.

Table 1

These specific types of sentences can be broken down into component parts, as shown in Table 2.

Command word in exam	**Type of sentence**	**Example sentence templates**	**Example sentences**
State… *Give…*	Declarative factual statement	The [noun] is [adjective]. [noun] is a/an [categorical noun].	The apple is red. Aluminium is a metal.
Compare…	Comparison - differences	The [noun] is [comparative] than the [noun]. [factual statement] but [factual statement]	The man is taller than the boy. The apple is red but the pear is green.
Compare…	Comparison - similarities	[noun] and [noun] are both [adjective].	Ammonia and sodium hydroxide solution are both alkaline.
Explain… *Why…?*	Causal explanation	[factual statement] because [factual statement]. [factual statement] because [comparison].	Ammonia turns red litmus paper blue because ammonia is an alkali. Aluminium melts in the oven because the temperature of the oven is hotter than the melting point of aluminium.

Table 2

The table shows that the basic building block of these sentences is the factual statement, extendable with "comparing words" to form comparisons. Factual statements or comparisons can be joined with "because" to form causal explanations.

This provides a model suitable for a long-term Deliberate Practice approach (Ericsson, 2006) by first practicing simpler types of sentences, then combining these to produce more complex sentences.

Designing an intervention

A meta-analysis of studies on writing instruction in secondary students (Graham & Perin, 2007) includes three techniques used in the intervention worksheets: setting clear and specific goals for what students should achieve in their writing (effect size d = 0.70); instruction in sentence combining (d = 0.50) (Saddler & Asaro-Saddler, 2010); providing models for each type of writing (d = 0.25).

The worksheets also use more general evidence-based methods (Hattie 2008, 2015, 2017). Their long-term use contributes to a Deliberate Practice approach (effect size d = 0.79), the worksheets use scaffolding (d = 0.82), setting clear learning goals (d = 0.62), and self-assessment (*d* = 0.75 for "evaluation and reflection") by checklists (Gawande, 2011).

Combining these methods, each worksheet shared a common structure of rules and examples first, then sentence construction from templates, followed by free-answer questions each supported by a self-assessment checklist.

The main research question became "Does the structured practice of specific, fine-grained writing skills improve attainment in GCSE-style written answers in Science? Does it have a larger effect compared to practice using past-paper questions?"

To test this, I used a randomised, controlled trial. Students in a middle-achievement Year 10 class who consented to take part in the research were randomly divided into 2 groups. The control group (n = 10) practiced and received feedback on past-paper questions, using the official mark schemes. The intervention group (n = 9) used the new worksheets. A test of past paper questions was set before and after the intervention.

Results and outcomes

The intervention group showed a larger, but not quite statistically significant, improvement in test scores (d = 0.71, p = 0.09), while the control group showed a smaller, less significant improvement (d = 0.37, p = 0.23). No statistically significant difference between the groups could be detected, though the intervention is promising given the small number of participants and merits further investigation.

Both groups had trouble decoding the test questions. For one *explain* question a majority of the answers were *descriptions* or *comparisons*, which scored no marks. This highlights the need for more support on question decoding.

One student spontaneously began using one of the study's checklists in other lessons. My observations also showed checklists supporting self-evaluation and assessment awareness. Combining this with the need for support in question decoding, I produced laminated (wipe-clean) checklists for each common command word in written questions. My students now use these for checking sentences, with positive effects.

References

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