

Investigating the efficacy of using error analysis data to inform explicit teaching of spelling

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ABSTRACT

Learning and teaching Standard English spelling is complex. While empirical evidence supports the view that explicit teaching can make a positive difference to learning, further research is needed to understand the impact on learning to spell if spelling error analysis is used to inform explicit instruction within mainstream school contexts. This paper presents findings of an intervention study involving 572 students in Years 3 to 6 from 31 classes across four Australian schools which were selected using stratified random sampling. Fourteen teachers from two of the participating schools engaged in an intervention to support all students learning to spell. This involved utilising spelling error analysis data to systematically plan and implement explicit and targeted spelling instruction. Sixteen teachers from the two comparison schools followed a 'business-as-usual' pedagogy which predominantly appeared less targeted and explicit. Results indicate that all classes in the intervention group demonstrated a statistically significant improvement in spelling while only one comparison class demonstrated a statistically significant improvement. The promising findings highlight the power of using assessment-informed practices to explicitly teach spelling skills that are relevant to individual student needs.

Introduction

Communication through writing is fundamental to being literate, and spelling is one of the critical skills required to communicate via well-crafted texts (Abbott et al., 2010). The weight of research evidence supports the view that spelling ability is a key predictor of success in learning to read and write (Conrad et al., 2019; Daffern et al., 2017a; Joshi et al., 2008; Moats, 2005/06; Schlagal, 2007; Treiman et al., 2019). Spelling serves as a foundation for higher-level literacy tasks such as writing (Zhang & Treiman, 2020). Poor spelling can result in slower overall writing time and compromised vocabulary (Sumner et al., 2016). It can also impede fluency and comprehension when reading (Bowers & Bowers, 2018; Moats, 2005/06). In an age of fast-paced digital modes of communication such as texting, emailing and messaging through social media platforms, it seems more important than ever to be able to efficiently spell words in a range of contexts.

Given the predictive power of spelling, understanding how school-aged students can be effectively supported to become proficient spellers should be a priority in the fields of literacy education research, curricula, teaching and professional learning. The study described in this article focussed on assessment-informed teaching practices in the domain of spelling. The overall aim of the intervention study was to examine the efficacy of using an instructional approach that is explicit and informed by spelling error analysis data to improve learning outcomes in spelling.

Learning and teaching Standard English spelling

Becoming proficient in Standard English spelling is complex, largely because this particular alphabetic language system is shaped by its rich etymology. It demands an understanding of “written symbols in conventional sequences (orthography) that represent speech sounds (phonology) and word parts that signal meaning and grammar (morphology)” (Garcia et al., 2010, p. 63). The development of spelling skills is not merely a matter of memorising word lists by rote (Joshi et al., 2008). Rather, it involves learning how phonological, orthographic and morphological concepts can be combined to produce written words. A well-grounded theoretical framework, employed in previous studies to understand the progression of spelling skills is Triple Word Form Theory (Bahr, 2015; Berninger et al., 2010; Daffern et al., 2015; Daffern & Ramful, 2020; Garcia et al., 2010; Richards, Aylward, Field, et al., 2006). According to this theory, awareness of phonology, orthography and morphology can be developed concurrently from the early years of learning to spell, and these three linguistic forms need to be integrated when learning to spell (Berninger et al., 2010).

Several neuro-cognitive and behavioural studies have provided converging evidence to support Triple Word Form Theory. For example, some studies have involved comparisons

of individuals with and without dyslexia, demonstrating the unique and common brain regions that are activated during spelling and reading related tasks (Berninger et al., 2010; Garcia et al., 2010; Richards, Aylward, Berninger, et al., 2006; Richards, Aylward, Field, et al., 2006; Richards et al., 2009). Specifically, phonological tasks have been found to activate the “left inferior temporal gyrus” and “left middle temporal gyrus”; orthographic tasks activate the “left superior temporal gyrus”; morphological tasks activate the “left cerebellum, bilateral striatal and occipital regions, the right posterior parietal region”; and common brain regions known to be activated across the three word forms include the “left middle frontal gyrus, left posterior parietal regions, right lingual” (Richards, Aylward, Field, et al., 2006, p. 564). In this body of research, brain imaging analyses have also provided insight into brain plasticity in response to instruction in the three word forms. Experimental research in regular classroom learning contexts is needed to build on these current insights in order to better understand the extent to which explicit and targeted instruction in the phonological, orthographic and morphological word forms helps students learn to spell.

To illustrate Triple Word Form Theory from a conceptual perspective, what follows is a hypothetical description of the task of spelling the word, ‘clipped’, to illustrate how phonology, orthography and morphology need to be cross-mapped (or integrated) in order to correctly spell this word. There are multiple connections that need to be made during this process, assuming the learner does not yet know how to spell this word with automaticity. The learner may need to consider what the verb means and also recognise that <-ed> is needed to represent past tense in this word. The learner also needs to know how to treat the base word when it is suffixed. Without considering these morphological constituents in the word, <clipped> could be misspelled as <clipt>. In addition, the learner may need to segment each phoneme (that is, /c/l/i/p/t/ has five speech sounds) and recognise that the base word ends in a short vowel followed by a single consonant. Furthermore, the learner needs to select the correct grapheme to represent the initial consonant (<k> as in <klipped> or <ck> as in <cklipped> are not orthographically plausible in this position). If a breakdown in the coordination of these linguistic processes occurs, the learner may incorrectly spell the word. If the process of combining phonological, orthographic and morphological word forms is explicitly taught, students may learn to coordinate the word forms with increasing efficiency and accuracy over time (Silliman et al., 2018).

Considering learning to spell in Standard English is not an easy linguistic undertaking, effectively teaching spelling is equally challenging. Teachers need to be equipped with insight into spelling development and an understanding of the spelling errors

that children may produce (Zhang & Treiman, 2020). However, research suggests that many classroom teachers feel dissatisfied with how they are teaching spelling (Adoniou, 2014; Daffern & Mackenzie, 2020; Treiman, 2018; Westwood, 2018). Longitudinal research further suggests that teachers do not always accurately identify students who display difficulty in spelling-related skills such as decoding, resulting in misalignment of instructional supports (Graham et al., 2020).

Assessment underpins explicit teaching. In order to explicitly teach, a teacher must draw on assessment data to decide on “the learning intentions and success criteria”, make them “transparent to the students”, demonstrate them by “modelling”, check for understanding, and “retell” key concepts that have been taught to “bring closure” to each teaching episode (Hattie, 2009, p. 206). In the domain of spelling, regular and increased amounts of explicit instruction can positively impact performance outcomes in spelling (Graham & Santangelo, 2014). Meta-analytic research has also shown that teaching phonics explicitly may be less effective in improving students’ performance in spelling in Years 2 to 6 than it is in the first few years of schooling (Ehri et al., 2012). Insights from other studies indicate that students may benefit from learning about the orthographic and morphological regularities of the written language, in combination with phonics instruction, from the early years of learning to write (Carlisle et al., 2010; Devonshire et al., 2013; Kirk & Gillon, 2009). Experimental research in naturalistic mainstream school settings is still needed to better understand how explicit instruction in the components of spelling can be effectively implemented to improve student learning.

While explicit teaching is broadly considered an important teaching practice, teachers need to be adequately equipped for explicit teaching (Moats, 2014). This includes being able to use assessment data to identify where students are in their learning and to plan for the next steps (Van Geel et al., 2016). In order for teachers to appropriately respond to student learning needs, access to relevant and comprehensive assessment data is fundamental (Timperley, 2009). However, as Goss et al. (2015) assert, many teachers may not be collecting the data they actually need to inform their teaching, nor effectively use the data they do collect. Furthermore, insights into the limitations of teachers’ linguistic knowledge and their preparedness for teaching spelling have also been revealed (Adoniou, 2014; Daffern & Mackenzie, 2020; Herrington & Macken-Horarik, 2015; Moats, 2014). It has been argued that teachers who can demonstrate linguistic skills such as phonemic awareness may be more successful in teaching spelling (Puliatte & Ehri, 2018). Indeed, providing teacher professional learning that focusses on linguistic knowledge as well as how to interpret and use assessment data may need to be considered as a pathway to enhance student learning (Timperley, 2009).

It can be hypothesised that implementing effective instruction in spelling is at least partly contingent upon whether or not assessments are sufficiently sensitive to identify strengths and weaknesses in spelling (Bahr et al., 2009; Daffern et al., 2017b; Kohnen et al., 2009). However, popular measures of spelling ability are based on models of spelling development that do not necessarily align with contemporary understandings of how children learn to spell (see, for example, Bear et al., 2012; Gentry, 2012), or they merely offer a summary of words that are correct and those that are not (see, for example, Westwood, 2005). While some research evidence highlights the potential benefit of explicitly teaching a range of linguistic skills and spelling strategies (Devonshire et al., 2013; Herrington & Macken-Horarik, 2015; Robinson-Kooi & Hammond, 2020a), further research is needed to understand the extent to which assessment-informed instructional approaches enhance student learning in the domain of spelling.

The current study

The current study sought clarity on best practice in spelling instruction. The focus was on understanding the impact of using spelling error analysis data as a form of assessment to guide the design and delivery of explicit teaching in mainstream classroom contexts. Previous research has highlighted the importance of being able to spell, and it has yielded some evidence of the types of Standard English spelling skills students demonstrate across various stages of schooling (Daffern, 2017; Treiman, 2017). Qualitative research further suggests that the teaching and assessment of spelling in regular classroom settings appears unsystematic (see, for example, Daffern & Mackenzie, 2020). However, there is a dearth of experimental research that offers educators the practical insights that are needed to effectively teach spelling in regular classrooms. In the present study, we examined the effectiveness of an assessment-informed, explicit approach to teaching spelling within mainstream classroom contexts.

The research question pertinent to this study is:

Do students who receive instruction that is explicit and informed by spelling error analysis data demonstrate greater improvements in spelling than students involved in the comparison classes?

Method

Participants

Stratified random sampling was used to select four primary schools located in the Australian Capital Territory (ACT). The schools were randomly selected within stratified bands based on the Index of Community Socio-educational Advantage (ICSEA) (Australian, Curriculum,

Assessment & Reporting Authority (ACARA), 2015). The stratified bands were labelled as 'low' and 'high' (that is, schools identified in the lower and upper quarters of the ICSEA values within the ACT, respectively) (ACARA, 2018; ACT Government, 2018). Within the ICSEA bands, schools were randomly assigned to either an intervention group or a comparison group. Both groups comprised a school identified in the low and the high ICSEA bands. Classroom teachers in Years 3 to 6, and their students, were invited to participate in the study, which took place during the second half of the school year. In total, 31 class teachers responded to the invitation to participate (14 intervention classes and 16 comparison classes). The sampled teachers had an average of 9.2 years of teaching experience (SD = 6.45). Overall, the study involved 572 students across Years 3 to 6. The class-based division resulted in 291 students being captured in the intervention group and 281 being captured in the comparison group. The intervention group consisted of 143 male participants and 148 female participants with the average age for this group being 10.2 (SD = 1.31). The comparison group consisted of 135 male participants and 146 female participants with the average age for this group being 10.4 (SD = 1.22). Overall, the mean age and gender distributions in the two group samples were similar. There was no attrition throughout the intervention period, which spanned ten weeks.

The comparison group: A business-as-usual approach

Prior to the intervention, all participating teachers in the study completed a survey in the presence of the chief researcher (first author). The survey required the teachers to describe how they were teaching and assessing spelling during the school year so that a 'business-as-usual' approach could be identified and described for the comparison group. In a typical school context, it is not possible to prevent any teaching of spelling to naturally occur. Therefore, the term 'comparison' rather than 'control' group is referred to in the present study. Overall, the participating teachers reported devoting between 30 minutes and one hour to teaching spelling each week, with the exception of two teachers who claimed that they did not teach spelling during class time. One of those two teachers stated that spelling was 'not taught' during class time and that word lists were sent home at the start of each week instead. The other teacher stated that 'I don't really teach spelling specifically in my classroom'. Broadly, the reported instructional approaches appeared unsystematic, dominated by a combination of rote learning methods (typically by providing students with an activity labelled as *Look-Say-Cover-Write-Check*), some incidental phonics (often using a mix of commercial programs as resources), and seemingly random 'activities' or 'games' that did not appear to have specific or relevant learning intentions. As one teacher described, 'spelling instruction is somewhat ad hoc'. Four teachers used commercial programs that involved

teaching lessons of approximately 20-minutes, usually 3 days a week. Programs included *Sound Waves* (a whole class phonics-based year-level workbook program) and *Spelling Mastery* (a levelled workbook program whereby students are allocated into levelled groups based on whole-word testing that is void of error analysis). Another teacher stated that ‘classroom spelling occurs incidentally during writing lessons’ while another explained that ‘incidental teaching’ occurs ‘if a word comes up in maths, inquiry, science ... students can choose an activity – these range from uppercase, lowercase, backwards words, silly sentences, making riddles using their words’.

Overall, the teachers in this study reported using assessment strategies that did not appear to sufficiently inform their instructional planning. Weekly spelling tests of ‘sight words’ were mentioned by the majority of teachers, with whole-word accuracy scores being determined from these tests rather than error analysis techniques being employed. Teachers explained that ‘weekly words’ were mostly selected by the students from their own written compositions. Other words were generally drawn from topics being studied at the time in other subject areas. Students were required to memorise those words through a repetitive routine of Look-Say-Cover-Write-Check, or variations of this. With the exception of six teachers, error analysis methods were not reported. Where error analysis was mentioned, an adapted version of a spelling inventory, sourced from a commercial program known as *Words Their Way* (Bear et al., 2012), was used. One teacher in the comparison group specified that data from these inventories were used to group students according to identified skills, for the purposes of ‘differentiation’. This teacher also reported conducting weekly tests to monitor student progress. While the other five teachers reported using this same spelling inventory to assess spelling, their survey responses suggest that they did not use the error analysis data to directly inform their teaching. It is possible their assessment methods may have been adopted for compliance or summative purposes only.

For the present study, teachers in the intervention group were provided a copy of the pre-intervention spelling error analysis data for the respective students in their class. They were required to use that data to inform their teaching as part of the intervention design. On the contrary, the teachers involved in the comparison classes did not receive the error analysis data collected for this study until the conclusion of the intervention period. Those teachers were required to continue implementing their usual practice.

Teachers’ linguistic knowledge

In the presence of the chief researcher, all teachers were surveyed on their linguistic knowledge before the intervention commenced. The primary purpose of this survey was to inform the design and delivery of a professional learning program for the participating

teachers in the intervention group (also see Fidelity section, below). For equity, a similar professional learning program was offered to the teachers involved in the comparison group at the conclusion of the study. Forty-six items were included in the teacher linguistic knowledge survey and these were sourced and adapted from existing surveys designed to measure teachers’ linguistic knowledge (Carreker et al., 2010; Puliatte & Ehri, 2018; Stark et al., 2016). Whilst the results of this survey are not directly pertinent to the research question being addressed in the current study, it is worth noting that the descriptive results appear consistent with other studies illustrating gaps in teachers’ linguistic knowledge (Daffern & Mackenzie, 2020; Herrington & Macken-Horarik, 2015; Puliatte & Ehri, 2018; Stark et al., 2016). As can be seen in Table 1, the participating teachers’ knowledge at the phoneme level was particularly weak, highlighting substantive difficulty in being able to accurately identify the number of phonemes in words. The results also demonstrate very low levels of knowledge about specific orthographic and morphological conventions and generalisations. Of the skills that were surveyed, it seems the teachers were better able to identify and manipulate onset and rimes as well as correctly count the number of syllables in words. There were no statistical differences in mean scores between the teachers in the intervention group and teachers in the comparison group.

Table 1. Mean scores and standard deviations for the teacher linguistic knowledge survey

Linguistic knowledge survey items	Items <i>n</i>	Mean scores [% items correct] (SD)
Syllable identification	7	71.43 (18.07)
Phoneme identification	14	43.09 (17.93)
Onset and rime identification and manipulation	10	78.71 (24.32)
Orthographic and morphological conventions	15	44.30 (10.96)
Total	46	56.00 (11.14)

Fidelity

Before and during the 10-week intervention period, the teachers assigned to the intervention group participated in a professional learning program, designed and delivered by the chief researcher. This program was reviewed and accredited by the ACT Teacher Quality Institute. This measure of fidelity sought to ensure that the teachers were well-equipped to implement the intervention. By engaging in the program, teachers had an opportunity to refine their linguistic knowledge, learn about current research on how children learn to spell, and understand how to use error analysis data to inform an explicit and targeted approach to teaching spelling. As Moat’s (2014) asserts, “the quality of implementation of an instructional program” is critical to producing effective student learning outcomes and it “is

greatly enhanced by mentoring and coaching by individuals who themselves are highly skilled” (p. 87). The teachers involved in the intervention group received a full-day of professional learning and were provided with a 220-page manual which contained templates to assist with error analysis processes based on a standardised spelling assessment tool informed by Triple Word Form Theory (Daffern et al., 2015). The manual also included a comprehensive set of instructional guidelines, lesson planning templates and teaching resources, all of which are aligned with the standardised spelling error analysis assessment tool. The teachers were shown how to use the colour-coded instructional recommendations, which were aligned to the error analysis (see appendix and Figure 1), when planning their lessons. As part of this professional learning, the participating teachers also viewed a series of pre-recorded demonstration spelling lessons, prepared by the chief-researcher. In addition, the chief researcher worked alongside the teachers to help them to design and deliver the assessment-informed spelling lessons. The chief researcher has previous experience as an accredited ‘Highly Accomplished’ classroom teacher and literacy specialist in schools, so it was possible to observe several lessons in each class throughout the intervention period. The chief researcher showed the teachers how to use the colour-coded instructional recommendations to make informed decisions on the teaching focus for each lesson. Lesson planning templates were used by the teachers to design and document the lessons to ensure they aligned with the identified needs of the students, based on the colour-coded instructional recommendations for their class (see Figure 1 for an illustrative example). The colour-coded instructional recommendations were based on results of the error analysis. For fidelity, the teachers did not have access to the test items and the words from the CoST throughout the lesson planning and implementation but they did have access to the colour-coded instructional recommendations for the participating students in their class. They also had access to the accompanying teaching resources for each of the coded instructional recommendations. An intervention that involves overt teaching of the words that are part of the assessment can cause issues to the validity of the findings. For this reason, the teachers were not given the test words for instructional purposes. Rather, the instructional recommendations were designed for far transfer of spelling knowledge and strategies. To ensure the teachers were implementing their planned lessons, the lessons were regularly observed by the chief researcher and also by a school team leader. The lesson observations were followed-up with professional learning conversations with those teachers. While these support provisions helped to maintain the fidelity of the intervention, it also provided opportunities for the teachers to critically reflect upon and refine their teaching within a supportive and collaborative professional learning environment.

Spelling ability measure

At the commencement of the study and then ten-weeks later, all participating students completed a 70-word dictation test known as the Components of Spelling Test (CoST) (Daffern et al., 2015, 2017b). This standardised test is designed to measure student knowledge of the phonological, orthographic and morphological components of Standard English. The CoST is informed by Triple Word Form Theory and provides a means from which to analyse student knowledge of the spelling system using an error analysis technique. Across the 70 words that students spell, the CoST allows for a total of 101 items to be analysed. Each item constitutes a component word part rather than a whole word, and some words are analysed using more than one item. For example, the word ‘carries’ is analysed using multiple items. To illustrate, one item is classified within the orthographic component to determine if the student uses the correct double consonant letter at the syllable juncture (for example, <rr> in ‘carries’ is correct while ‘caries’ is incorrect). Another item for this word is classified within the morphological component to determine if the student knows how to treat the base word when adding the inflected tense marking suffix (for example, <ies> in ‘carries’ is correct and ‘carryies’ is incorrect). The correct spelling of an item is allocated a score of 1 while incorrect spelling is allocated a score of 0. Strong internal consistency results for this spelling test have been reported, with Cronbach’s alphas ranging from .78 to .94 (Daffern et al., 2015). During regular class time, students completed the CoST online whereby 70 target words were dictated in the context of prescribed sentences. The pre- and post-test was administered by the chief researcher during regular class time and in the presence of the respective school support teachers. Students’ spelling attempts were then automatically analysed using predefined computer-coding. This online platform has been successfully used in previous research (Daffern & Ramful, 2020). The benefit of the online platform lies in its capacity to automatically generate the spelling error analysis, making it time-efficient, reducing the potential for testing bias to occur, and removing the possibility for unintended mistakes that may otherwise arise as a result of a manual error analysis. The online test platform also automatically generates a colour-coded summary of instructional recommendations for each student, based on the results of the computer-generated error analysis (for a condensed example, see Figure 1). The computer coding is entirely rule based to ensure the errors for each item are analysed and scored exactly as they are prescribed in the paper scoring sheets. For the computer-generated and colour-coded instructional recommendations, green is used if all respective items for a ‘code’ are correct, amber is used if 21 to 99 percent of respective items are correct, and red is used if zero to 20 percent of

respective items are correct. The appendix provides a summary of the alignment between the coded instructional recommendations and the CoST.

Intervention design

The intervention phase occurred during the second semester of the school year and for a period of 10 weeks. Key features of the intervention design included:

- Using Triple Word Form Theory as a foundation for systematic spelling error analysis to inform teaching priorities;
- Planning and implementing targeted instruction focussed on identified areas of need based on error analysis data (see, for example Figure 1);
- Identifying and explaining the learning intentions to the students at the start of each lesson;
- Explicitly teaching and modelling relevant spelling strategies and generalisations;
- Teaching spelling explicitly at least 3 times each week, for 20 to 30 minutes each lesson, following a multi-tiered and cyclic structure each week as outlined in Figure 2;
- Modelling and encouraging the use of metalanguage as a way to explain and understand how and why words are linguistically structured;
- Frequent opportunities for students to handwrite words onto blank flash cards and then categorise those words according to phonological, orthographic and morphological properties;
- Inclusion of regular revision activities such as dictation and cloze tasks;
- Frequently checking for understanding by asking students to explain linguistic features in words, spelling generalisations and/or strategies;
- Embedding regular opportunities for students to apply and consolidate their learning in other contexts (such as during reading and writing lessons in a range of subject areas).

STUDENT	PHONOLOGICAL CODES				ORTHOGRAPHIC CODES														MORPHOLOGICAL CODES					
	P1	P2	P3	P4	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	M1	M2	M3	M4	M5	M6
Student 1																								
Student 2																								
Student 3																								
Student 4																								
Student 5																								
Student 6																								
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Student 22																								
Student 23																								

Key: NOT DEMONSTRATED SOMETIMES DEMONSTRATED CONSISTENTLY DEMONSTRATED

Note. For full descriptions of each code, their alignment with the CoST and accompanying instructional recommendations, see Daffern (2018)

Figure 1. An illustrative class summary of coded instructional recommendations

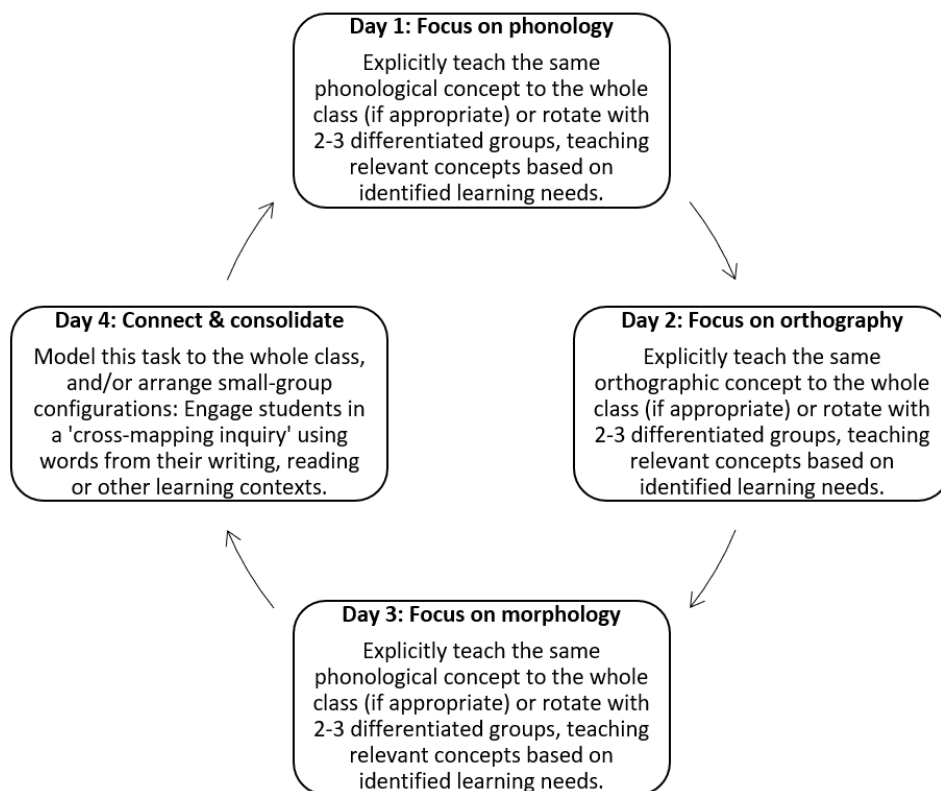


Figure 2. A multi-tiered and cyclic instructional structure

Figures 3a-d present a sample of activities relating to a selection of coded instructional recommendations. The lesson planning template shown in Figure 3e enabled teachers to plan for a targeted approach to teaching spelling each lesson. Their lesson plans were discussed and refined while working with the chief researcher throughout the intervention phase. Differentiation occurred for each of the three components each week. Grouping configurations were distinct for Day 1 (a focus on phonology), and these differed to those on Day 2 (a focus on orthography) and Day 3 (a focus on morphology). Differentiation occurred consistently across Days 1 to 3. For example, on Day 1, a teacher may have focussed on P4 when working with one group of students for about 10 minutes and then rotated to work with another group of students focussing on P3 for about 10 minutes. Most lessons for Days 1 to 3 involved at least two differentiated groups of instructions. The cross-mapping activity on Day 4 involved a combination of explicit teaching and some small group or independent work whereby the students selected their own word to study in depth.

P4: ACTIVITY TEMPLATE 1

Words with 3 syllables	1 st syllable	2 nd syllable	3 rd syllable
September			
vanishing			
establish			

Words with 4 syllables	1 st syllable	2 nd syllable	3 rd syllable	4 th syllable
identical				
administer				
celebration				

Words with 5 syllables	1 st syllable	2 nd syllable	3 rd syllable	4 th syllable	5 th syllable
individual					
generosity					
flexibility					

P4: ACTIVITY TEMPLATE 2

Text/s used to find these words:			
	Three-syllable Word	Four-syllable Word	Five-syllable Word
Spell the word:			
Identify the number of phonemes in each syllable.	1. 2. 3.	1. 2. 3. 4.	1. 2. 3. 4. 5.

Figure 3a. Sample Day 1: A focus on phonology (P4)

O13. Explicitly demonstrate how to encode syllable juncture consonant doublets by:

1. Modelling how to identify the medial consonant doublets in base words: *throttle, waddle, paddle, fiddle, pillow, ladder, rabbit, wobble*. Clap syllables when explaining syllable juncture. Emphasise that these words have a medial short vowel phoneme followed by a consonant doublet. The first syllable in each word is stressed. When the consonant letter , <d>, <g>, <m>, <t>, <n>, or <p> appears after a short vowel in two-syllable base words, the medial consonant letter is doubled. However, if the medial vowel phoneme is long (including if it is followed by the letter <r>), the consonant is not doubled.
2. Contrasting the above word types with the following words: *pilot, violet, silent, crater, fever, table, label, harvest, purple, margin, dairy*. Emphasise that these words do not have a medial short vowel phoneme and that the first syllable is stressed.
3. Students then identify words with the medial consonant doublet. A range of texts should be available to enable the student/s to undertake a 'word hunt' (see Activity Template 1).
4. Students write words containing a medial consonant doublet in the context of complete sentences (see 'Consonant Doublets' task card).
5. Students consolidate with a partner game, 'double or don't' (see Activity Template 2).

O13: ACTIVITY TEMPLATE 1

-bb-	-dd-	-gg-	-mm-
-nn-	-tt-	-pp-	-ll-

Task card: Consonant Doublets

1. Find two syllable words containing a medial consonant doublet. Write each word on a separate card.
2. Highlight the consonant doublet in each word. Underline the part of the word that represents an unaccented final syllable.
3. Write sentences using those words.

Figure 3b. Sample Day 2: A focus on orthography (O13)

O13: ACTIVITY TEMPLATE 2

Double or Don't

How to play: Cards are cut out and shuffled and then stacked face down in a pile. Players take turns taking a card off the pile and reading the word but not revealing it to the other players. Players put two hands up if they think the word read out contains a medial consonant doublet and only one hand up if they think that it does not. Each time players are correct they score a point. The winner is the person who has scored the most points at the end of the game.

Challenge: Players write the word that is read out on a mini whiteboard and reveal this to score a point.

gl itter	throt tle	rab bit	l adder	w addle
silent	bot tle	pilot	dri bble	table
stag ger	fever	crater	ban ner	label
harvest	gr apple	manner	violet	dairy
pad dle	purple	margin	fi ddle	pillow
mid dle	hotel	dri bble	pos sum	happ en

Figure 3b. Sample Day 2: A focus on orthography (O13), *continued*

Explicitly teach the following generalisations for the *-ing*, tense marking suffix:

- If the base verb ends with a letter that makes a vowel sound then consonant graph, double the last letter of the base word and then add the suffix *-ing*
- If the base verb ends with the letter *x*, or any consonant blend, digraph, or trigraph, just add the suffix: *-ing*
- If the base verb has a vowel digraph in the last syllable, just add the suffix *-ing*
- If the base verb ends in *y*, or a vowel digraph, trigraph or quadgraph such as *ow*, *er*, *igh* or *eigh* just add the suffix *-ing*
- If the base verb ends in *e* and the final *e* is not part of a vowel digraph or trigraph, drop the final *e* then add the suffix *-ing*

Silly sentences task:

Students create silly base verbs and write a silly sentence for each in future tense. The present tense base verb must end with a single short vowel followed by a consonant. Then, students transform each sentence into present tense.

Example to model:

Silly base word: *plip*

Sentence in future tense: *I will plip across the road.*

Sentence in present tense: *I am plipping across the road.*

Word sorting task:

The teacher reads the picture book out loud, *Magic Beach*, by Allison Lester (2004) Allen & Unwin. ISBN: 9781741144888. The teacher points out some examples of the suffixed verbs from this text (refer to list, below). Students then create flashcards by writing (some or all of) the listed words. Students then sort the handwritten word cards according to the generalisations that have been explicitly taught.

swim	swimming	ride	riding
splash	splashing	spit	spitting
shriek	shrieking	crash	crashing
laugh	laughing	search	searching
jump	jumping	drift	drifting
race	racing	look	looking
toss	tossing	thrash	thrashing
fade	fading	watch	watching
play	playing	struggle	struggling
dig	digging	fight	fighting
creep	creeping	paddle	paddling
trap	trapping	steal	stealing

Figure 3c. Sample Day 3: A focus on morphology (M1)

The word is _____

Phonological lens

1. How many syllables can I hear in this word?
2. How many phonemes can I hear in this word?
3. What consonant phonemes can I hear in this word?
4. What vowel phonemes can I hear in this word?

Orthographic lens:

1. What are the graphemes in this word?
2. Are there any tricky graphemes such as trigraphs or quadgraphs? Do these graphemes remind me of other words?
3. Can I find small words within this word?
4. Are there any letter-sequencing generalisations or mnemonics that I can use to help me spell this word?

Morphological lens:

1. How can I use this word in a sentence?
2. What are the morphemes in this word?
3. What do the morphemes mean?
4. Is the word inflected or derived from a base or root word? What is the base/root?
5. Is there a generalisation for adding a prefix or suffix to the base/root?
6. What other words require this generalisation to be used?

Closure:
What strategies help me to spell this word?

Figure 3d. Sample Day 4: A focus on cross-mapping and consolidating

Day 1: Focus on Phonology		Lesson Duration: _____
Group 1 students:	Group 2 students:	Group 3 students: (if required)
Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)
Where to next:	Where to next:	Where to next:
Day 2: Focus on Orthography		Lesson Duration: _____
Group 1 students:	Group 2 students:	Group 3 students: (if required)
Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)
Where to next:	Where to next:	Where to next:
Day 3: Focus on Morphology		Lesson Duration: _____
Group 1 students:	Group 2 students:	Group 3 students: (if required)
Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)	Code: _____ Lesson Details: (sequence and resources)
Where to next:	Where to next:	Where to next:

Figure 3e. Lesson planning template

Data analysis

In order to assess the effectiveness of the intervention on the students' scores, a pre-test/post-test method was used. A repeated measures t-test was employed to investigate whether a significant difference was present between the test scores for each class. For each of the tests, an achieved (or observed) power calculation was performed as a way to validate the significant differences found. Effect size was calculated for each class as well to indicate the relative effectiveness of the intervention versus the effectiveness of a business-as-usual approach to teaching spelling.

Results

At the commencement of the intervention, there were no significant differences between the mean scores for the intervention group and the comparison group as a function of year level. Table 2 summarises the CoST scores at T1 (pre-test) and T2 (post-test) by Class ID and Group. Additionally, the overall mean and SD for each group are displayed indicating that at T1 there was no significant difference between the comparison group and intervention group, $t(29) = 0.723, p = .05$.

See next page for Table 2

Table 2. Mean and SD for CoST scores at T1 and T2 by Class ID and Group

Group	Class ID	T1 Mean	T1 SD	T2 Mean	T2 SD
		CoST Score	CoST score	CoST score	CoST score
Intervention	1	61.63	22.18	66.89	21.55
	2	59.19	19.24	65.00	18.52
	3	59.42	17.41	66.35	16.06
	4	60.29	18.90	69.25	19.67
	5	69.48	17.57	77.90	15.15
	6	64.11	16.47	74.44	14.57
	7	71.08	15.58	76.04	14.63
	8	39.78	18.65	48.56	20.37
	9	50.27	22.89	55.40	23.48
	10	72.50	18.14	78.10	16.14
	11	43.00	17.20	52.22	17.69
	12	43.52	17.01	56.40	18.69
	13	50.26	16.37	58.93	16.62
	14	76.58	14.03	82.05	11.44
	Total	58.74	20.79	66.47	19.85
Comparison	15	79.63	14.21	80.37	13.32
	16	77.20	16.84	76.80	18.62
	17	68.57	19.20	70.52	19.37
	18	47.50	16.62	50.63	17.70
	19	74.33	16.47	75.95	16.39
	20	47.00	9.19	50.47	12.68
	21	66.35	27.56	68.12	25.33
	22	51.36	22.75	50.21	26.56
	23	68.71	16.56	69.65	17.83
	24	51.60	22.01	55.00	21.06
	25	44.60	23.50	44.60	24.26
	26	64.12	13.90	67.00	10.66
	27	62.13	28.96	63.19	29.44
	28	28.71	16.21	28.57	15.09
	29	49.25	14.63	48.50	14.93
	30	67.95	15.00	69.74	17.13
	31	87.53	8.09	89.11	7.02
	Total	62.18	22.95	63.60	23.22

Note. CoST raw scores are based on a total 101 items analysed.

Table 3 presents a summary of the t-test results for each class divided by group. Included in the table is a calculation of the t-score for each class along with the critical t-score. Further, a calculation of the effect size (Cohen's *d*) is given to indicate the magnitude of the change observed. The results indicate that all the individual classes in the intervention group demonstrated significant differences between Test 1 and Test 2, and the effect sizes can be considered large ($ES > 0.8$) (Cohen, 1992). Conversely, only one class from the comparison group demonstrated a statistically significant positive difference and a large effect size (Class ID 24). The effect size of 2.048 is clearly an outlier within the comparison group, with the closest value after that being 0.714. It needs to be noted that this outlier class was taught by the teacher who reported using spelling error analysis data to inform a differentiated teaching approach. Notably, the comparison group also has four classes which see a decline in test scores overtime (Class IDs 16, 22, 28, 29). Overall, the effect sizes for the intervention group range from 0.8453 to 2.146 while the effect sizes for the comparison group range from -0.239 to 2.048.

See next page for Table 3

Table 3. Summary of t-tests indicating significant differences, effect sizes and calculated power, by teacher ID.

Group	Class ID	t-score	ES	Power	Critical t-score	Sig diff	Large ES (>0.8)
Intervention	1	9.559	2.124	1.000	1.734	yes	yes
	2	5.377	1.332	0.999	1.753	yes	yes
	3	6.570	1.293	0.999	1.708	yes	yes
	4	6.419	1.311	0.999	1.714	yes	yes
	5	4.742	1.032	0.998	1.725	yes	yes
	6	7.822	1.842	1.000	1.740	yes	yes
	7	5.880	1.177	0.999	1.711	yes	yes
	8	5.425	1.280	0.999	1.740	yes	yes
	9	8.034	2.146	1.000	1.761	yes	yes
	10	4.774	1.070	0.998	1.729	yes	yes
	11	6.935	1.633	0.999	1.740	yes	yes
	12	4.273	0.854	0.993	1.711	yes	yes
	13	6.403	1.231	0.999	1.706	yes	yes
	14	4.607	1.056	0.997	1.734	yes	yes
Comparison	15	0.507	0.116	0.124	1.734	no	no
	16	0.629	-0.205	0.148	1.833	no	no
	17	2.077	0.452	0.640	1.725	yes	no
	18	3.425	0.031	0.063	1.753	yes	no
	19	2.737	0.589	0.831	1.725	yes	no
	20	2.767	0.714	0.837	1.761	yes	no
	21	1.389	0.338	0.378	1.746	no	no
	22	0.891	-0.239	0.213	1.771	no	no
	23	1.123	0.270	0.280	1.746	no	no
	24	8.500	2.048	1.000	1.729	yes	yes
	25	0.000	0.000	0.050	1.833	no	no
	26	1.995	0.484	0.605	1.746	yes	no
	27	2.012	0.557	0.684	1.753	yes	no
	28	0.138	-0.037	0.065	1.771	no	no
	29	0.910	-0.226	0.217	1.753	no	no
	30	2.158	0.491	0.660	1.734	yes	no
	31	2.535	0.489	0.657	1.734	yes	no

Note. ES = Effect size (Cohen's *d*). Sign in effect size column indicates direction of change over time.

Discussion

This intervention study sought to understand the impact of using spelling error analysis data as a form of assessment to guide the design and delivery of explicit instruction in spelling within mainstream school contexts. A unique feature of the intervention design was the use of a spelling error analysis tool informed by Triple Word Form Theory as the foundation for an explicit approach to teaching phonological, orthographic and morphological components of spelling.

Addressing the pedagogical content knowledge among teachers in the intervention group was a critical fidelity measure for the implementation of the intervention in this study. Resonating with other studies (Daffern & Mackenzie, 2020; Herrington & Macken-Horarik, 2015; Puliatte & Ehri, 2018; Stark et al., 2016), pre-intervention data obtained from the teachers in this study highlighted a need for quality professional learning in spelling. Teaching spelling demands metalinguistic skills (Daffern, 2016), and this includes the ability to accurately model strategies such as blending, segmenting and syllabification. Consistent with other studies conducted in Australian contexts (Adoniou, 2014; Robinson-Kooi & Hammond, 2020b), the survey data also revealed a general absence of explicit teaching. Inadequate linguistic knowledge among the teachers in this study may partly explain why explicit instruction did not appear to be a feature of the 'business-as-usual' pedagogy.

According to the Australian Curriculum: English (Australian Curriculum, Assessment & Reporting Authority (ACARA), 2019), students are expected to develop their spelling skills at each year level of schooling. Hence, it is reasonable to expect some learning to occur in every class involved in the study. However, in the comparison classes, some scores were static or did not significantly improve over time, and four classes demonstrated a decline in performance (Class IDs 16, 22, 28, 29). Contributing factors for these observed declines may relate to potential changes in students' levels of engagement, or changes to their perceptions of what is or isn't valued by their teacher. The survey data for these classes suggest that spelling instruction may not have been a priority. Instruction was either non-existent or not substantive, explicit and informed by error analysis. If students are not afforded frequent opportunities to revise or expand their knowledge of words in a range of contexts, they may start to consider that spelling is no longer important, or they may not remember how to apply certain skills that have been taught by previous teachers (Adelman et al., 2006). As Graham and Santangelo (2014) assert, increased amounts of explicit teaching can make a positive difference to learning outcomes in spelling. Moreover, identifying spelling errors and providing timely and constructive feedback in relation to those errors may prevent the occurrence of repeated errors and subsequent poor spelling habits to manifest over time.

All classes in the intervention group demonstrated statistically significant improvements. One of the fundamental points of difference between the intervention classes and the comparison classes relates to assessment-informed practice. The teachers in the intervention classes were given access to detailed spelling error analysis results. Provision for such detailed diagnostic assessment data enabled the teachers to explicitly teach the subskills of spelling that were relevant to individual student learning needs at the time. This finding is further reinforced by the results of the only class in the comparison group that demonstrated a statistically significant post-hoc improvement (class ID 24). Even though this class was not part of the intervention group, the teacher reported using error analysis to inform an explicit teaching approach. In the intervention classes, explicit instruction occurred three to four times each week and encompassed relevant phonological, orthographic and morphological components. Much like the findings of a recent study involving younger children (Robinson-Kooi & Hammond, 2020b), the findings of the present study demonstrate the impact on student learning when teachers implement explicit and targeted instruction in the phonological, orthographic and morphological aspects of words.

The provision of professional development to the teachers in the intervention group, the availability of the error analysis scores (but not specific item responses) and instructional recommendations prior to the intervention, the explicit nature of the instruction, and the total time spent on spelling activities may have all jointly contributed to the outcomes that were observed in the intervention classes. The only class in the comparison ('business-as-usual') group that did show a statistically significant gain was the class that adopted error analysis to inform a differentiated approach to teaching spelling. While this insight is based on the respective teacher's self-reported claims (Class ID 24), it needs to be interpreted cautiously. Thus, from this study alone, it is not possible to conclude what the active variable/s were that produced the positive outcomes. Nonetheless, the findings shine a light on the promising impact that the combination of these key variables has on student learning outcomes in spelling. The findings suggest that children may learn best (i) if their teachers make conscious use of error analysis data to provide targeted and explicit teaching on a regular basis, and (ii) in situations where teachers are supported through professional development by an expert in the field to ensure they are well-equipped to teach spelling in this way.

Conclusion

Regular classroom teachers are expected to support the varied learning needs of their students. A challenge that a teacher faces is being able to achieve this in a class setting where students' spelling skills are so diverse. Assessment-informed and explicit teaching

approaches may be crucial pedagogic ingredients for yielding positive learning outcomes. The intervention design employed in the present study utilised a multi-tiered, assessment-informed approach to explicit instruction in spelling. The design was embedded in a naturalistic school environment and the teachers in the intervention group were enabled and encouraged to make informed instructional decisions. Implementation of the intervention proved feasible and potentially sustainable in a typical diverse mainstream classroom context. While the present study focussed on students and their teachers in Years 3 to 6 from four schools, the promising findings provide impetus to replicate this study in other contexts and populations including younger students or students with specific learning difficulties. It is beyond the scope of this paper to provide finer-grained details of the CoST, the accompanying instructional recommendations and sample lesson plans; however, these have been published elsewhere (see, for example, Daffern, 2016; Daffern, 2018; Daffern et al., 2020). Each week, the participating teachers in the intervention group referred to their students' respective spelling error analysis data to inform their instructional planning. Students in the intervention group benefited from receiving regular and targeted instruction in phonological, orthographic and morphologic skills. Professional learning and mentoring among the teachers in the intervention group was a necessary inclusion, given the identified gaps in teachers' knowledge. It was not possible to obtain post-intervention survey data from the teachers. Such data could have been helpful in understanding both the effectiveness of the professional learning on teachers' linguistic knowledge and its potential direct contribution to students' learning outcomes. Nonetheless, the findings of this study have also revealed a need for educational leaders in school contexts to carefully consider how classroom teachers can be supported through professional learning in both linguistics and assessment practices so that they are well-equipped to provide sustained effective instruction in spelling.

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Appendix. Summary of the alignment between instructional recommendations and the CoST

Codes	Instructional recommendations: Descriptions	Alignment with number of CoST items (item samples, <>)
P1	Encoding consonant-vowel-consonant words	10 items (<t> in 'tag'; <a> in 'tag' and <g> in 'tag')
P2	Comparing short vs. long vowel phonemes	5 items (<o> in 'rob' as opposed to 'robe')
P3	Encoding consonant blends and digraphs	5 items (<th> in 'thorn')
P4	Encoding polysyllabic words	16 items (<ubstan> in 'substantial')
O1	Encoding graphemes for long /i/ vowel	2 items (<i-e> in 'stripe')
O2	Encoding graphemes for long /a/ vowel	3 items (<a-e> in 'shade')
O3	Encoding graphemes for long /e/ vowel	1 item (<ea> in 'speaker')
O4	Encoding graphemes for long /o/ vowel	1 item (<oa> in 'moat')
O5	Encoding graphemes for /ar/ in medial position of base word	1 item (<ar> in 'marched')
O6	Encoding graphemes for diphthongs: /oy/ and /ow/	2 items (<oi> in 'boil'; <ou> in 'shouted')
O7	Encoding graphemes for /er/ in medial position	1 item (<er> in 'serving')
O8	Encoding graphemes for /ew/	1 item (<ew> in 'grew')
O9	Encoding graphemes for /aw/	1 item (<aw> in 'hawk')
O10	Encoding graphemes for /str/ and /shr/	2 items (<str> in 'stripe' and <shr> in 'shrink')
O11	Encoding graphemes for /n/ in initial position	1 item (kn) in 'knotted')
O12	Encoding consonant trigraphs in final position of base word	2 items (<tch> in 'scratch' and <dge> in 'smudge')
O13	Encoding syllable juncture consonant doublets	5 items (<bb> in 'nibble')
O14	Encoding graphemes for vowel phonemes in unaccented final syllable	5 items (<ar> in 'collar')
M1	Encoding inflected suffixes	7 items (<ed> in 'marched')
M2	Encoding derivational suffixes	8 items (<ible> in 'incredible')
M3	Encoding morpheme juncture schwas	5 items (<o> in 'opposition')
M4	Encoding homophones	7 items (<ssel> in 'mussel')
M5	Encoding Greek & Latin root words	7 items (<medic> in 'medicinal')
M6	Encoding assimilated prefixes	7 items (<ir> in 'irrelevant')

Note. <> indicates alphabetic letters