



Advancing teachers' linguistic knowledge through a large-scale professional learning and development initiative

Gail Gillon¹ · Brigid McNeill¹ · Amy Scott¹ · Megan Gath¹ · Lisa Furlong¹

Received: 16 September 2025 / Accepted: 12 June 2026
© The Author(s) 2026

Abstract

This study investigated the enhancement of teachers' linguistic knowledge, skills, pedagogy, and self-rated ability within a large-scale implementation of early literacy instruction in New Zealand. Data were collected from pre- and post-learning surveys from 592 educators enrolled in online professional learning and development (PLD). Linguistic knowledge scores across phonics, phonological awareness, and morphology increased from 56–70% correct prior to PLD to 81–89% after PLD. Mixed-effects models examining predictors of change in knowledge and self-rated ability indicated that educators with lower levels of linguistic knowledge and lower self-rated ability made the most growth from pre-test to post-test. Further, self-rated ability increased more for less experienced educators. Online PLD with the practical application of linguistic knowledge and skills may be a useful strategy to enhance teachers' linguistic knowledge at scale and within regular teaching contexts.

Keywords Linguistic knowledge · Professional learning and development · Teacher knowledge · Structured literacy

✉ Gail Gillon
gail.gillon@canterbury.ac.nz

✉ Megan Gath
megan.gath@canterbury.ac.nz

Brigid McNeill
brigid.mcneill@canterbury.ac.nz

Amy Scott
amy.scott@canterbury.ac.nz

Lisa Furlong
lisa.furlong@canterbury.ac.nz

¹ University of Canterbury, Christchurch, New Zealand

Introduction

Implementation of effective early literacy instruction requires teachers to possess strong knowledge of the linguistic structures that underpin reading and writing development. Teachers' understanding of oral language, phonology, orthography, and morphology supports their ability to provide explicit instruction in foundational literacy skills and to accurately interpret children's reading, spelling and writing attempts. However, research across several countries has shown substantial variability in teachers' linguistic knowledge and suggests that many educators may not receive sufficient preparation to support evidence-based literacy instruction (Moats, 2020; Stark et al., 2016). As education systems increasingly adopt structured literacy approaches within Multi-Tiered Systems of Support (MTSS) frameworks (Fien et al., 2021), strengthening teachers' linguistic knowledge through professional learning and development (PLD) has become a priority.

Surveys of teachers' linguistic knowledge of the English language indicate wide performance variability. Teachers may demonstrate strong phonics knowledge (e.g., short and long vowel identification in words) (Mahar & Richdale, 2008), but show considerable variability in their phoneme and morphological awareness (Carroll et al., 2012; Goldfeld et al., 2021; Mahar & Richdale, 2008). Self-rated ability to teach phonics and phonemic awareness in particular, may not always correlate with teachers' actual knowledge and skills in these areas (Fielding-Barnsley & Purdie, 2005; Stark et al., 2016). Teachers' self-reported confidence in their personal linguistic knowledge may also be low (Stark et al., 2016). Those teachers reporting higher levels of confidence in their linguistic knowledge most commonly attribute this to PLD or classroom experience, rather than their initial teacher education programmes (Stark et al., 2016). There is a need then to examine how large-scale implementation of PLD focused on effective literacy teaching helps develop teachers' confidence and competence in their explicit linguistic knowledge. This study examines factors that influence the advancement of teachers' linguistic knowledge as they engage in a nationwide implementation of a structured early literacy teaching approach, referred to as the Better Start Literacy Approach (Gillon et al., 2023, 2024). This approach is set within a MTSS framework and is being implemented in junior school classrooms across New Zealand. This study is within the context of a new Government initiative within New Zealand. The Government has mandated that all children in state-funded schools will be taught to read using a "structured literacy"¹ approach and that teachers will regularly monitor children's growing phonological knowledge through phonics checks. In addition, the New Zealand Government has mandated that children who require additional reading support will be provided with evidence-based interventions utilising structured literacy approaches. The successful implementation of these mandates will require teachers to have strong linguistic knowledge and the ability to use this knowledge effectively in the teaching of reading and writing.

¹ The New Zealand Ministry of Education (2025) defines structured literacy as an evidence-based, explicit, systematic, and cumulative approach to literacy instruction. It focuses on teaching essential components directly, including oral language, phonemic awareness, synthetic phonics, handwriting, vocabulary, morphology, syntax, fluency, and comprehension.

Importance of teachers' linguistic knowledge

It is generally acknowledged that teachers' linguistic knowledge and the quality of their instruction is fundamental to children's reading success (Goldfeld et al., 2021). Within a broader conceptual framework, teachers' linguistic knowledge can be understood as a foundational component of effective literacy instruction within cognitive-linguistic models of reading development. The Simple View of Reading (Hoover & Tunmer, 2018), alongside related frameworks such as the Reading is Language model (Snowling & Hulme, 2025), highlight the central role of code-based skills (e.g., phonics, phonological awareness, and morphology) and the importance of oral language skills to reading development. Years of accumulated research findings have demonstrated the benefits of explicit and structured teaching instruction to advance children's phonics (phoneme-grapheme) knowledge, phoneme awareness, morphological awareness and orthographic knowledge to the development of word recognition and spelling skills (for recent discussions see Dilgard et al., 2022; Duncan, 2018; Ehri, 2020; Galuschka et al., 2020; Gillon, 2017; Torgerson et al., 2019; R. Treiman, 2017) as well as the development of other oral language skills for reading comprehension (Hjetland et al., 2020; Hoover & Tunmer, 2018; Nation & Snowling, 2004). Within the context of this significant body of research, teachers' linguistic knowledge may be seen as underpinning their ability to deliver explicit, accurate, and responsive literacy instruction (Moats, 2009, 2020). Professional learning and development (PLD) can be conceptualised as a mechanism through which teachers' linguistic knowledge is enhanced, thereby strengthening their literacy instructional capacity.

Variation in teachers' linguistic knowledge may be associated with differences in instructional practices and, in some cases, student outcomes. For example, Puliatte and Ehri (2018) examined the relationship between second- and third-grade teachers' linguistic knowledge, their spelling instruction, and students' spelling achievement. Teachers demonstrated strong knowledge of syllables ($M=91\%$ accuracy) but weaker knowledge of phonemes ($M=57\%$) and morphology ($M=33\%$). Higher levels of teacher linguistic knowledge were associated with greater use of linguistic-based instructional strategies and more frequent assessment of students' phoneme and morphological awareness. For weaker spellers in particular, students' spelling gains were significantly related to teachers' phoneme awareness, explaining 31% of the variance in students' improvement.

Similarly, in Piasta et al. (2009) an investigation of first-grade teachers' linguistic knowledge in Florida, USA, showed substantial performance variability. Teachers answered on average 52% of questions correctly on a linguistic knowledge survey. They demonstrated stronger knowledge of phonics and onset-rime units in words but showed weaker understanding of phonemes and syllable types. Analyses indicated that explicit word decoding instruction was most effective when teachers possessed stronger linguistic knowledge. In contrast, when teachers had weaker linguistic knowledge, increased time spent on word decoding instruction was associated with poorer student outcomes, possibly reflecting the use of inaccurate modelling and feedback strategies.

These studies highlight the importance of teachers' linguistic knowledge not only for selecting effective instructional strategies, but also for delivering them accurately. They underscore the need for professional learning that develops both teachers' linguistic knowledge and their capacity to apply this knowledge within evidence-based literacy instruction.

Professional learning and development within large-scale implementation

Quality teacher PLD is an essential element of supporting teachers to enhance or change their current literacy teaching practices. Recent metaanalyses suggest that in general, teacher PLD in language and literacy has a moderate positive effect on students' reading achievement (Didion et al., 2020). Quality teacher PLD (e.g., inclusive of in-class coaching and teacher reflective practices) of relatively short duration (e.g., 30 h or less) is associated with improvements in students' reading (Basma & Savage, 2018). However, there is wide variability in the types of PLD in literacy teaching offered to teachers and continued research in this field is necessary (Basma & Savage, 2018; Didion et al., 2020).

The importance for teachers to receive quality PLD in relation to teaching literacy within MTSS frameworks, particularly in supporting struggling readers and children with dyslexia, has been identified (Al Otaiba et al., 2019; Catts et al., 2015). Teaching within MTSS frameworks typically involves teachers providing evidence-based instruction at Tier 1 (universal or class level teaching), Tier 2 (supplementary small group instruction for learners who require additional support), and Tier 3 (individualised support for children with complex learning challenges). Effective reading and spelling instruction within each of these tiers of support draws upon teachers' linguistic knowledge. A key feature of MTSS frameworks is the careful monitoring of children's progress to differentiate learners' needs, guide next steps for teaching and identify children who require Tier 2 or Tier 3 support (Fien et al., 2021). Such monitoring will engage teachers in analysing children's growth in phonic, phoneme awareness and morphological knowledge, the transfer of this knowledge to their reading and spelling (e.g., via analysis of nonword reading and spelling attempts), analysing children's vocabulary growth and oral narrative abilities, analysing children's attempts at reading and spelling words within connected reading and writing contexts and analysing children's listening comprehension skills. All these types of analyses and data interpretation will draw upon teachers' personal linguistic knowledge. Surprisingly, few studies have examined the impact of PLD to advance teachers' linguistic knowledge with the context of large-scale implementation of early literacy initiatives within MTSS frameworks.

Previous studies have shown that relatively short periods (e.g., 6–7 h) of targeted linguistic knowledge course work can significantly enhance linguistic knowledge for pre-service teachers (Purvis et al., 2016) and in-service teachers (Spear-Swerling & Brucker, 2003). It was noted however, that more intensive teaching may be necessary for some teachers to enhance their knowledge of word structure (Spear-Swerling & Brucker, 2003). A randomised controlled trial has also indicated the effectiveness of four days of face-to-face PLD, in combination with in-school support on enhancing teachers' linguistic knowledge, including their knowledge of oral language con-

structs (Goldfeld et al., 2021). Effective methods, however, for large-scale upskilling of teachers' personal linguistic knowledge within regular education teaching contexts have received little research attention.

In one of the few studies to consider the effectiveness of literacy PLD in large-scale, real world settings, Piasta et al. (2017) examined the development of early childhood educators' knowledge, beliefs and practices in relation to language and literacy teaching. This was a state sponsored programme within the USA where PLD contract providers (early language and literacy specialists) designed and implemented the PLD. Teachers ($n=533$; mostly lead teachers) of children aged 3–5 years participated in the study. They were assigned to differing PLD delivery models (language and literacy PLD with and without coaching, or an alternative curriculum PLD). The PLD involved 30 h of participation in a workshop-style format over one year. The coaching added 4–6 h per month. Outcome measures included teachers' language and literacy disciplinary knowledge, and linguistic skills, such as their ability to identify syllables and phonemes in words.

Data analyses revealed no significant effects from the language and literacy PLD with or without coaching on the teachers' knowledge, or indeed on any of the outcome measures. Although there were main effects for teacher characteristics (teachers with higher level qualifications generally showed stronger knowledge), there was no interaction with the type of PLD they received. Overall data suggested minimal growth over the 18-month period of the study. The authors offered several hypotheses for lack of outcomes including the PLD being too broad based, insufficient connection between the PLD to class practice, and insufficient exposure to targeted coaching related to PLD (i.e., the aim of 4–6 h per month was not reached). The study highlighted the need for continued efforts and research into large-scale implementation of literacy PLD for teachers in regular class settings.

With the advancement in developed countries of the availability of high-quality internet access, both within schools and homes, the opportunities for online learning to develop teachers' linguistic knowledge within large-scale initiatives is feasible. In addition, due to the COVID-19 pandemic school closures, teachers are likely to have increased confidence in using online learning platforms and attending online workshops and webinars, although there are still barriers to overcome (Haleem et al., 2022; Winter et al., 2021). Understanding how teachers' familiarity with learning online can best be leveraged for PLD in early literacy is an important area for research.

Donovan et al. (2022) recently compared the effectiveness of online learning and in-person learning for improving teacher knowledge of early reading concepts. Participants in their study were 102 teachers from grades k-5 in two school districts in Southern USA who were assigned to differing learning contexts or a wait control group. The same high-quality PLD based on scientific evidence of effective reading strategies was presented for both the in-person context (30 h over five days with literacy experts) and online context (with a variety of learning strategies including quizzes, lectures, videos, and interactive activities). Online participants had four weeks to complete the course. Content covered a range of areas related to theoretical frameworks based on research evidence (e.g., the Simple View of Reading) and effective teaching strategies to support children's word recognition and reading com-

prehension abilities. Pre- and post-test teacher knowledge via a survey was assessed in the areas of phonology, word decoding, spelling, reading fluency, morphology, vocabulary, and comprehension. Data analyses indicated both in-person and online PLD significantly improved teacher knowledge outcomes compared to a wait control comparison group. In-person had some advantage over online learning but the effect size between these two conditions was smaller than for the difference between the PLD wait groups and the control group. There was no difference in teachers' reported satisfaction of the course between online and in-person, although it was noted a few participants withdrew from the online course stating workload as an issue. Given the scalability of the online learning context and reach to teachers in rural and remote areas, further research into advancing the effectiveness of online PLD for early literacy instruction is a worthwhile pursuit.

This current study extends previous research through investigating one area of teacher PLD, namely teachers' growth in personal linguistic knowledge, in response to online PLD learning, as part of a large-scale early literacy implementation project. The course was part of a large-scale PLD package implemented in over 1000 schools across New Zealand. The aim of the PLD was to support class teachers and literacy specialists' teaching of 5–7-year-old children's early literacy skills within a MTSS framework. In this study, our key objectives were to examine:

- (1) How teachers' personal linguistic knowledge in the areas of phonics, phonological awareness, and morphological knowledge advance when they participate in a self-paced online, micro-credential university course, and
- (2) Whether improvements in linguistic knowledge and self-rated ability hold across individuals and different contextual factors.

Method

Participants were enrolled for one-year in a self-paced online micro-credential course to support the implementation of Tier 1 and Tier 2 quality literacy teaching through the Better Start Literacy Approach (BSLA; Gillon et al., 2019, 2023, 2024). The BSLA is set within a MTSS framework and provides teachers with structured lesson plans to enhance children's phonic, phonological awareness, reading, writing, oral narrative and listening comprehension skills in English (see Gillon et al., 2023 for more information). Within BSLA for the junior school years, the Tier 1 (class level) daily lesson plans have four teaching components: 1. Explicit teaching of vocabulary, listening comprehension, story structure elements, and story retelling skills using a quality children's story book. 2. Explicit and structured teaching of phoneme awareness (Ph), orthographic knowledge (O) and morphological awareness (M) (PhOM skills) following a scope and sequence. 3. Structured teaching activities to support children transfer their PhOM skills to word reading and spelling; and 4. Small group reading instruction using a decodable text reading series developed to reflect the New Zealand cultural context. The BSLA Tier 2 manualised lesson plans provide more intensive small group teaching of PhOM skills, use of these skills in word reading and spelling and reading instruction using the decodable reading series. As part

of the micro-credential course teachers accessed high-quality online PLD in both synchronous and asynchronous forms. The PLD focused on supporting teachers to implement Tier 1 lessons with fidelity, monitor and analyse students' responses to Tier 1 teaching, and identify students for Tier 2 teaching. There was also the option for teachers to engage in more in-depth PLD focused on implementation of small group Tier 2 lesson plans and monitoring and analysing students' response to Tier 2 teaching.

The online learning content was modularised and was designed specifically for the New Zealand cultural context. Participants first worked through a theoretical frameworks and linguistic knowledge module before progressing to course content focused on assessment and teaching practice. The linguistic knowledge module required teachers to work through a series of 10–15-min interactive videos as well as engaging with written content. Focus areas included: phonology, morphology, parts of speech, orthography including spelling patterns and linguistic knowledge underpinning reading comprehension teaching strategies. A pronunciation guide for New Zealand English (NZE, Hay et al., 2008) phonemes was provided and consideration of variations in English discussed (particularly within the context of supporting learners less familiar with NZE or English Language Learners). To supplement the self-paced learning content, teachers also attended weekly one-hour Zoom sessions with an expert team. These zoom sessions highlighted relevant content from the online course as it related to their implementation of the approach and were held during the first 10 weeks of the teachers' PLD course. In-school or across-school literacy specialists (who had received PLD in the BSLA teaching approach) supported teachers in their assessment and teaching implementation. To successfully complete the micro-credential course teachers were required to pass an assessment (online quiz) directly related to the linguistic knowledge learning content. Teachers were encouraged to complete this assessment prior to engaging in further PLD learning modules. Teachers could re-take the quiz (with alternative versions provided) as often as necessary.

Following controlled research trials indicating the effectiveness of the BSLA (Gillon et al., 2019, 2023), the New Zealand Ministry of Education funded teachers across New Zealand to engage in PLD to implement the approach. Between 2021 and 2023, over 3500 teachers engaged in the BSLA micro-credential across six intakes, or "cohorts" of educators. The current study examines the linguistic knowledge of a subset of these teachers. Data on educators' linguistic knowledge was collected starting with the fourth cohort of educators. Educators were only included in our analysis subset if they had provided informed consent for their linguistic survey data to be used for research purposes, and if they completed both the pre- and post-linguistic knowledge-survey. (This was optional within the PLD funded model). Data from 592 class teachers and literacy specialists were included in the analyses.

Participants

Of the 592 participants in this study, 485 identified as class teachers. These teachers were mostly female (97.3%) and taught in schools across all 16 regional council areas of New Zealand. Half of these teachers (47.4%) gained their qualification in primary teaching more than 15 years ago. Most teachers reported that they had been teaching

junior level students (students in Years 0–2; aged 5–7 years) for 10 or fewer years (72.6%).

The remaining participants were literacy specialists ($n = 107$). They were qualified teachers who had a specific role in supporting class teachers with literacy instruction and/or in supporting children with literacy learning difficulties. These literacy specialists were also mostly female (99%) and were from 15 of New Zealand's 16 regions. Most literacy specialists (60%) gained their qualification in primary teaching more than 20 years ago, with only a small number reporting gaining their qualification in the last 10 years (9%). Within the group of literacy specialists, 56% had a postgraduate qualification (in addition to their teaching qualification) in an area relevant to literacy.

Survey tool

Given the complex and multifaceted nature of reading, and the knowledge and skills required to teach reading, there is much debate as to what a survey of teacher knowledge and skills should focus on. Areas of focus could include linguistic knowledge, knowledge of reading comprehension instruction, familiarity with children's literature (Reutzel et al., 2011), Response to Teaching procedures (Al Otaiba et al., 2019; Spear-Swerling & Cheesman, 2012) and dyslexia and learning difficulties (e.g., Washburn et al., 2011a, 2011b). For the reasons previously described, the survey used in the current study focused on the code-based constructs of reading. There are several existing survey tools that evaluate teachers' linguistic knowledge across both code- and meaning-based constructs (Davis et al., 2022; Hall et al., 2024; Stark et al., 2016) which have been used primarily in cross-sectional studies (e.g., Binks-Cantrell et al., 2012; Davis et al., 2022; Stark et al., 2016) and with samples that differ from the current study, such as teacher educators and pre-service teachers (Binks-Cantrell et al., 2012).

In the current study we sought to evaluate change in practising teachers' knowledge, skills, and pedagogy in relation to online PLD; therefore, we custom-designed a survey focused on the code-based constructs of reading, aligned to the PLD content delivered to teachers and to the BSLA approach. Survey development was primarily guided by the earlier surveys of Binks-Cantrell et al. (2012) and Stark et al. (2016). The survey for the current study adopted the framework used by Stark et al. (2016) in their study exploring Australian teachers' knowledge and self-rated ability of language and reading instruction in the early years. This framework organises survey items according to aspect (e.g., phonics, phonological awareness, morphology) and domain, being *knowledge* (explicit knowledge of definitions for linguistic terms or concepts), *skill* (actual ability to perform a linguistic task, e.g., counting phonemes in words) and *pedagogy* (the practice associated with teaching a construct or concept). Pedagogy is a domain which has not been used in earlier studies but was added by Stark et al. (2016) with the rationale that teachers must possess specialised knowledge to teach these foundational constructs and skills. Within this framework, seventeen items were adopted from Stark et al. (2016), of which ten also appeared in the earlier Binks-Cantrell et al. (2012) survey. A further four items were developed by the research team to provide coverage of key concepts and skills taught as part of the

PLD and within the BSLA approach. These four items are marked with an asterisk in the survey provided in Appendix A.

The final survey included seven knowledge-based questions (e.g., *A phoneme is...*), 25 skill-based questions (e.g., How many speech sounds are in *chop*?) and three pedagogy-based questions (e.g., Which of the following is a phoneme awareness activity?) across three aspects (phonics, phonological awareness, and morphology). The survey was reviewed by five academics across New Zealand and Australia with expertise in literacy. These academics were given the survey draft and were asked to provide feedback primarily in relation to representation of the three aspects (phonics, phonological awareness, morphology) and alignment of these aspects to the PLD and BSLA approach. The survey was then piloted with three experienced class teachers who provided feedback relating to survey length, number and distribution of survey questions, question wording and survey navigation. These class teachers each indicated that the survey took no more than 15 min to complete. Parallel forms were developed for pre- and post-learning surveys. Questions relating to definitions of terms were the same in both surveys, but differing word examples (with the same phonological or morphological structure) were given for the skills and pedagogy questions. For example, identifying the number of phonemes in the word 'brush' in the pre-survey versus 'crash' in the post-survey. The survey questions used in the analyses for this paper for the pre-learning survey are provided in Appendix A.

The 35 survey items were each scored as 1=correct or 0=incorrect. Internal consistency was calculated for each domain and aspect subscale using Cronbach's alpha. When the items are organised into domains, internal consistency was found to be acceptable for the 20 phonological awareness items ($\alpha=0.74$) and the 9 morphology items ($\alpha=0.83$). However, consistency of the 6 phonics items was low ($\alpha=0.53$). When the items are organised into aspects, internal consistency was acceptable for the 25 skill items ($\alpha=0.79$) but low for the 7 knowledge items ($\alpha=0.46$) and the 3 pedagogy items ($\alpha=0.44$). Thus, the results for some of the subscales should be interpreted with caution; however, given Cronbach's alpha is dependent on the number of scale items (and would be expected to be low for subscales with few items), we proceeded with our analyses. Cronbach's alpha across all 35 survey items was 0.85. Total accuracy scores were calculated as the percentage correct of all knowledge, skill and pedagogy items across the three aspects out of the possible 35 points.

Self-rated ability

Teachers also self-rated their ability across seven areas: phonics, phoneme awareness, reading fluency, vocabulary, reading comprehension, spelling, and using assessment to inform their reading and spelling instruction. These items are the same as those used by Stark et al. (2016). Each self-rated ability item was rated on a scale from 1=Minimal to 4=Expert. The seven self-rated ability items showed high internal consistency (Cronbach's $\alpha=0.88$; item-total correlations range .63–.73). A total score was created to reflect overall self-rated ability as the mean of the seven ratings.

Procedures

This project was approved by the University of Canterbury Human Ethics Committee (HREC 2021–98). As part of their BSLA micro-credential course, teachers and literacy specialists completed this online survey at two timepoints: (1) immediately prior to beginning their micro-credential and (2) after completion of the micro-credential course requirements (typically 6–9 months after completing the pre-learning survey). Prior to beginning each survey, respondents were asked whether they consented to having their responses used for research purposes. Responses were only included in analysis where consent was provided. At the beginning of the pre- and post-learning surveys, teachers were asked to create a 6-character code so that their pre- and post-learning surveys could be matched for research purposes. Survey questions were presented in a set order to avoid differences in responses due to random ordering effects (Schofield & Forrester-Knauss, 2016). Survey data were only included in comparisons over time where pre- and post- data could be linked, to ensure we were comparing the same group of teachers over time.

Statistical methods

Data from three cohorts of educators (collected in July 2022 through December 2023; $n=592$) was used for analysis. Two sets of analyses were undertaken, as outlined below.

Longitudinal change in domains of accuracy and self-rated ability

We first compared data at pre-learning and at post-learning to measure individual change in the subdomains of accuracy and self-rated ability in response to completing the BSLA PLD. When examining change in accuracy from pre-learning to post-learning, we used paired-samples *t*-tests. Effect sizes for these tests are calculated using Cohen's *d* with the standard deviation of the mean difference as the standardizer (Lakens, 2013). We utilise the *d* effect size to interpret the magnitude of effects, using the following thresholds: small effect $d=0.2$; medium effect $d=0.5$; large effect $d=0.8$ (Cohen, 1988).

Given that self-rated ability items were scored on an ordinal scale, we have described change from pre-learning to post-learning through a descriptive analysis of the percentage of educators who responded with each level of self-rated ability. We also used Pearson correlation coefficients to determine the association between total accuracy and total self-rated ability at pre-learning and post-learning.

Change in accuracy and self-rated ability across individual and contextual factors

Next, we used linear mixed-effects models to examine whether improvements in linguistic knowledge and self-rated ability hold across individuals and different contextual factors. In this analysis we used total accuracy scores and total self-rated ability (each combined across subdomains), and we examined the following set of predic-

tors: educatory type (class teacher or literacy specialist), education level (i.e. additional qualifications to their initial teacher qualification relevant for literacy teaching: 0=no additional education qualification; 1=an additional bachelor's degree or diploma in area relevant to education/teaching/literacy; 2=an additional master's degree in area relevant to education/teaching/ literacy), experience teaching junior students (i.e. children in their first 3 years of formal schooling); 6 levels ranging from 0–2 years of junior school teaching experience though to more than 20 years' experience), baseline self-rated ability (total scores), baseline accuracy scores (total scores), and urbanicity. Urbanicity was identified based on the Regional Council area where educators resided. We used the Stats NZ Urban Rural Indicator classification (Stats, 2018), which categories small geographic areas into: Major urban areas (5), Large urban areas (4), Medium urban areas (3), Small urban areas (2), or Rural Settlements (1). We calculated the mean level of urbanicity in each region to include in our model.

Changes in accuracy and self-rated ability over time were examined using linear mixed-effects models estimated with restricted maximum likelihood (REML) in SAS PROC MIXED. Repeated observations (Level 1) were nested within individuals (Level 2), and a random intercept was included to account for within-person correlation across time. Time was modelled as a continuous variable, such that model coefficients represent the average rate of change in accuracy or self-rated ability over time.

Fixed effects included demographic characteristics (educator type, education level, teaching experience, and urbanicity), cohort, and baseline scores (either accuracy or self-rated ability). To assess whether these variables were associated with differential change over time, interactions between time and each predictor were included (i.e., predictor $\times$ time terms).

Baseline scores were included as a covariate to account for initial differences in scores, and its interaction with time was used to examine whether initial status predicted subsequent change. This approach allowed us to distinguish predictors of baseline accuracy and self-rated ability from predictors of growth over time. Model parameters were estimated using REML, and statistical significance was evaluated at $\alpha=0.05$. To quantify model fit, marginal and conditional R^2 values were calculated following Nakagawa and Schielzeth (2013). The marginal R^2 represents the proportion of variance explained by the fixed effects alone, while the conditional R^2 represents the proportion explained by the fixed and random effects combined.

Results

Change in knowledge, skill and pedagogy in response to PLD training

Table 1 provides the mean accuracy scores on all survey items pre- and post-learning by domain and aspect. Participants' accuracy scores increased across all domains and aspects in response to the online PLD. The total average accuracy score across all 35 items improved from 66.3% correct at the pre-learning point, to 82.1% correct at the post-learning survey point.

Table 1 Participants' total accuracy scores pre- and post-learning by aspect and domain

	Mean percentage correct (SD) from survey items			
	Knowledge	Skill	Pedagogy	Aspect total
Phonics				
Pre-learning	58.5% (37.6)	55.4% (23.9)	45.7% (49.9)	56.4% (23.3)
Post-learning	82.5% (25.1)	82.0% (20.9)	96.6% (18.1)	82.1% (17.4)
	$p<0.001$; $d=0.58$	$p<0.001$; $d=0.88$	$p<0.001$; $d=0.99$	
Phonological awareness				
Pre-learning	65.8% (29.1)	74.3% (14.6)	46.9% (50.0)	70.2% (14.7)
Post-learning	81.9% (22.2)	80.4% (11.8)	69.7% (46.0)	80.8% (11.7)
	$p<0.001$; $d=0.49$	$p<0.001$; $d=0.39$	$p=0.007$; $d=0.37$	
Morphology				
Pre-learning	69.1% (40.0)	65.1% (34.3)	70.4% (45.7)	66.6% (30.0)
Post-learning	92.0% (21.8)	86.6% (25.7)	95.5% (20.8)	88.8% (19.5)
	$p<0.001$; $d=0.53$	$p<0.001$; $d=0.53$	$p<0.001$; $d=0.52$	
Domain total				
Pre-learning	64.1% (26.4)	68.5% (15.9)	54.1% (30.8)	66.3% (16.5)
Post-learning	83.8% (17.1)	81.2% (14.4)	86.8% (20.1)	82.1% (13.7)

Paired samples *t*-tests indicated significant change from pre-learning to post-learning across all phonics, phonological awareness, and morphology domains (see Table 1). Effect sizes were medium to large (range 0.37–0.99) across all knowledge, skill, and pedagogy domains. Overall, educators' phonics scores increased by 25.7% from the pre- to post-learning survey, their phonological awareness scores increased by 10.6% from pre- to post-learning survey,

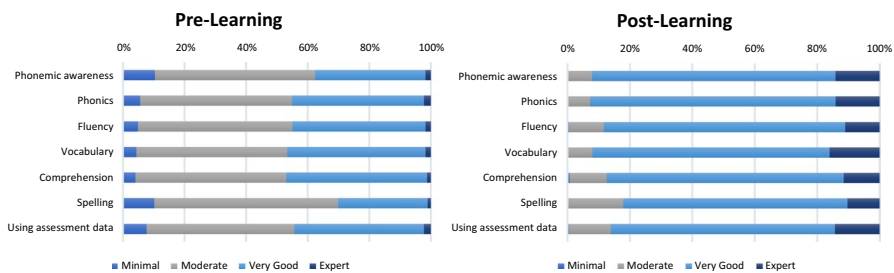
and their morphology scores increased by 22.2% from the pre- to post-learning survey.

Change in self-rated ability

Table 2 and Fig. 1 provide self-rated ability values pre- and post-learning and show a shift in the distribution of ratings between surveys. Most teachers (approximately three quarters) rated their ability to support early literacy learning as "Very Good" following completion of the PLD (compared to less than half prior to the PLD). Further, less than 1% rated their ability as "Minimal" following completion of the PLD.

Table 2 Self-rated ability pre- and post-learning

	Pre-learning (n = 592)				Post-learning (n = 592)			
	Minimal (%)	Moderate (%)	Very good (%)	Expert (%)	Minimal (%)	Moderate (%)	Very good (%)	Expert (%)
Teaching phonemic awareness	10.4	52.0	35.8	1.7	0.2	7.7	78.0	14.1
Teaching phonics	5.6	49.3	42.8	2.2	0.2	7.1	78.7	14.1
Teaching reading fluency	4.9	50.2	43.2	1.7	0.5	11.2	77.3	11.0
Teaching vocabulary	4.4	49.0	44.9	1.7	0.3	7.7	75.9	16.0
Teaching comprehension	4.1	49.0	45.7	1.2	0.7	11.9	75.9	11.5
Teaching spelling	10.2	59.7	29.0	1.0	0.3	17.6	71.8	10.3
Using assessment data to inform reading and spelling instruction	7.7	48.0	42.2	2.2	0.5	13.4	71.8	14.3

**Fig. 1** Distribution of self-rated ability pre- and post-learning

Association between self-rated ability and accuracy

There was a small positive correlation between total accuracy scores and self-rated ability at both the pre-learning survey ($r = .28$, $p < .001$) and post-learning survey ($r = .21$, $p < .001$). Further, there was also a small positive correlation between the change in self-rated ability and the change in accuracy scores from pre-learning to post-learning ($r = .13$, $p = .002$).

Change in accuracy and self-rated ability across individual and contextual factors

Our second research objective was to determine whether improvements in linguistic knowledge and self-rated ability hold across individuals and different contextual factors, again using our longitudinal sample of 592 educators. In this analysis we examined the following set of predictors: educatory type, education level, experience teaching junior students, baseline teaching self-rated ability (total scores), baseline accuracy scores (total scores), urbanicity, time (pre vs post), and cohort.

Mixed-effects models were run to predict each of accuracy and self-rated ability from our set of predictors as well as their interactions with time, while including a random effect for individual educators. The results for fixed effects within the models are presented in Table 3 for accuracy and Table 4 for self-rated ability. For accuracy, the marginal R^2 , representing variance explained by the fixed effects alone, was 0.32.

Table 3 Fixed effects results from mixed effect model predicting accuracy

Outcome: total accuracy scores			
Predictor	Estimate (SE)	<i>t</i> -value	<i>p</i> -value
Time (Pre vs Post)	0.66 (0.03)	20.47	<0.001
Educator type	−0.03 (0.02)	−1.04	0.30
Education level	−0.00 (0.01)	−0.13	0.90
Teaching experience	−0.00 (0.02)	−1.00	0.32
Urbanicity	0.00 (0.02)	0.10	0.92
Baseline accuracy	1.79 (0.05)	33.02	<0.001
Cohort 2 ¹	−0.03 (0.03)	−1.14	0.26
Cohort 3 ¹	−0.01 (0.02)	−0.31	0.76
<i>Time x</i> educator type	0.03 (0.02)	1.62	0.11
<i>Time x</i> education level	0.00 (0.01)	0.20	0.84
<i>Time x</i> teaching experience	0.01 (0.00)	1.57	0.12
<i>Time x</i> urbanicity	−0.00 (0.01)	−0.15	0.88
<i>Time x</i> baseline accuracy	−0.79 (0.03)	−22.99	<0.001
<i>Time x</i> cohort 2 ¹	0.03 (0.02)	1.79	0.07
<i>Time x</i> cohort 3 ¹	0.01 (0.01)	0.48	0.63

¹Cohort 1 served as the reference category

Table 4 Fixed effects results from mixed effect model predicting self-rated ability

Outcome: self-rated ability			
Predictor	Estimate (SE)	<i>t</i> -value	<i>p</i> -value
Time (Pre vs Post)	2.44 (0.10)	23.82	<.001
Educator type	−0.06 (0.07)	−0.88	0.38
Education level	−0.03 (0.03)	−0.92	0.36
Teaching experience	−0.02 (0.02)	−1.34	0.18
Urbanicity	−0.01 (0.06)	−0.14	0.89
Baseline self-rated ability	1.81 (0.06)	32.57	<0.001
Cohort 2 ¹	−0.02 (0.07)	−0.27	0.79
Cohort 3 ¹	−0.00 (0.06)	−0.07	0.94
<i>Time x</i> educator type	0.06 (0.04)	1.38	0.17
<i>Time x</i> education level	0.03 (0.02)	1.45	0.15
<i>Time x</i> teaching experience	0.02 (0.01)	2.11	0.04
<i>Time x</i> urbanicity	0.01 (0.04)	0.22	0.82
<i>Time x</i> baseline self-rated ability	−0.81 (0.04)	−22.93	<0.001
<i>Time x</i> Cohort 2 ¹	0.02 (0.04)	0.43	0.67
<i>Time x</i> Cohort 3 ¹	0.00 (0.04)	0.12	0.91

¹Cohort 1 served as the reference category

The conditional R^2 , representing variance explained by both fixed and random effects was 0.57. Thus, approximately 32% of the variation in accuracy was explained by fixed effects, with an additional 26% explained by subject-specific random effects. As seen in Table 3, when predicting total accuracy scores, there was a significant effect of time, with educators scoring significantly higher at post-learning than at pre-learning. There was also a significant time $\times$ baseline interaction, indicating that educators who started out with lower accuracy showed a higher rate of growth from pre-learning to post-learning. Figure 2 plots the simple slopes of accuracy at pre-learning and post-learning for educators at three levels of baseline accuracy (−1 SD, mean, and +1 SD).

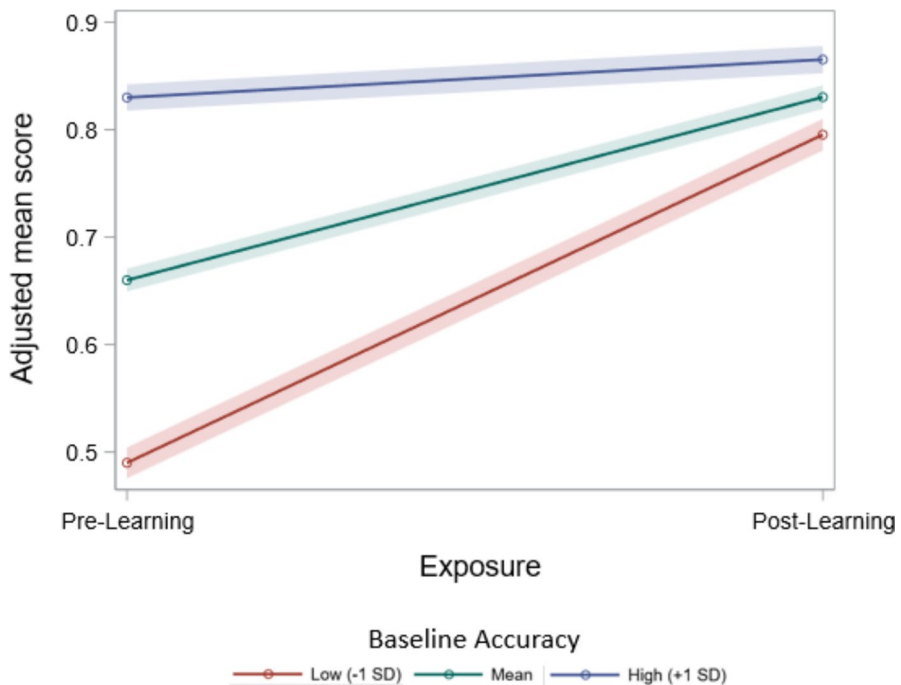


Fig. 2 Accuracy scores at pre-learning and post-learning based on baseline levels of accuracy

In the model predicting self-rated ability, fixed effects explained approximately 75% of the total variance. Random effects accounted for an additional 9% of the variance, while 15% remained unexplained. Table 4 presented the results for fixed effects for self-rated ability. Educators scored significantly higher at post-learning than at pre-learning and there was a significant time $\times$ baseline interaction, such that those who started out with lower self-rated ability showing significantly more improvement in their self-rated ability. In addition, there was a significant time $\times$ experience interaction. Educators with lower level of teaching experience showed more change in their self-rated ability from pre-learning to post-learning.

Tables 3 and 4 show that growth from pre-learning to post-learning did not differ based on type of educator (teacher vs literacy specialist), education level, or urbanicity. In addition, there were no differences in the amount of growth observed within each cohort of educators.

Figure 3 plots total accuracy scores for educators with and without PLD training at each data collection point across the three cohorts of educators included in analysis. The figure shows that those with PLD training are, as a group, scoring higher than those without PLD training (significant effect of time) and that there are no differences in growth between cohorts.

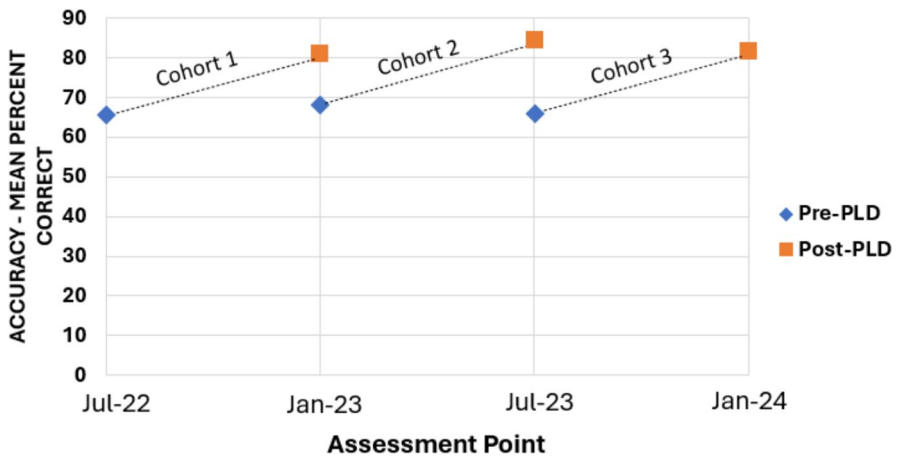


Fig. 3 Total accuracy scores for educators with and without PLD training by cohort

Discussion

Large-scale implementation of teacher professional learning and development (PLD) to support effective early literacy teaching practice is essential to address global literacy challenges. In New Zealand, the Government has recently mandated the implementation of evidenced based structured literacy approaches in the teaching of reading and writing. Such practices necessitate teachers to demonstrate strong linguistic knowledge skills and pedagogy in universal teaching for all children (Tier 1 teaching within a Multi-Tiered System of Support framework) as well as to support children with literacy learning challenges such as dyslexia (Tier 2 and Tier 3 teaching support). This study investigated how teachers' personal linguistic knowledge in the areas of phonics, phonological awareness, and morphological knowledge advances when they participate in a large-scale PLD initiative through a self-paced online, micro-credential university course. Factors that influence teachers' gains in linguistic knowledge and self-rated ability were also investigated.

Consistent with previous findings in New Zealand and internationally (Carroll et al., 2012; Goldfeld et al., 2021; Mahar & Richdale, 2008), analyses from pre-learning survey data showed that teachers and literacy specialists involved in teaching reading and writing to young children in New Zealand demonstrate wide variability in their linguistic knowledge. Average total accuracy scores across phonics, phonological awareness, and morphology were between 56 and 70% prior to PLD. Pre-learning data highlight the need within the New Zealand education context to focus attention on both pre-service and in-service PLD to enhance teachers' personal linguistic knowledge. Our data mirror data reported in other countries (e.g., Australia, USA) for teachers' linguistic knowledge and suggest urgent attention needs directing towards, this issue within education systems. Strong personal linguistic knowledge is a fundamental first step towards ensuring educators can successfully implement researched informed structured literacy approaches within classroom teaching as well as to implement effective interventions for children with additional literacy learning needs.

Encouragingly, significant gains in teachers' linguistic knowledge were associated with their participation in online PLD implemented at scale across the country and within teachers' regular teaching contexts. Post-learning survey data showed significantly enhanced linguistic knowledge, skill and pedagogy and reduced variability in participants' performance across areas of phonics, phonological awareness and morphology compared to their pre learning survey data. Importantly, participants showed particularly strong change in pedagogy (moving from an average of 54% correct pre-learning to an average of 87% correct in the post-learning survey). This improvement suggests teachers were utilising enhanced linguistic knowledge to complete literacy assessment and teaching activities. Findings of significant growth from pre-learning to post-learning were supported by a cross-sectional comparison between trained and untrained educators. At the post-learning assessment, educators in our longitudinal sample scored significantly higher in their linguistic knowledge, skill and pedagogy compared to a comparison group of educators who had not received online PLD. Not only was the PLD-trained group scoring higher on average, but there was substantially less variability in their scores, compared to the non-PLD-trained group.

The strong positive change in teachers' linguistic knowledge contrasts to Piasta et al. (2017) findings which showed minimal growth from large-scale PLD implementation on early childhood teachers' literacy knowledge (which included skills of counting syllables and manipulating phonemes). Several differences in the PLD design may account for these differences. In contrast to the project reported in Piasta et al. (2017), the PLD in the current study was designed and developed by researchers with extensive experience in speech-language therapy and teacher education. In addition, the content of the PLD in the current study directly targeted teachers' linguistic knowledge, skills and pedagogy using direct and explicit teaching content and examples. The online course ensured all teachers had access to the same content presented in a consistent manner with quizzes for teachers to check their linguistic knowledge proficiency. Although the PLD was manualised in the Piasta et al. (2017) study, facilitators who delivered the content had flexibility to vary the content implementation. In addition, the broader micro-credential PLD involved in supporting teachers' and literacy specialists' implementation of the BSLA focused their attention on the practical application of their enhanced linguistic knowledge to literacy assessment, analysis and teaching activities in both Tier 1 (class level) and Tier 2 (small group) within the MTSS framework. Furthermore, this online PLD was delivered at times relevant to teachers' assessment and teaching as part of the BSLA. The lack of connection between theory to classroom practice was reported as a limitation in the Piasta et al. (2017) study. More positive findings in the current study from a large-scale PLD implementation suggest that concurrent development of both teachers' personal linguistic knowledge and application of this knowledge to practice through explicit and direct training may be particularly beneficial.

Self-rated ability in teaching phonics, phonological awareness, reading fluency as well as other aspects of reading and spelling significantly improved from pre-learning to post-learning, and was significantly higher in the PLD-trained groups than in those without PLD training. In the present sample, we found a significant positive correlation between self-rated ability and accuracy, indicating consistency between self-ratings and scores on a measure of linguistic knowledge. Whilst self-rated ability

is a slightly different construct than confidence, this finding is encouraging as data from other reports (Fielding-Barnsley & Purdie, 2005; Stark et al., 2016) have suggested teachers' confidence in their personal linguistic knowledge may be inconsistent with their demonstrated performance on linguistic tasks (i.e., they may over- or underestimate their own abilities).

The outcome from modelling predictors of change in teachers' linguistic knowledge is also encouraging. The data suggest the PLD implemented at large-scale benefited those that needed it most; that is, educators who showed lower levels of accuracy on linguistic knowledge tasks on the pre learning survey.

The self-paced online learning implemented in the current study has several potential advantages for both in-service and pre-service training of teachers. The model allowed an efficient way to upskill teachers at large-scale with flexibility in teachers' access to the learning content. It allowed teachers to revisit learning content as often as required to achieve proficiency in linguistic knowledge, skills and pedagogy. These features catered for the wide variability evident in teachers' existing knowledge. It enabled teachers who had advanced linguistic knowledge to quickly move through learning content to focus on applying their linguistic knowledge to literacy assessment, analysis, and teaching activities. It provided teachers who needed more in-depth learning to advance their personal linguistic knowledge in a private space without the added pressures that may be present in live workshop formats. The advantage of online PLD is accessibility, regardless of geographical location. This online PLD enabled teachers in small rural schools, or schools with less resources, to access the same high quality learning content as their colleagues in larger urban schools. It facilitated the involvement of part-time teachers and teachers involved in job sharing positions to be able to access the same high-quality PLD.

Two important features of the PLD in the current study supported the positive outcomes from the online PLD to advance teachers' linguistic knowledge within regular school settings: (1) investment in technological infrastructure; and (2) content specifically designed for a high-quality online learning experience. The teachers accessed the content through a robust online learning platform which could accommodate thousands of teachers accessing the learning content simultaneously. The teachers had quality computers and stable internet access in their schools to engage in the learning. They could access personal support in using the technologies as required and through weekly Zoom sessions with the researchers. The online learning content, format, and activities were specifically designed to incorporate features that support online learning engagement such as short learning sessions with key messages, video demonstrations, and interactive activities such as pop-up quizzes for teachers to monitor the progression of their linguistic knowledge throughout the course. These features addressed some of the concerns regarding online PLD for teachers (Haleem et al., 2022; Winter et al., 2021).

The linguistic knowledge, skills and pedagogy associated with the assessment and teaching of reading and spelling is consistent across languages with alphabetic writing systems. Teachers need to understand the phonological and morphological structure of the language being taught as well as the orthographic patterns that represent these structures (albeit that this may be more challenging in opaque languages such as English). Teachers need to understand how to apply this knowledge to reading and

spelling assessment, analysis of students' reading and writing attempts and to the teaching of reading and writing. High-quality online learning for a given language could potentially be shared across education providers to advance teachers' personal linguistic knowledge of the language being taught (including acknowledgment of regional variations in the language). Such opportunities may be particularly advantageous as we strive to achieve global literacy goals of more equitable education outcomes for all children.

Study limitations and future directions

Understanding the benefits of large-scale implementation of PLD in real-world settings for teachers poses several challenges for data collection. First, completion of the pre- and post-PLD linguistic knowledge survey in the current study was not compulsory for the teachers. The data collected and analysed, therefore, represents a subset of a much larger group of teachers. This potentially introduces bias. We were unable to determine if the performance of teachers who chose to give informed consent for study participation and who completed both the pre- and post-linguistic knowledge surveys differed from the larger cohorts of teachers who completed the PLD. Second, direct observation of teachers' application of linguistic knowledge to their regular teaching activities was not undertaken in the current study nor was data collected relating to the impact of teachers' improved linguistic knowledge on children's reading and spelling performance. Both areas warrant further investigation within the context of large-scale implementation of teacher PLD. Further, although the online survey used to explore change in teachers' knowledge was based on previous studies and teacher feedback from pilot work, an increased focus on teachers' ability to transfer knowledge to the analysis of children's reading and spelling attempts is recommended in future studies.

A third limitation of the current study is that the amount of time individual teachers spent on the linguistic knowledge activities within the online PLD was not available in this study. The use of online technologies to better understand and track the learning content teachers engage with online and how long they spend on specific PLD activities would be useful in future research.

It is important to note that within our mixed-effects models, baseline accuracy and self-rated ability were included as predictors of change, which means that estimates of its association with growth may be influenced by regression to the mean and should be interpreted with caution. Further, it is important to note that some subscales demonstrated low reliability in this sample, and that only one pedagogy item was included within each aspect of accuracy. Finally, well-researched theoretical models of skilled reading, including the Simple View of Reading (Hoover & Tunmer, 2018) advocate that systematic teaching of the linguistic skills for *both* word recognition and language comprehension is essential. The survey questions used in the current study focused exclusively on linguistic skills for word recognition. Evaluating the impact of PLD to facilitate growth in educators' knowledge, skills and pedagogy relating to semantics, syntax, linguistic comprehension and narrative skills to support reading comprehension and spelling within the broader context of writing development, is an important next step.

Conclusion

This study explored growth in teachers' personal linguistic knowledge following an online micro-credential as part of the nationwide implementation of the BSLA. A pre/post learning survey was used to measure change across a range of aspects and domains. Whilst wide variability in linguistic knowledge, skills and pedagogy was evident at the pre-learning survey point, post-learning survey results following 6–9 months online PLD demonstrated significantly improved linguistic knowledge, skills and pedagogy and, self-rated ability. Educators with lower levels of linguistic knowledge and lower self-rated ability at pre learning showed the most growth over time. Further, after completing their online PLD, educators scored significantly higher on linguistic knowledge, skills, pedagogy and self-rated ability than a comparison group of educators who had not received online PLD. Understanding how the implementation of large-scale PLD approaches to enhance teachers' linguistic knowledge and the use of this knowledge within their reading and writing teaching practices is an important area for continued research.

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1007/s11145-026-10871-9>.

Acknowledgements The authors are very grateful to the teachers and literacy specialists who participated in this project. They also acknowledge the work of the wider Better Start Literacy Approach team in their implementation of this project. This study was funded by the New Zealand Ministry of Education and the Better Start National Science Challenge.

Author contribution G.G. and B.M. conceptualized and supervised the study. A.S. and L.F. contributed to project administration and resource development. M.G. curated and analyzed the data. G.G., M.G., and L.F. wrote the initial draft and all authors provided review and editing and approved the final version.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions. Ministry of Education- New Zealand, MOE 08814, MOE 08814, Better Start National Science Challenge, 3710593, 3710593

Data availability The data that support the findings of this study are not openly available due to ethical and privacy considerations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Al Otaiba, S. A., Baker, K., Lan, P., Allor, J., Rivas, B., Yovanoff, P., & Kamata, A. (2019). Elementary teacher's knowledge of response to intervention implementation: A preliminary factor analysis. *Annals of Dyslexia*, 69(1), 34–53. <https://doi.org/10.1007/s11881-018-00171-5>
- Basma, B., & Savage, R. (2018). Teacher professional development and student literacy growth: A systematic review and meta-analysis. *Educational Psychology Review*, 30(2), 457–481. <https://doi.org/10.1007/s10648-017-9416-4>
- Binks-Cantrell, E., Joshi, R. M., & Washburn, E. K. (2012). Validation of an instrument for assessing teacher knowledge of basic language constructs of literacy. *Annals of Dyslexia*, 62, 153–171.
- Carroll, J., Gillon, G., & McNeill, B. (2012). Explicit phonological knowledge of educational professionals. *Asia Pacific Journal of Speech, Language and Hearing*, 15(4), 231–244.
- Catts, H. W., Nielsen, D. C., Bridges, M. S., Liu, Y. S., & Bontempo, D. E. (2015). Early identification of reading disabilities within an RTI framework. *Journal of Learning Disabilities*, 48(3), 281–297. <https://doi.org/10.1177/0022219413498115>
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Davis, D. S., Samuelson, C., Grifenhagen, J., Delaco, R., & Relyea, J. (2022). Getting KnERDI with language: Examining teachers' knowledge for enhancing reading development in code-based and meaning-based domains. *Reading Research Quarterly*, 57(3), 781–804. <https://doi.org/10.1002/rrq.445>
- Didion, L., Toste, J. R., & Filderman, M. J. (2020). Teacher professional development and student reading achievement: A meta-analytic review of the effects. *Journal of Research on Educational Effectiveness*, 13(1), 29–66. <https://doi.org/10.1080/19345747.2019.1670884>
- Dilgard, C., Hodges, T. S., & Coleman, J. (2022). Phonics instruction in early literacy: Examining professional learning, instructional resources, and intervention intensity. *Reading Psychology*, 43(8), 541–575. <https://doi.org/10.1080/02702711.2022.2126045>
- Donovan, S. L., Odegard, T. N., Farris, E. A., & Flipse, J. L. (2022). Testing the impact of online training in areas of reading instruction on educator knowledge. *Reading and Writing*, 35(1), 199–221. <https://doi.org/10.1007/s11145-021-10179-w>
- Duncan, L. G. (2018). Language and reading: The role of morpheme and phoneme awareness. *Current Developmental Disorders Reports*, 5, 226–234.
- Ehri, L. C. (2020). The science of learning to read words: A case for systematic phonics instruction. *Reading Research Quarterly*, 55, S45–S60.
- Fielding-Barnsley, R., & Purdie, N. (2005). Teachers' attitude to and knowledge of metalinguistics in the process of learning to read. *Asia-Pacific Journal of Teacher Education*, 33(1), 65–76.
- Fien, H., Chard, D. J., & Baker, S. K. (2021). Can the evidence revolution and multi-tiered systems of support improve education equity and reading achievement? *Reading Research Quarterly*, 56(S1), S105–S118. <https://doi.org/10.1002/rrq.391>
- Galuschka, K., Görgen, R., Kalmar, J., Haberstroh, S., Schmalz, X., & Schulte-Körne, G. (2020). Effectiveness of spelling interventions for learners with dyslexia: A meta-analysis and systematic review. *Educational Psychologist*, 55(1), 1–20. <https://doi.org/10.1080/00461520.2019.1659794>
- Gillon, G., McNeill, B., Scott, A., Denston, A., Wilson, L., Carson, K., & Macfarlane, A. H. (2019). A better start to literacy learning: Findings from a teacher-implemented intervention in children's first year at school. *Reading and Writing*, 32(8), 1989–2012. <https://doi.org/10.1007/s11145-018-9933-7>
- Gillon, G., McNeill, B., Scott, A., Arrow, A., Gath, M., & Macfarlane, A. (2023). A better start literacy approach: Effectiveness of Tier 1 and Tier 2 support within a response to teaching framework. *Reading and Writing*. <https://doi.org/10.1007/s11145-022-10303-4>
- Gillon, G., McNeill, B., Scott, A., Gath, M., Macfarlane, A., & Taleni, T. (2024). Large scale implementation of effective early literacy instruction. *Frontiers in Education*, 9, Article 1354182. <https://doi.org/10.3389/feduc.2024.1354182>
- Gillon, G. T. (2017). *Phonological awareness: From research to practice*. Guilford Publications.
- Goldfeld, S., Snow, P., Eadie, P., Munro, J., Gold, L., Orsini, F., Connell, J., Stark, H., Watts, A., & Shingles, B. (2021). Teacher knowledge of oral language and literacy constructs: Results of a randomized controlled trial evaluating the effectiveness of a professional learning intervention. *Scientific Studies of Reading*, 25(1), 1–30.
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285.

- Hall, C., Solari, E. J., Hayes, L., Dahl-Leonard, K., DeCoster, J., Kehoe, K. F., Conner, C. L., et al. (2024). Validation of an instrument for assessing elementary-grade educators' knowledge to teach reading. *Reading and Writing*, 37(8), 1955–1974. <https://doi.org/10.1007/s11145-023-10456-w>
- Hay, J., MacLagan, M., & Gordon, E. (2008). *New Zealand English*. Edinburgh University Press.
- Hjetland, H. N., Brinchmann, E. I., Scherer, R., Hulme, C., & Melby-Lervåg, M. (2020). Preschool pathways to reading comprehension: A systematic meta-analytic review. *Educational Research Review*, 30, Article 100323. <https://doi.org/10.1016/j.edurev.2020.100323>
- Hoover, W. A., & Tunmer, W. E. (2018). The simple view of reading: Three assessments of its adequacy. *Remedial and Special Education*, 39(5), 304–312. <https://doi.org/10.1177/0741932518773154>
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4(863). <https://doi.org/10.3389/fpsyg.2013.00863>
- Mahar, N. E., & Richdale, A. L. (2008). Primary teachers' linguistic knowledge and perceptions of early literacy instruction. *Australian Journal of Learning Difficulties*, 13(1), 17–37. <https://doi.org/10.1080/19404150802093703>
- Ministry of Education. (2025). *Structured literacy approaches*. New Zealand Curriculum – Tāhūrangi. <https://newzealandcurriculum.tahurangi.education.govt.nz/new-zealand-curriculum-online/teaching-support/structured-literacy-approaches/5637144675.c>
- Moats, L. (2009). Knowledge foundations for teaching reading and spelling. *Reading and Writing*, 22, 379–399.
- Moats, L. C. (2020). Teaching reading" is" rocket science: What expert teachers of reading should know and be able to do. *American Educator*, 44(2), 4.
- Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R^2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, 4(2), 133–142.
- Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading*, 27(4), 342–356. <https://doi.org/10.1111/j.1467-9817.2004.00238.x>
- Piasta, S. B., Connor, C. M., Fishman, B. J., & Morrison, F. J. (2009). Teachers' knowledge of literacy concepts, classroom practices, and student reading growth. *Scientific Studies of Reading*, 13(3), 224–248.
- Piasta, S. B., Justice, L. M., O'Connell, A. A., Mauck, S. A., Weber-Mayr, M., Schachter, R. E., Farley, K. S., & Spear, C. F. (2017). Effectiveness of large-scale, state-sponsored language and literacy professional development on early childhood educator outcomes. *Journal of Research on Educational Effectiveness*, 10(2), 354–378. <https://doi.org/10.1080/19345747.2016.1270378>
- Puliatte, A., & Ehri, L. C. (2018). Do 2nd and 3rd grade teachers' linguistic knowledge and instructional practices predict spelling gains in weaker spellers? *Reading and Writing*, 31(2), 239–266. <https://doi.org/10.1007/s11145-017-9783-8>
- Purvis, C. J., McNeill, B. C., & Everatt, J. (2016). Enhancing the metalinguistic abilities of pre-service teachers via coursework targeting language structure knowledge. *Annals of Dyslexia*, 66, 55–70.
- Reutzel, D. R., Dole, J. A., Read, S., Fawson, P., Herman, K., Jones, C. D., Sudweeks, R., & Fargo, J. (2011). Conceptually and methodologically vexing issues in teacher knowledge assessment. *Reading & Writing Quarterly*, 27(3), 183–211. <https://doi.org/10.1080/10573569.2011.560098>
- Schofield, M. J., & Forrester-Knauss, C. (2016). Surveys and Questionnaires in Health Research. In Liamputtong, P., Bondas, T., & Anderson, K. (Eds). *Research Methods in Health: Foundations for Evidence-Based Practice* (3rd ed.) (pp. 235–256). Melbourne: OUPANZ.
- Snowling, M., & Hulme, C. (2025). The reading is language model: A theoretical framework for language and reading development and intervention. *Annual Review Developmental Psychology*, 7, 195–218. <https://doi.org/10.1146/annurev-devpsych-111323-084821>
- Spear-Swerling, L., & Brucker, P. O. (2003). Teachers' acquisition of knowledge about English word structure. *Annals of Dyslexia*, 53, 72–103.
- Spear-Swerling, L., & Cheesman, E. (2012). Teachers' knowledge base for implementing response-to-intervention models in reading. *Reading & Writing*, 25(7), 1691–1723. <https://doi.org/10.1007/s11145-011-9338-3>
- Stark, H. L., Snow, P. C., Eadie, P. A., & Goldfeld, S. R. (2016). Language and reading instruction in early years' classrooms: The knowledge and self-rated ability of Australian teachers. *Annals of Dyslexia*, 66, 28–54.
- Stats NZ (2018). *Statistical standard for geographic areas 2018*. Wellington: Stats NZ Tatauranga Aotearoa.

- Torgerson, C., Brooks, G., Gascoine, L., & Higgins, S. (2019). Phonics: Reading policy and the evidence of effectiveness from a systematic 'tertiary' review. *Research Papers in Education*, 34(2), 208–238. <https://doi.org/10.1080/02671522.2017.1420816>
- Treiman, R. (2017). Learning to spell words: Findings, theories, and issues. *Scientific Studies of Reading*, 21(4), 265–276. <https://doi.org/10.1080/10888438.2017.1296449>
- Washburn, E. K., Joshi, R. M., & Binks Cantrell, E. (2011a). Are preservice teachers prepared to teach struggling readers? *Annals of Dyslexia*, 61, 21–43.
- Washburn, E. K., Joshi, R. M., & Binks-Cantrell, E. S. (2011b). Teacher knowledge of basic language concepts and dyslexia. *Dyslexia*, 17(2), 165–183. <https://doi.org/10.1002/dys.426>
- Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' use of technology and the impact of Covid-19. *Irish Educational Studies*, 40(2), 235–246. <https://doi.org/10.1080/03323315.2021.1916559>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.