Using Fluency-Building Approach to Increase the Knowledge and Fluency of Signing with Preschool Teachers: A Pilot Study

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ABSTRACT

Keyword signing, an augmentative communication strategy, is known to promote language acquisition in young children, yet staff in educational settings often receive insufficient training, leading to low retention and usage rates. This pilot study examined the feasibility and impact of a Precision Teaching-based intervention designed to improve preschool teachers' proficiency and fluency in Makaton signing. Eleven teachers from a mainstream preschool in North Wales, with limited prior training, participated in a six-week intervention involving fluency training with 238 Makaton signs. Pre- and post-intervention assessments measured knowledge acquisition, and post-intervention tests evaluated fluency through retention, endurance, and application. Results demonstrated significant improvements in participants' signing proficiency, with high retention and application of skills even after periods without practice. These findings suggest that Precision Teaching may offer an effective, time-efficient approach to improving sign language fluency in educational settings. Implications for teacher training and future research directions are discussed.

Keywords: language acquisition, augmentative communication strategy, sign training, teacher training, precision teaching, behavioural fluency

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Children typically communicate using gestures before they develop the ability to speak (Özçalışkan et al., 2016). For example, a child might shake their head to indicate 'no', point to their favourite toys to share their interests with others, or hold their arms to ask to be lifted. These early gestures are not only foundational for communication but are also closely tied to later language development. Studies suggested that children who use a greater variety of gestures in early childhood tend to acquire broader vocabularies as they grow older (Goldin-Meadow, 2014; Iverson and Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2010). A child's ability to combine gestures with spoken words has also been shown to predict the onset of multi-word sentence production, suggesting that there is a tight association between gestures and spoken language development (Iverson and Goldin-Meadow, 2005).

Evidence shows that children develop language faster when they receive gestural input from their carers or teachers (Rowe and Goldin-Meadow, 2009). Gestures produced alongside speech can facilitate the acquisition of verbal labels in a child's physical environment and help them understand abstract speech such as spatial language (Klsa et al., 2019). Gestures also contribute to drawing children's attention to a particular object thus making them more readily to learn these labels (Cartmill et al., 2012). These findings have spurred an interest in using keyword signing as an augmentative communication strategy with typically developing infants and young children.

Keyword Signing and Makaton

Keyword signing is an augmentative communication strategy that uses local sign language to emphasise key words in spoken communication and support understanding (Cologon and Mevawalla, 2018). For example, when saying, 'Give me an apple', a person using keyword signing would sign the words GIVE-ME-APPLE while verbalising the sentence in normal grammatical order. Unlike formal sign languages like British Sign Language (BSL) or American Sign Language (ASL), keyword signing does not follow sign language grammar and instead integrates signs into spoken language in a simplified manner. One of the most widely used systems of keyword signing for young children is Makaton[1], a language program that uses both signs and symbols to support communication (Ford, 2006).

Research has highlighted several benefits of using signing with infants and young children. Signing can enhance communication between caregivers and children, reduce tantrums and frustration, foster early verbal skill development, and even improve intellectual abilities of young children (Acredolo et al., 1999; Doherty-Sneddon, 2008; Goodwyn et al., 2000). Studies have shown that children exposed to signing tend to have larger vocabularies and produce longer sentences by 24 months of age compared to children who do not use signs (Goodwyn et al., 2000). In response to these benefits, Makaton has become increasingly popular in early childhood settings, with numerous resources such as videos, DVDs, and flashcards created to train parents and teachers (Makaton Charity, n.d.). The British Broadcasting Corporation's (BBC) children's program Something Special has also contributed to promoting Makaton through engaging content that introduces young viewers to signs (Ford, 2006).

Within the Welsh context, the use of Makaton holds particular relevance as a tool for supporting early language development, especially among children who may enter school with limited communication skills. Recent reports have highlighted growing concerns about speech, language, and communication needs (SLCN) among young learners in Wales. For example, research from the Wales Institute of Social and Economic Research and Data (WISERD, 2023) notes that children from the most disadvantaged backgrounds are already behind in language development by the time they start school. Similarly, the Royal College of Speech and Language Therapists (RCSLT, 2022) and the Welsh Government's Talk With Me strategy (Welsh Government, 2020) underscore the urgent need for accessible, early interventions that promote inclusive communication. Integrating Makaton, the combination of speech with signs, into classroom practice could potentially contribute to national efforts aimed at closing the early language gap across Wales.

Barriers to Implementation in Educational Settings

Despite the well-documented advantages of keyword signing, barriers to implementing Makaton in educational settings persist. One key challenge is the cost of formal Makaton training, which can be prohibitively expensive for many schools. Attending a complete series of Makaton training sessions can cost upwards of £80 to £90 per session (Makaton Charity, n.d.). While Makaton training is available to educators

across the UK, including in Wales, this financial burden limits access to official training, often resulting in teachers receiving informal training from colleagues, which can lead to significant variations in proficiency (Sheehy and Duffy, 2009). Even for teachers who receive substantial training, it is common to see issues with fluency in signing and the lack of signs used in interactions with students (Green et al., 2011). Often, teachers may have learned the signs during training but lack the confidence and the ability to use signs in their daily conversation (Green et al., 2011). This suggests a lack of connection between sign training and practices in a school environment, with the use of signs in an applied setting requiring higher levels of *fluency*.

Fluency is often referred to as "automaticity" (Kubina and Morrison, 2000, p.89), "second nature" (Lindsley, 1996), and the ability to show both accuracy and speed when performing a behaviour (Binder, 1996). Fluent behaviour is an indicator of mastery and a characteristic of expert behaviour (Binder, 1996; Kubina and Yurich, 2012). Haring and Eaton's Hierarchy of Learning (1978) indicated that skill fluency is important to ensure that a skill can be maintained for a long time, generalised, and adapted to various settings. Kubina and Yurich (2012) also supported this notion. They discussed the benefits of behavioural fluency in offering three desirable outcomes in learning: *Retention* (the ability to perform the behaviour fluently even after an interval of no training days), *endurance* (the ability to carry out the task fluently for a more extended period), and *application* (the ability to combine two or more element behaviours in performing a more complex behaviour). In the context of signing, fluency enables teachers to use signs naturally and consistently, which is critical for creating an environment where signing can effectively support language acquisition in children. Fluent signers are more likely to retain the skill over time, apply it in varied contexts, and maintain endurance during extended interactions (Kubina and Yurich, 2012; Haring and Eaton, 1978).

Precision Teaching as a Tool for Developing Fluency

Precision Teaching offers a systematic approach to building fluency by breaking complex skills into smaller, measurable components (Johnson and Street, 2013). It is not a teaching method per se, but a framework for defining target behaviours, monitoring performance, and using data to make timely adjustments to improve learning (Lindsley, 1991; White, 1986). One of the core strategies within Precision

Teaching is frequency building, which involves repeated practice of a specific skill in short, timed intervals, followed by immediate feedback (Evans et al., 2021; Kubina and Yurich, 2012). Unlike conventional practice sessions, frequency building uses short practice sprints and works towards a predetermined goal in response rates (e.g. increase the number of correct words typed to 60 per minute). Immediate feedback provided after each timed sprint serves as a foundation for subsequent improvement (Kubina & Yurich, 2012).

Extensive literature has shown that the frequency-building approach is suitable and can be adapted to meet different learning needs. Frequency building has been used to help students to achieve fluency in a wide range of academic skills, ranging from oral reading fluency (Griffin and Murtagh, 2015; Hughes et al., 2007; Lambe et al., 2015), mathematics (Chiesa and Robertson, 2000; Hayden and McLaughlin, 2004), and academic terminologies (Stockwell and Eshleman, 2010). A large-scale frequency-building intervention like the Great Falls Precision Teaching Project also showed that students who received thirty minutes of frequency-building intervention daily within their school curriculum outperformed by 20–40 per cent higher in standardised reading and mathematics tests than those who did not receive the intervention (Beck, 1979, 1981; White, 1986). Another example is the Centre for Individualised Instruction of Jacksonville State University, which integrated Precision Teaching and frequency-building intervention into academic curricula to support college students in achieving fluent academic skills (McDade and Goggan, 1993).

The success of Precision Teaching in other educational contexts suggests it may be equally effective in improving fluency in Makaton signing. This study explored the application of a frequency-building intervention within a Precision Teaching framework to improve preschool teachers' knowledge and fluency in Makaton signing. Specifically, we aimed to assess whether this approach could lead to meaningful gains in the acquisition, retention, and application of Makaton signs.

Method

Participants

A total of eleven preschool teachers were recruited through convenience sampling from a mainstream preschool. Participants were aged between seventeen to

Table 1 Participants characteristics.

PIC	*Age*	*Level of education*	*Attended official training*
1	20	Diploma	No
2	27	Diploma	Yes
3	26	Diploma	No
4	28	Diploma	Yes
5	21	Diploma	Yes
6	20	Diploma	Yes
7	17	GCE O Levels	No
8	34	Diploma	Yes
9	28	Diploma	Yes
10	24	Diploma	No
11	25	Diploma	No

Note. PIC = Participant identification code

thirty-four years old (M_{age} = 24), with the highest education attainment at a diploma level. Six participants had previously attended one official Makaton training programme; the rest did not receive any sign training prior to the study. Table 1 provides a summary of participant demographic characteristics. Ethical approval was obtained from the University's School of Psychology.

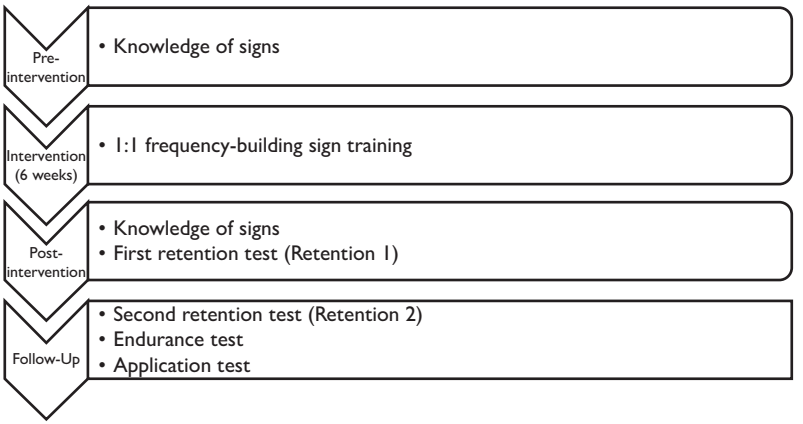
Setting

The study was conducted at a mainstream preschool in Wales, UK that offers daytime childcare services for children aged 0 to 5. All testing and training sessions took place in the lounge area of the preschool, with a table and chairs available. Training sessions were scheduled during participants' lunch breaks or in between their regular caregiving duties to minimise disruption to their work.

Research Design

The study used a quasi-experimental (A-B) design with pre- and post-intervention measurements. A schematic diagram of the study appears in Figure 1. Due to time

Figure 1. Schematic of the study. Pre- and post-intervention measures were taken a week before and after the intervention period. Follow-up measures were taken one month after the intervention.

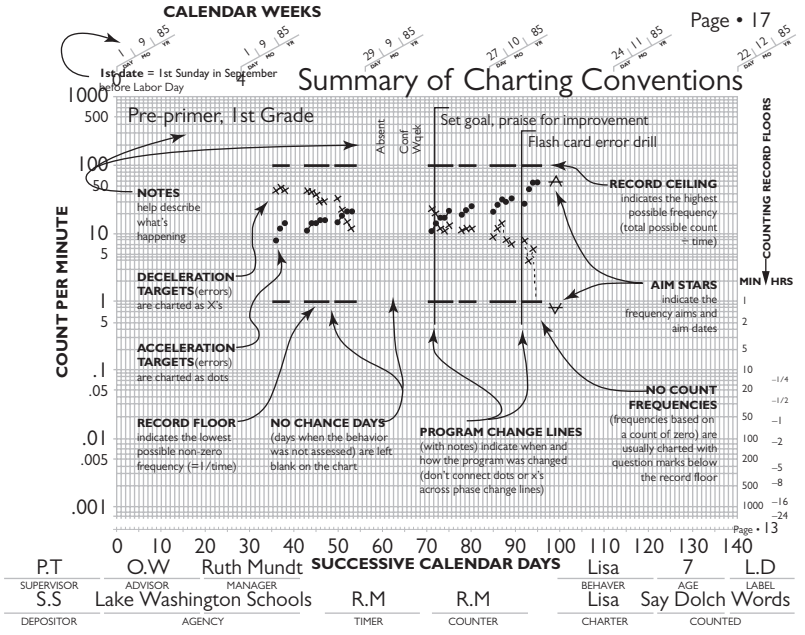


constraints and the practical limitations of a real-world case study, a control group was not included. All participants received one-to-one frequency-building practice sessions for an average of fifteen minutes per session from the researchers three times a week over the six-week intervention.

Materials

A set of 238 instructional cards was created for the study. Each card measured 9 x 4.5 centimetres (3.45 x 1.77 inches) and featured an English word on the front with a picture of the corresponding Makaton sign on the back. A full copy of all materials used can be found on the projects OSF page (available at: https://osf.io/58wgk/?view_only=363f797f87be4998b67ceb8c1e7191f9). The preschool headteacher chose the signs based on the vocabulary items frequently used by staff when interacting with children. The 238 signs were divided into four packs (Pack 1: 57 cards, Pack 2: 57 cards, Pack 3: 60 cards, Pack 4: 64 cards) to optimise learning during the intervention. These cards were used for both the training sessions and the pre- and post-intervention knowledge assessments.

Figure 2. The Standard Celeration Chart and charting conventions (Source: White & Neely, 2012).



Additionally, forty sentence strips were developed to test sign application. These sentence strips were modelled after common teacher-child interactions, incorporating signs from the instructional cards. They were displayed in black, 88-point Calibri font on a white background using PowerPoint on a laptop.

Datasheets were provided for each participant to record the date, the current learning target, the total number of trials conducted, the length of each trial, and the number of correct and/or incorrect responses per minute in each trial.

Use of the Standard Celeration Chart (SCC)

Precision Teaching encourages the use of the Standard Celeration Chart (SCC) as a standardised method for recording and monitoring performance over time (Kubina and Morrison, 2000). The SCC enables educators and learners to visually

track progress in targeted skills, making improvements or plateaus in learning immediately apparent. Its use is well established in the research literature (e.g., Beverley et al., 2009; White, 1986; White and Neely, 2012), particularly for its capacity to represent learning over extended periods. The x-axis of the SCC spans 140 calendar days, approximately 20 weeks or one academic semester, allowing for long-term tracking on a single chart, which is not easily achievable with hand-drawn graphs (White and Neely, 2012). In this study, the SCC was used to record participants' best score pair (corrects and incorrects) after each training session.

Procedures

Pre-intervention Assessment

Participants' knowledge of the 238 Makaton signs was assessed prior to the intervention. During this assessment, the researcher presented each instructional card by showing the English word on the front and reading it aloud. Participants were asked to respond by both saying the word and signing it. Cards were categorized as 'correct' if the participant accurately performed the sign, and 'incorrect' if they either failed to respond within two seconds or produced the wrong sign. The total number of correct and incorrect responses was recorded. The two-second response window was chosen to align with fluency-based instruction principles, which emphasize both accuracy and speed as indicators of skill mastery (Lindsley, 1996). While two seconds may appear brief, it reflects the goal of developing automaticity in sign production, which is particularly relevant in communication contexts where rapid recall is essential.

Intervention

Participants were randomly assigned to one of three researchers, each of whom served as the trainer for their assigned participants throughout the intervention. The training sessions employed a frequency-building approach, where participants were given timed practice to increase the number of correct signs they could produce per minute. Each session lasted approximately fifteen minutes and included

three one-minute timed trials with immediate feedback provided after each trial. A correct response was defined as when the participant performed the specific sign shown in the picture at the back of the instructional card. For example, if the participant signed APPLE in response to reading the word 'apple' on the instructional cards, the trainer scored it as 'correct'. An incorrect response was defined as when the participant did not respond or made a sign that did not correspond to the picture on the back of the instructional card. At the end of the trial, the trainer counted and recorded the number of cards on each pile on a data sheet. The best scores across the three trials conducted per session would be plotted on the Standard Celeration Chart.

During the training, participants worked on one pack of instructional cards at a time, starting with Pack 1. They progressed to the next pack after meeting the mastery criterion of performing at least thirty-five correct signs with three or fewer errors per minute for three consecutive sessions. This fluency aim, adapted from prior research (Hughes et al., 2007; Lambe et al., 2015), ensured stable performance before advancing to the next set of signs.

Post-intervention Assessment

Following the six-week intervention, participants were reassessed using the same procedure as the pre-intervention assessment to evaluate their knowledge of all 238 signs. Fluency was further evaluated through retention, endurance, and application tests conducted after the intervention.

Retention: The retention of the Makaton signs was assessed one week after the intervention and again four weeks later. Participants were tested on the packs they had mastered during training. The number of correct and incorrect signs-per-minute was recorded in three one-minute trials, and the best score from the trials was used for analysis.

Endurance: Participants' endurance was measured by extending the trial duration to two minutes. Signs from the mastered packs were shuffled together, and participants were asked to sign as many correct responses as possible within the time limit.

Application: The application of Makaton signs was assessed by presenting participants with one-minute trials using the sentence strips. The number of correct signs-per-minute produced in response to the sentences was recorded.

Inter Observer Agreement (IOA)

To ensure the reliability of the data, more than 80 per cent of the sessions were independently coded by two researchers. Inter-observer agreement was calculated using a trial-by-trial method, dividing the number of agreements by the sum of agreements and disagreements, then multiplying by 100 (Reed and Azulay, 2011). The average agreement rate was 82 per cent, indicating an acceptable level of reliability.

Social Validity

At the conclusion of the study, participants were asked to complete a social validity questionnaire to assess their perceptions of the training's effectiveness. Questions focused on their experiences with Precision Teaching, the usefulness of the training in their daily practice, and any suggestions for improvement. The responses were collected by an independent supervisor to avoid bias.

Results

Pre- and post-Intervention Knowledge of Signs

Table 2 illustrates participants' total number of training sessions attended over the six-week intervention and their knowledge of signs pre- and post-intervention. Shapiro-Wilk tests confirmed that normality assumption was met for all measures, $p = .382$ (pre-intervention), $p = .197$ (post-intervention). However, given the small sample size, a Wilcoxon Signed Ranks Test was used. Our results showed a significant increase in knowledge of signs from an average of 42 signs to 203 signs following the intervention, $Z = –2.93$, $p = .003$.

Fluency Measures

Shapiro-Wilk tests showed that normality assumptions were met for all measures ($p > .05$), except for Pack 4 ($p < .001$). Similar to the analysis above, non-parametric analyses were conducted to compare the mean number of correct signs-per-minute during the first and the last training sessions on Pack 1 (P1), Pack 2 (P3), and Pack 3

Table 2 Participants' total number of sessions and knowledge of signs at pre- and post-intervention.

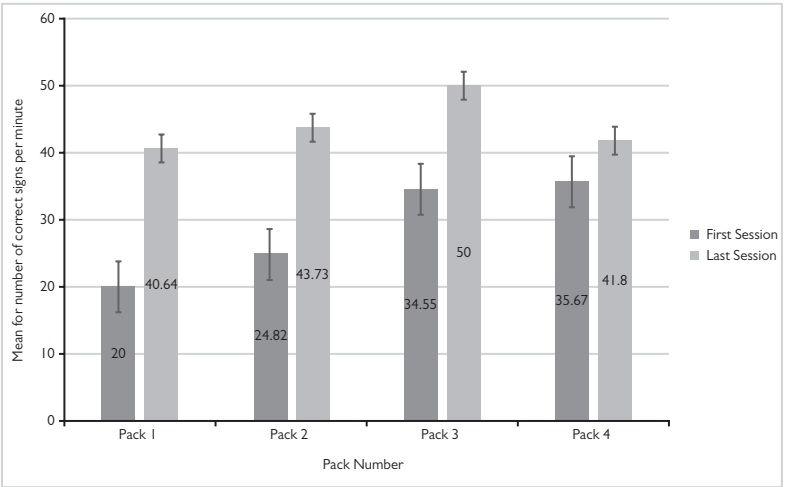
PIC	*Number of Sessions*	*Knowledge of Signing*		*Change*
		Pre-Intervention	*Post-Intervention*	
1	15	19	180	+161
2	21	65	192	+127
3	18	2	139	+137
4	18	60	212	+152
5	19	20	165	+145
6	19	77	217	+140
7	18	12	227	+215
8	18	67	227	+160
9	15	90	211	+121
10	18	32	233	+201
11	17	28	238	+210

Note. PIC = Participant identification code

(P3) across all participants. Figure 3 shows that participants scored significantly higher at the last sessions compared to the first sessions across all three packs, P1, $Z = -2.94$, $p = .003$; P2, $Z = -2.94$, $p = .003$; and P3, $Z = -2.80$, $p = .005$. There were also significant improvements in the number of accurate signs-per-minute between the first sessions of P1 and P2, $Z = -2.82$, $p = .005$ and between the first sessions of P2 and P3, $Z = -2.85$, $p = .004$. A significant increase was also found between the last sessions of P1 and P2, $Z = -2.64$, $p = .008$, but no significant difference in means was reported between the last sessions of P2 and P3, $Z = -0.77$, $p = .44$ (Figure 3).

A Wilcoxon Signed Ranks Test was utilized to compare the mean number of correct signs-per-minute between the first and the last sessions on Pack 4 revealed that participants had higher accuracy of at the last session compared to the first session, $Z = -2.20$, $p = .028$. Participants also had higher number of accurate signs–per–minute at the first session of Pack 4 compared to the first session of Pack 3, $Z = -2.50$, $p = .012$. However, there was no significant difference in between the last sessions of P3 and P4, $Z = -1.60$, $p = .109$ (Figure 3).

Figure 3. Means for participants' number of correct signs-per-minute during the first and the last training session for all four packs.



Retention

A frequency multiplier was used to quantify and demonstrate the magnitude of change in performance from the first training session to the first and the second retention tests. An increase in performance is denoted using a multiplication sign (x), whereas a decrease in performance is denoted using a division sign (÷). For example, a x2.00 indicates a 100 per cent growth in performance whereas a ÷2.00 indicates a 50 per cent reduction in performance (Vostanis et al., 2021).

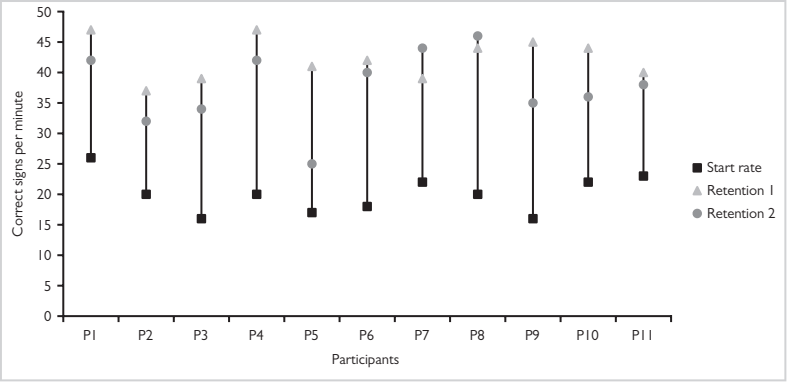
Figure 4 shows differences between participants' number of accurate sign-per-minute obtained on the first day of training (start rate), the first retention test (Retention 1), and the second retention test (Retention 2). Overall improvement from the first training day to the first retention test was 116 per cent (min = 74% / x1.74 – max = 181% / x2.81). This indicates that participants produced over twice as many accurate signs-per-minute during the first retention test compared to their scores obtained on the first training day. Wilcoxon Signed Ranks Test also demonstrated significant improvements in signing frequency for the first retention test, even following a period of non-practice days, $Z = -2.95$, $p = .003$.

Improvement from the first training day to the second retention test was 90 per cent (min = 47% / x1.47 – max = 122% / x2.22). Similar to the first retention test, participants showed significant increases in signing frequency compared to the first day of training, $Z = -2.94$, $p = .003$. With the exception of Participant 5, all participants maintained high frequencies of signing at the mastery criteria of more than thirty-five signs per minute during the second retention test. Participants 7 and 8 even showed a stable improvement in their frequencies of signing from the first to the second retention tests.

Endurance

Table 3 shows participants' frequency scores obtained during the two-minute endurance test. The mean number of correct and incorrect sign-per-minute for the endurance test were 39.37 and 1.78 respectively. Generally, participants who achieved higher frequencies of signing during the retention tests also achieved higher frequency scores for the endurance test. In particular, Participant 8 who scored higher during the second retention test compared to the first retention test, achieved the highest score for the endurance test amongst all eleven participants.

Figure 4. Average number of accurate signs-per-minute for the first training session (Start rate), the first retention test conducted during the last training session (Retention 1), and the second retention test (Retention 2).



Application

According to Table 3, participants produced 23 to 55 signs (M = 36, SD = 11.73) during the one-minute application test that involved signing while reading sentences. Participants went through 17.55 sentences on average (M = 17.55, SD = 4.87). Participant 8 who had the highest score for the endurance test also outperformed the other participants in the number of signs and sentences per minute.

Individual Data on SCC

Figure 5 illustrates the use of a SCC to record a participant's learning performance during the intervention and at follow-up. Following the pre-intervention measure, this participant began working on Pack 1 with the trainer by conducting three one-minute trials and recording the best score pairs after each training session. A 'cross-over jaw' learning picture was displayed on the SCC, indicating that she

Table 3 Participants' number of correct signs-per-minute on both stability and application tests.

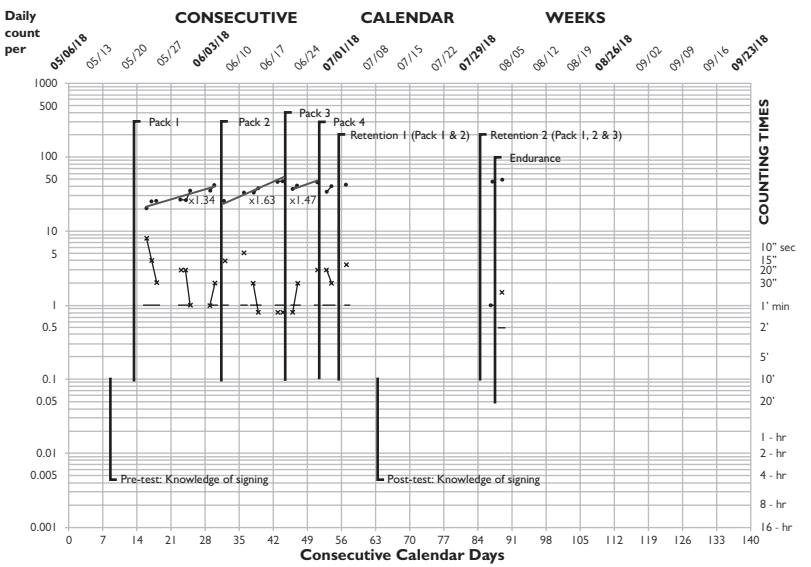
PIC	*Endurance*	*Application*	
	(corrects/incorrects)	*Signs/minute*	*Sentences/minute*
P1	41.5/1.5	23	14
P2	36.5/3	30	21
P3	35/2.5	29	24
P4	46.5/1.5	45	23
P5	29.5/1.5	26	14
P6	34/3	27	14
P7	44.5/0.5	55	14
P8	49.5/1.5	57	26
P9	35/2.5	36	14
P10	42.5/0.5	29	15
P11	38.5/1.5	39	14

Note. PIC = Participant identification code

showed improvement in her learning as the number of correct responses was low and incorrects were high at the beginning, but soon, incorrects decreased as corrects increased.

During the transition of one to another pack, there was an apparent drop in correct responses made. Nevertheless, the frequency of correct responses soon began to increase again over the subsequent sessions. The data displayed on the SCC also demonstrated that the participant maintained high frequencies of correct responses for both retention and endurance even after a period without practice.

Figure 5. A daily per minute standard celeration chart showing the best daily score pairs for one of the participants, Participant 8. The Y-axis indicates frequency (count per minute) on a multiply-divide scale ranging from .0001 minute (1 in 16 hours) to 1000 per minute. The x-axis is a calendar scale indicating day 1–140. Correct responses per minute are denoted by dots and incorrect responses by Xs. The black dashed line (-) indicates the counting period (timing floor) and denote the length of the practice sprint: a line on the '1' indicates the counting period is 1 minute and '2' indicates the counting period is 2 minutes. A score below the counting floor represents zero responses.



Social Validity

Overall, participants' responses to the social validity questionnaires were positive. All participants indicated that they had gained confidence in signing following the intervention. More than half of the participants (N = 7) also reported more frequent use of signs after the intervention in their daily interactions with children at the preschool. Some participants noted that children paid more attention to them and started learning signs when they incorporated signs into their daily activities:

> It (Signing) comes more natural now, and the children are responding better. They join in with the singing and the songs. (Participant 3)
>
> I am lots more confident now. I can use a lot more signs during story and circle time. Kids are starting to copy us. A child signed bicycle yesterday. (Participant 4)
>
> I have started to sign more. I realise you need to say a word in a more enthusiastic way, and the children pay more attention. (Participant 9)

When asked about their experiences of learning signs through Precision Teaching, participants commented that the frequency-building intervention was enjoyable, time-effective, and easy to get on. Most of them alluded to the flexibility of the approach to support individualised learning, that is, to learn at their own pace. This is evident in the participants' responses below:

> I felt I was proud of myself every time I beat the personal best. You had to be on the ball. (Participant 5)
>
> (Most useful parts of the training was) That we did it consistently and that you were competing against yourself basically. (Participant 11)

When asked about the potential of such intervention to teach signs to others, all participants responded that they would recommend the use of Precision Teaching to others.

Discussion

Frequency building has successfully improved the learning for a range of academic skills (e.g. Griffin and Murtagh, 2015; Lambe et al., 2015). Yet, no known study has

investigated the application of frequency building in helping to improve performance in keyword signing. This study focused on evaluating the effectiveness of a frequency-building intervention aimed at improving the performance of Makaton signing with preschool teachers who received limited or no official training. Eleven participants who varied in their knowledge of Makaton signs took part in this study. Our result demonstrated that all participants showed a significant increase in their knowledge of signs following the intervention (associated with a large effect size). Furthermore, one participant showed acquisition of all 238 signs chosen for this study post-intervention. These improvements suggested that although the intervention was brief (an average of three sessions per week for six weeks), frequency building could offer an effective and efficient approach, leading to important gains in signing.

Improvements in signing performance were also reflected in the results of fluency outcome measures, whereby none of the participants reverted to their start rates (i.e. scores obtained on their first training day) during follow-up. Our results also demonstrated that participants maintained their performance level, scoring above the fluency aim (≥35 corrects with three or fewer incorrect responses per minute) during the first retention test. Equally encouraging were the results of the second retention test, where two participants showed continuous improvement in their signing frequencies from the first retention test, and seven of them achieved high frequencies of signing above the fluency aim. Both endurance and application tests also revealed that participants who maintained higher frequencies in signing endured a more extended on-task period and applied the skill to novel stimuli.

Our results supported the accounts on the benefits of achieving behavioural fluency. The attainment of fluency aim is associated with positive learning outcomes on long-term retention, endurance, and application of the skills involved (Kubina and Yurich, 2012). Individual data from our study also suggested that those who retained higher frequencies of signing performed better during the endurance and the application tests, thus demonstrating that greater fluency in performing basic Makaton signs may aid the maintenance and application of the skill under a novel, unlearned environment. Results of the application test offer preliminary evidence consistent with extensive literature that suggested fluency in basic element skills serves as the foundation for complex, compound skills performance (Binder, 1996; Johnson and Street, 2013). Nevertheless, it is important to note that the small

sample size (*N* = 11) may increase the likelihood of effect size inflation. As such, the results should be interpreted with appropriate caution.

There were some important observations from this study. First, it was noticed that some participants needed more sessions to achieve the fluency aim than others. For example, Participant 10 took six practice sessions across two weeks to achieve the aim for Pack 1, while Participant 3 needed nine sessions across three weeks. These findings are vital as they suggest that the current practice of providing a one-size-fits-all sign training on Makaton might not be optimal. Precision Teaching which focuses on differentiating instructional designs based on individual learners' skills and readiness could be a valuable addition to the current practice to move learners towards a more successful mastery of Makaton signs (Vostanis et al., 2021).

Second, variations in prior knowledge of signs almost did not impact participants' frequencies and signing performance post-intervention. All teachers made significant gains in accurately performing basic Makaton signs post-intervention, regardless of the number of signs known or whether they had attended official Makaton training before the intervention. Those who had not received training also achieved similar frequency scores during fluency measures compared to those who had been trained. This suggests that the Precision Teaching procedures to adapt to individual learners' needs could ensure that all individuals were making significant progress with sufficient practice.

Further benefits of this frequency-building intervention include the shorter duration and the minimum amount of materials required for the training programme. Teachers had, on average, 17 training sessions of approximately 15 minutes each (a total of 255 minutes or 4.25 hours). Compared to long hours of mass practice over a few days, frequency-building intervention focuses on learning smaller, manageable chunks of information at a time and distributing practice over days or months. This approach offers preschool teachers with limited time availability a more time-efficient way to practice. The social validity data of our study also confirmed that distributed practice was highly preferred by teachers. The materials involved, master copies of the instructional cards and the datasheets were filed and could be re-used indefinitely for reminder activities or training if required. All these benefits, together with critical learning outcomes (retention, endurance, application) associated with frequency building (Binder, 1996; Kubina and Yurich, 2012), could ultimately reduce the time and cost required to help teachers learn basic signs in Makaton.

This study offered preliminary results to suggest that frequency-building practice can complement the current provisions of sign training to promote the acquisition and maintenance of Makaton signs. Our study demonstrated that frequency-building practice could enhance knowledge of Makaton signs and other desirable learning outcomes, especially in retaining and applying the skills in a novel context. This study contributes evidence on the merits of Precision Teaching and frequency building in promoting fluency in Makaton signing.

The findings of this pilot study have practical implications for early childhood education, particularly within the Welsh context where addressing speech, language, and communication needs is a national priority. By demonstrating that Precision Teaching, and in particular frequency building, as an effective method to improve the fluency and retention of Makaton signs among preschool educators, this study supports the integration of such methods into teacher training programmes. Importantly, the frequency-building component also has potential as a tool for retrieval practice following formal Makaton training, supporting the consolidation and maintenance of signing skills over time. This could lead to more consistent and confident use of Makaton in classroom settings, thereby enhancing inclusive communication practices.

Research Limitations

We acknowledge some limitations associated with the current study. First, our study utilised a quasi-experimental design without a control group to investigate if the frequency-building practice could improve teachers' performance in signing. Using a quasi-experimental design enabled us to conduct the research in a real-world context with fewer controls but may have restricted our ability to draw a causality relationship between the variables (Siedlecki, 2020). Continuous research would benefit from incorporating a control group to increase the robustness in demonstrating the effectiveness of the intervention in helping to improve signing proficiency.

Second, it is possible that there were some unavoidable differences in the number of practice opportunities between participants. As some participants made more incorrect responses and engaged in a longer error correction phase than others, it is possible that the error correction procedures may have confounded

the degree to which frequency building was the sole variable responsible for performance change post-intervention in this study. Nevertheless, after considering the variability in incorrect responses across days over the six-week intervention, this might have little impact on their daily performance and their scores during retention, endurance, and application tests.

Third, while the application tests demonstrated that fluency in basic signs supports complex sign use, further research is needed to investigate how increased fluency in Makaton signing translates into improved communication outcomes with children in real-world educational settings.

Lastly, the small sample size represents a notable constraint of the present study, limiting the generalisability of the findings. While the results provide promising preliminary evidence, future research with larger and more diverse participants is necessary to ensure the robustness of the findings.

Conclusions

In summary, this pilot study provides preliminary evidence that Precision Teaching, and specifically frequency building, can effectively improve the fluency and retention of Makaton signs among preschool teachers. The findings suggest that adopting this approach could enhance teacher training programs, leading to more consistent and confident use of Makaton in early childhood education. Future studies with larger samples and more rigorous designs will be crucial in validating these findings and further exploring the potential benefits of Precision Teaching for keyword signing.

Disclosure of Interest

The authors report no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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End Notes

1 Makaton is a language that uses signs and symbols to aid communication. It was introduced by a speech-language-therapist, Margaret Walker, in the 1970s (Ford, 2006). https://www.makaton.org/aboutMakaton/

2 Makaton Vocabulary is a product of The Makaton Charity. https://www.makaton.org/