

**Educators' perspectives on facilitating computer-assisted
speech intervention in early childhood settings**

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Abstract

Early childhood educators are frequently called on to support preschool-aged children with speech sound disorders and to engage these children in activities that target their speech production. This study explored factors that acted as facilitators and/or barriers to the provision of computer-based support for children with SSD in early childhood centres. Participants were 23 early childhood educators at 13 centres who participated in the Sound Start Study, a randomised controlled trial that examined the effectiveness of the *Phoneme Factory Sound Sorter*® (PFSS) computer program (Wren and Roulstone, 2013). Following the trial, participants completed a telephone interview discussing their experiences implementing the program. Transcripts from the interviews were analysed and three categories emerged as factors that influenced the provision of support: (a) *Personal factors* that related to the children (engagement with PFSS, inclusion/exclusion experience), peers, and educators (service provision, educator engagement, and support of child PFSS use); (b) *Environmental factors* that related to policies and philosophies (child-centred practice, technology), the physical environment (inclusion/exclusion), and logistics (time, technology); and (c) *Program factors* that related specifically to PFSS (program format, specific games, game duration). In order to best meet the needs of children, parents, educators, and clinicians, these factors need to be taken into consideration in the provision of speech and language therapy services in early childhood centres.

Keywords

Children, speech sound disorders, phonology, intervention, preschool, service provision, early childhood educators, teachers, speech and language therapy, early childhood education, computer-based intervention.

Introduction

Speech sound disorders (SSD) impact on children's abilities to communicate and participate in day-to-day life (McCormack et al., 2011). Thus, children with SSD need to receive early, effective, and evidence-based intervention (United Nations, 2007) that supports their real world functioning in all aspects of their life (World Health Organization, 2007). Although speech and language therapists (SLTs) have the training and expertise to provide this intervention, it is important to consider how other people in children's lives can be involved, and what this involvement might look like. Educators are important people to consider for four key reasons. Firstly, the education environment and education professionals are a significant part of children's lives. For example, in Australia, children spend 10,710 hours in formal education (OECD, 2014) with 82.8% of 4- to 5-year-old children attending preschool (Australian Bureau of Statistics, 2014). Secondly, as speech and language competence is fundamental to children's ability to access social and learning aspects of education programs, health and education professionals both need to be involved in working with these children (Dockrell and Lindsay, 2001; Lindsay et al., 2002). Thirdly, when parents are unable to undertake therapy activities at home this responsibility is often deferred to educators (teachers and teaching assistants) to provide additional therapy and support for children (Glover, McCormack and Smith-Tamaray, 2015). Finally educators may help address identified gaps between recommended intensities for effective speech interventions (e.g., 3x week; Allen, 2013) and the relative availability of SLT services (McAllister et al., 2011).

Service delivery choices in speech and language therapy can be complex and multidimensional and require consideration of factors such as service location, service provider roles, service format, schedule of service, service intensity, and pre-service experiences (Cirrin et al., 2010; Fairweather, Lincoln and Ramsden, 2016; Jago and Radford, in press; Schooling, Venediltov and Leech, 2010). Two of the currently most

employed models in which SLTs and educators jointly provide services in education settings are collaborative and consultative models. Collaborative practice involves SLTs and educators engaging in an equal partnership where they effectively combine skills and knowledge and work jointly to accomplish goals with children that neither professional may be able to attain on their own (Baxter et al., 2009; Hernandez, 2013; Lindsay and Dockrell, 2002). The collaborative model is favored as a model as it allows greater generalisation of new speech, language, and communication skills (Mount, 2014), simultaneous attention to speech, language, communication, literacy, social, and curricular issues which may be interdependent (Wright and Kersner, 2004), inter-professional growth and skills (Hong and Shaffer, 2015; Marshall, Ralph and Palmer, 2002), and increased understanding of the roles, skills, and knowledge of other professionals (Mount, 2014). However, there is only limited research evidence available that demonstrates collaborative models are effective for the “delivery of intervention targeting specific speech and language skills” (Jago and Radford, in press: 4). Collaborative intervention requires educators and SLTs to have access to the same space, which poses difficulties in many contexts due to factors such as geographic distance between the SLT and the education environment, SLTs not being employed to work within education environments, and workforce shortages (El-Choueifati et al., 2012; McAllister et al., 2011; O'Brien et al., 2006). In such cases a consultative model is often used out of necessity.

In a consultative model an SLT acts as an expert who provides indirect therapy through liaising with therapy agents (i.e., educators) who are in regular contact with children (Baxter et al., 2009; Hartas, 2004; Law et al., 2002). Consultative models have the potential to reduce barriers to accessing speech and language therapy services in clinical settings, such as long waiting times, cost, non-availability, and distance (McAllister et al., 2011). However, empirical evidence suggests that consultative models are not as effective as direct models of service provision. For instance, a manualised expressive language intervention for

school-age children was reported to be effective when delivered by SLTs and SLT assistants (Boyle et al., 2009). When the same program was delivered by educators via consultation with SLTs, it was not effective (McCartney et al., 2011). It was suggested that “different amounts of intervention and adherence to the therapy programme” contributed to the outcome (McCartney et al., 2011: 80). Dodd and Barker (1990) reported a similar finding. In an intervention study involving 11 preschoolers with SSD, five children were treated by their parents, and six treated by their educator (preschool teacher). The parents and educators received approximately 24 hours of training from the child’s SLT. The parent-delivered intervention was more effective than the educator intervention. Based on video observations of the teachers’ implementation of the intervention, the authors noted that the educators did not always provide feedback to the children in keeping with the training. They also noted that the educators had less time available to provide the intervention. In order to service the needs of preschool children with SSD we need to find a model of practice that removes the logistical difficulties of the collaborative model but improves the efficacy of intervention provided through a consultative model.

The use of computer-based intervention programs is one approach that has the potential to provide effective intervention through a consultative model where educators are able to support/facilitate the delivery of less complex or simple interventions for speech and language difficulties. The development of computer-based interventions for speech language therapy services, or “virtual speech therapists” (Chen et al., 2016: 100) are gaining popularity due to factors such as their portability, adaptability, availability, impartiality, and their potential for making up for SLT service shortages (Chen et al., 2016; Kagohara et al., 2013; van Vuuren and Cherney, 2014). Tabletop interventions known to be effective in treating SSD have been developed into app-based technologies for use by SLTs (e.g., Jesus et al., 2015). In fact, Pereira, Brancalioni and Keske-Soares (2013) reported that computer-based intervention for phonological difficulties was associated with more change in

children's phonological systems than traditional therapy. Chen et al. (2016) conducted a systematic review of evidence for a variety of software programs designed to act as a virtual SLT for people with speech disorders and concluded that software was an effective means of non-SLTs delivering an intervention planned by SLTs. The way in which children interact with computer-based intervention should also be considered. Given et al. (2014) reported that 3- to 5-year old Australian children were able to use a mouse and keyboard in their home environment without asking for or needing assistance from their parents or siblings. However, in laboratory tasks Hourcade et al. (2004) found that although 4- and 5-year-old children were able to comfortably use a mouse, their mouse use was both slower and less accurate than adults.

While the efficacy of computer-based interventions for SSD are being investigated, it is important to also consider the environmental influences that may impact on the success of implementing such therapy approaches in education environments, especially early childhood environments. To date, the majority of investigations into implementation of speech and language therapy services in education settings have occurred in school-age education settings (e.g., Baxter et al., 2009; Gardner, 2006; McCartney, Boyle and Ellis, 2015; Snow et al., 2014) with less attention to early childhood settings (e.g., Dodd and Barker, 1990; Grunwell, 1983), and none identified concerning computer-based interventions. Understanding barriers to successful implementation of computer-based services, as well as factors that facilitate successful implementation is as important as investigating the effectiveness of computer-based interventions themselves. Successful intervention relies on administration of the required therapeutic dose (teaching episodes per session) and frequency (sessions per week), and duration (weeks of intervention), with non-optimal dose, frequency, and duration potentially rendering effective treatments ineffective in practice (Allen, 2013; Warren, Fey and Yoder, 2007; Williams, 2012). Administration of the prescribed dose, frequency, and duration of intervention may be greatly influenced by

the receiver of the intervention, the provider of the intervention, and the environment in which the intervention occurs.

One computer-based intervention readily adaptable to implementation in an early childhood environment is Phoneme Factory Sound Sorter® (PFSS) (Wren and Roulstone, 2013). The British English version of the software was examined in Wren and Roulstone (2008). Although Wren and Roulstone (2008) did not find PFSS to be any more effective than traditional table-top, they speculated the reasons for this may have related to sub-optimal dose, a small sample size, heterogeneity within the sample, and children's stimulability for consonants targeted in PFSS. McLeod et al. (2016) conducted a cluster randomised control trial to evaluate PFSS as first-phase intervention for preschool children with SSD in which educators (teachers and/or teaching assistants) implemented PFSS using SLT designed intervention targets. PFSS is based on Stackhouse and Wells (1997) psycholinguistic framework, and targets children's input phonological processing skills. Children receive computer-based feedback depending on their response, thus circumventing the implementation barrier of educator feedback accuracy identified by Dodd and Barker (1990). While no significant differences to children's speech production were found between PFSS and typical classroom practice in the PFSS trial by McLeod et al. (2016), this trial did provide an opportunity to examine the barriers and facilitators to computer-based intervention across a range of early childhood environments and with a range of educators. The aim of the current study was to examine the experiences of the educators who implemented PFSS with preschool children with SSD attending their centre to identify factors acting as barriers and facilitators to PFSS implementation.

Method

Context of the current study

Data in the current paper are drawn from the Sound Start Study. The Sound Start Study was a blinded cluster randomised controlled trial run across 39 early childhood

settings over a 3-year period. Nineteen early childhood settings were allocated to implement PFSS as part of the Sound Start Study. These 19 settings represented 16 unique sites, as three sites were involved in two different years of the study with separate cohorts of children (see Figure 1). Ten of the settings were funded by the New South Wales Department of Education and Communities, two were community preschools, two were local government preschools, one was a preparatory program in an independent private school, and one was a privately-owned long day care centre. Between 1 and 13 children participated in the PFSS program (mean 3.9, median 3.0) at each early childhood setting. All sites were located within the Greater Sydney area in NSW Australia in a diverse range of socioeconomic areas.

Insert Figure 1 about here

Phoneme Factory Sound Sorter ® Australia (PFSS) (Wren and Roulstone, 2013) was the computer-based intervention for SSD used in the Sound Start Study. The original PFSS software (Wren and Roulstone, 2006) was developed for children using British English and was a refinement of the software used in the PFSS trial reported in Wren and Roulstone (2008). The Australian version of PFSS used four Australian English speakers, dialect appropriate vocabulary, a module targeting cluster reduction, and an overall increase in the number of word and non-word stimuli used. PFSS utilizes an input-based phonological processing approach to target specific developmental phonological processes (e.g., fronting, stopping, gliding). All versions of PFSS use seven different games, which operate with the SLT-prescribed phonological targets, to actively engage children in phoneme detection, phoneme identification, phoneme blending, rhyme awareness, and minimal pair tasks. Each week children complete a level containing between three and five different games, each with ten trials. Each week the combination of games changed and the difficulty of targets increased. Further details about the content and format of PFSS can be found in other publications (McLeod et al., 2016; Wren and Roulstone, 2008).

Participants

All 39 educators/directors at the 19 early childhood settings involved with the implementation of PFSS were invited to participate in a post-intervention interview (site directors ($n = 15$), educators ($n = 20$), site directors/educators ($n = 4$)). Twenty-three directors/educators from 13 of these settings participated in the interview: 17 directors/educators had been directly involved in the implementation of the PFSS and six directors of the settings in which this intervention took place but who had not been directly involved in the implementation (see Figure 1).

Brief questionnaires describing participants' background information were returned by 15 of the 17 educators directly involved in implementing PFSS (background information was not collected from the six participants not directly involved in PFSS implementation). Of these 15 participants, all were female, aged between 25 and 64 years (mean 44.2 years) and had 1 to 25 years (mean 12.4 years, SD 8.5) experience working in early childhood settings. All participants reported that they spoke English well. Tertiary qualifications varied among participants from none to three, and the highest level of qualification reported ranged from postgraduate degree to certificate qualifications. All educators reported use of a computer at home and daily use of mobile devices (i.e., smart phone, tablet) and 12 (80%) participants reported contact with a SLT or SLT service prior to this study due to family/friend connections or through their work as an early childhood educator.

Procedure

Participating settings received laptops preloaded with the PFSS software and hardware (i.e., cordless mice, headphones). Multiple sets of laptops and hardware were provided to settings that had more than two children involved in the study with the same attendance pattern. SLTs set up individualised programs within PFSS for each participating child. A SLT trained each educator in the use of PFSS and study-specific protocols before the program was implemented and the roles and responsibilities of the research team and the

educators was described (See Table 1). Participants actively involved in implementing also completed a brief questionnaire outlining their personal information (i.e., age, qualifications, years of teaching experience, engagement with technology, and prior contact with SLTs). Participants and staff at participating settings were informed that the purpose of this research was to examine the effectiveness of a computer-based intervention for SSD when used in early education settings. As a result, data for the entire 3-year trial were not analysed until all data collection had concluded. No information about the effectiveness of the intervention in the current trial was available to participants beyond their own observations of the children that they were working with. Similarly, while informal observation of fidelity to dose protocols occurred during the three-year project, analysis of data describing these areas could not be conducted until after all data had been collected. Analysis of fidelity has subsequently shown that only half of the children received the prescribed number of trials (e.g., completed all prescribed attempts of all required games) required by the intervention protocol (McCormack et al., 2016). Centres received some financial compensation for participating in the intervention phase of the study. Payment was made to the early childhood setting as an amount per child involved in the study to assist in employing additional staff to maintain mandated teacher-child ratios within the centre. Centres were not involved in the selection of children for the study or the allocation of centres to the intervention or control condition.

Insert Table 1 about here

At the end of the intervention period a semi-structured phone interview was completed with the 23 educators and/or directors who were able to participate in this part of the study. Phone interviews were chosen as the most appropriate format for the interviews as they minimized disruption to participant schedules, could be conducted at times and places most convenient to the participants. Several attempts were made to reach all directors/educators involved in the implementation of the intervention however not all could

be reached. The phone interviews were conducted by an experienced early childhood educator and researcher who was external to the Sound Start Study. The phone interview focused on five broad areas: how using PFSS fitted into their preschool routine; what it was like to use PFSS; how the children used PFSS; what changes would make PFSS better/simpler to use; and, any other comments relating to their experiences of participation (see Appendix A). These questions were generated collaboratively by the authors of the paper. Interview length ranged from 3 – 17 minutes (mean length 10.8 minutes). All interviews were audio recorded and later transcribed by an external, accredited transcription service.

Analysis

Thematic analysis was conducted using procedures outlined in Cresswell and Plano Clark (2011). Initial codes were developed by the first and second authors based on the aims of the project and the themes that emerged from the first two transcripts reviewed. All transcripts were then coded in NVivo (QSR International, 2014) with codes added as required. The first two authors then refined the codes and the coding process through discussion and revision until consensus was reached and coding of all data were checked in line with these revisions. The first author then analysed coded data specifically in relation to the aim of the study: to examine the experiences of the educators who implemented PFSS with preschool children with SSD attending their centre, identifying factors acting as facilitators and barriers to PFSS implementation. Coded data were reviewed and data that described barriers and facilitators were extracted, grouped into themes and these were reviewed and discussed by the first three authors.

Although no external validation of data was conducted, the coding and analysis procedures were undertaken following Braun and Clarke's (2006) criteria for quality thematic analysis. This included undertaking a "thorough, inclusive and comprehensive" data analysis (p. 98), ensuring all data were coded and all relevant excerpts thematised.

Themes were also compared between themselves and the original data to ensure internal consistency and distinctiveness.

Results

Results will be reported in relation to three broad categories that influenced the provision of support: (a) *Personal factors* that related to the children, peers, and educators; (b) *Environmental factors* that related to policies and philosophies, the physical environment, and logistics; and (c) *Program factors* that related specifically to PFSS. Facilitators and barriers within each will be discussed. The structure of categories, themes, and subthemes can be seen in Table 2.

Insert Table 2 about here

a) *Personal*

The personal category describes the characteristics and experiences of people that acted as barriers and facilitators to implementation. Three themes (groups of people) emerged within this category: children, peers, and educators.

Children. This theme related to children's personal characteristics and how they acted as barriers/facilitators to intervention, as described by their educators. Two subthemes were identified: children's engagement with PFSS and the intervention process, and children's inclusion/exclusion experience. Children's participation in the PFSS program was dependent on their engagement with technology, their willingness to participate, and their ability to participate. Educators commented that children's engagement with technology facilitated implementation. For instance, "Most speechies they only really give us scrapbooks sometimes. And that's just little flashcards and stuff like that whereas this was more engaging and definitely much more appealing to the children [E7]". However, sometimes the use of technology was a limitation when children had difficulty engaging with technology, "You know, that was really a lot to ask of a 4-year-old, to manoeuvre a mouse around a maze [E9]". Some children were eager to participate, "He was quite

enthusiastic to do it ... I would say “Okay, come on [child’s name], we’ll go do your computer thing now” and he’d just jump up and run in. And some days he’d get here and that’d be the first thing he’d say, “Can I go do my work on the computer now?” [E4]”. In other cases, there were changes over time related to the long-term use of the program, “In the early days it was kind of all fun and then towards the end I think they were just a bit over it [E23]”, or the intensity of use, “I think they would really enjoy that kind of thing if they didn’t have to do it so often [E23]”. Further, children’s ability to participate was also impacted by factors such as attention, fatigue, and behaviour. For example, one educator commented, “I was sitting over half an hour with some children because they’re just not focused ... distracted, you know, it takes a long time, a lot more time than 15 minutes with a lot of them [E21]”. Another recognised that some children who “need” the intervention are also those who are least able to engage due to other, comorbid issues (e.g., attention).

Children’s engagement was also influenced by their awareness of their own performance, with awareness of good performance acting as a facilitator for some children, “They’d yell out, ‘I got 10 out of 10.’ ...they were really inspired to do better and progress within the program [E20]”. Awareness of poor performance was a barrier for some children, but not for others: One educator commented, “She was aware she wasn’t doing that well. I don’t think it had any detrimental effect on her [E5]” but another reported, “He would get really annoyed if it was wrong, and then that’s when he didn’t want to play, or he didn’t want to do it, he wanted us to do it [E12]”. Changes in engagement due to performance were also reported, “But then once he became more successful at it and he realised that, oh actually I can do it a bit quicker and I get a big fuss made of me ... he was then quite happy to be a part of it and to come and do his time on it [E14]”. Independence also facilitated participation, but this was not always possible, “We tried to make them do it independently. But sometimes it was just too much for them. Depends on the day they had here, they get a bit tired [E19]”.

The second subtheme was children's inclusion/exclusion experience that acted as both a barrier and a facilitator in different situations. Children's exclusion from the play environment was frequently mentioned as a barrier to implementation. For example, "Some days we didn't get to do it ... he was so interested in the other things, activities in the room and outside that he didn't want to participate in the game or in the program [E15]". However, completing PFSS within the play environment created a barrier in some cases due to the "distraction" it caused to everyone else. Interestingly, exclusion was a facilitator to participation for some children because the child was able to engage in an activity not available to peers, "I think she thought she was really special to be able to come in here and sit at a computer and do some work the same as we were [E5]".

Peers. Peers were described as barriers if they distracted children from PFSS, "All the other children would come over and, "Oh I want a turn. I want a turn. What's he doing?" and he would get really distracted by them being there [E4]". However, peers acted as facilitators when their desires to use PFSS encouraged intervention children to participate, "There might be six children around him watching and they all knew that they wanted to tell him the answers. So it was almost like it was a throne to him [E15]".

Educators. This theme related to educators' personal experiences and how they acted as barriers/facilitators to intervention. Educators' experiences of implementing PFSS formed three sub-themes: speech and language therapy service provision, educators' engagement with PFSS, and supporting children's PFSS use. Educators' experiences with service provision acted both as a barrier and a facilitator. Implementation was facilitated when educators felt the intervention in the current model was better than their previous speech and language therapy experiences. One educator commented, "The language cards ... I find quite annoying because we can do it as part of either a whole group or we try and grab a few minutes with one on one [E1]". Another commented on the benefit of a computer-based model for the child, "He was quite eager to go in ... as opposed to when we have a speech

therapist and we had one here all last term and they're a bit reluctant to go into their group time [E3]". But barriers existed as well. For example, one educator stated, "The computer program was far more difficult, in the sense that it was isolated learning. The other programs, we could incorporate that into everyday practice. And although you actually targeted it at a particular child, all the children got the benefit of it [E9]". Other educators felt that speech and language therapy services should be provided in the home not the early childhood environment, however they acknowledged the inherent difficulties in such a model, "I mean if you've got a parent you're probably better off instrumenting it at home ... But again you'd have to pick parents that are proactive in their child's development ... And parents who are willing to do the whole thing ... Because not all parents do. That's why we ended up doing speech here [E5]".

The ways in which educators engaged with PFSS were also important for the implementation of the program. Many educators found PFSS easy to use, even for educators who felt they had low levels of computer skills. The only barrier reported to using PFSS was that the educators needed to manually change the program level for children week to week, and this could be difficult to remember. Support from an SLT, especially with technology, was also important to educators and facilitated implementation of PFSS. Educators appreciated that support was available as needed, but for most, little support was necessary. However, the strong focus on educators providing input-based services that required listening and not speaking also created confusion for families, "Like they [the parents] were always asking "okay, its speech therapy but [their child] is not actually talking', they didn't understand the whole reasoning behind it [E22]".

Educators described barriers/facilitators in their ability to support children's technology use. Educators frequently supported children's PFSS engagement through operating technology that they had difficulty with, particularly using a mouse. One educator commented, "Sometimes I helped them and I said, "okay can you point to me which one, I

will click it for you”, so you make the process faster and they are more happy because they can go play after [E13]”. Educators encouraged children to participate in several ways. Firstly, some educators enlisted the help of peers, “It was quite hard to motivate him to, like I said before, to leave the activities, but to leave his friends. So the way we got around that was he could take a friend with him and show the friend what he was doing and after that he was really proud of doing it and was easy and fast [E4]”. Educators also encouraged participation by scheduling PFSS so that children would not miss out on favoured activities, “For some children we just found that it was a real punishment for them to come in during that outside playtime, so we would try really hard for those children not to let that happen [E23]” and providing extrinsic motivation, “So it was a bit of a bribe ... by saying look if we do this now then you can get time to play, you won’t miss out on play [E22]”.

b) Environmental

The environmental category describes the elements of the context that act as barriers/facilitators to service delivery using PFSS. Three themes emerged: policy and philosophy, physical environment, and logistic.

Policy and philosophy. Educators described two sub-themes relating to barriers and facilitators: child-centred practice and use of technology. The policies and philosophies of the setting regarding child-centred practice acted as barriers to the implementation of PFSS, for example in regards to child-centred practice, “We’re insisting they go onto a computer ... so that’s against our philosophy. We’re making them do something they didn’t particularly want to do [E11]”. However, another educator justified this deviation from child-centred practice, “It probably doesn’t run in line with the Early Years Learning Framework (Australian Government Department of Education Employment and Workplace Relations, 2009) ... but, when a child has a specific need, we are supposed to support that” [E20]. For another educator the deviation from typical child-centred practice was related to timing, rather than activity, “Because we had support for two hours in the morning, we were

trying to get them done in that time period as well. And then we would, you know, 'Can you come and do it now?' rather than having more time where they could probably come and choose when it suited them [E10]”.

For some early childhood centres, technology was not a typical part of the environment so the PFSS set-up represented a deviation from their philosophy and this acted as both a facilitator and a barrier. One educator from a setting in a less advantaged socioeconomic area said, “I think it was good to get a bit of experience using technology with the children [E15]”. In contrast, an educator from a more advantaged area said that their early childhood program deliberately focused on occupational therapy and motor skills and the addition of technology to their program created an additional problem for their philosophy, “Those kids that instantly gravitate to those sorts of games and play just hung around the laptop and so they weren’t out in the environment and they were the kids that needed that high activity sensory diet [E8]”.

Physical environment. The role of the physical environment on the inclusion/exclusion experience of children was discussed in three ways by educators. Firstly, in some cases the physical environment necessitated that children completing PFSS be physically separated from their peers. For example, “We have a room where the children could be viewable [E1]”. Secondly, the isolation created in the physical environment was sometimes a barrier to PFSS implementation, especially in terms of required staffing ratios, “I took him into the office and we did it in here, so then I had to remove myself from the room so we had to wait until there were two other staff members in the room, so I couldn’t do it in the middle of the day [E4]”.

Logistics. Temporal and technology factors were both raised as barriers/facilitators to the implementation of PFSS within the early childhood setting. In general, being able to complete PFSS sessions with children in the morning facilitated implementation while sessions in the afternoons were barriers. For example, “I found it better to do it in the

morning. Because towards the end of the day I think he's getting tired and he's less likely to sit there and concentrate for the full amount of time [E15]". Shorter sessions using PFSS also facilitated implementation, while longer sessions acted as a barrier. Duration of PFSS sessions was affected by many factors including the number of games to be played, game length, children's skills, and focus. For example, "Once they got used to it they could sit down and take five minutes and other kids who just weren't focusing could take 20, 25, half an hour [E18]". However, busy centre schedules acted as a barrier to the implementation where diverse needs had to be fitted within the program. For some educators the need to focus on other priorities within the centre was a barrier, for example, "It was a bit of a challenge at the time. Perhaps also because the child involved was also involved in the PALS [play and learning to socialise] program, and a school readiness program at the time [E6]". For another educator, the time of year that PFSS was implemented made a difference, "The intensity of fourth term for us is a bit of a nightmare [E1]" and for another it was the number of children participating at her centre that created a barrier "even if a maximum of two children did it on each day would make it a lot easier [E2]". However, a facilitator was commitment by educators to make time for the program, "the staff kind of made it fit in. They made time during the free play activity times to do things with that child [E16]".

Another logistical barrier related to children's attendance patterns, as this often meant limited time was available to complete PFSS each week, "The hardest thing that we found in using it was [that] with the children coming on a, for a 5-day fortnight, was the time for fitting it into our program ... Some days we didn't get to do it [E15]". Staff also reported challenges involved in having multiple children at the same setting using PFSS, and the availability of early childhood staff to either supervise PFSS participation or cover for staff who were supervising PFSS participation. For some settings, additional staffing allowed flexibility, "We used the extra funding for a person to come in and take our place within the classroom so us girls who actually know how to do it well could focus on that

[E23]”. In other settings the absence of additional staff was a barrier, “I think if we’d actually had someone that was with that child, doing it, so that one of the educators wasn’t taken away from it, it may have been a lot more manageable [E8]”.

Another logistical factor was the mode of technology used. Educators commented that children in the current cohort were less familiar interacting with non-touchscreen devices, “he’s used to the iPad, he found the mouse a bit difficult to manipulate, yeah. So in the end he was pointing to the screen [E17]”. Educators also saw wired technology as a barrier to implementation in the early childhood environment, “They used to get really frustrated with the headphones as far as like the wires ... like it would be great if they were cordless [E22]”.

c) Program-Specific

The program-specific category describes the features of the PFSS program and the implementation protocol that acted as barriers and facilitators to service delivery. From the educators’ point of view, the visual design of the PFSS software facilitated the children’s participation and engagement, for example, “It’s visual, it’s cute, it’s everything really a 4-year-old would want so it’s very enticing like that [E1]”. However, educators reported that barriers included the different focus within each of the PFSS activities (e.g., switching from initial sound identification to rhyming tasks) and educators being unable to view children’s progress from within a game. Games that were easy and could be completed more quickly were favourites and facilitated participation while harder games were a barrier, “Those easier ones I felt that they really did get a lot of enjoyment out of, but it was just when we got to some of the harder ones like blend and seek and often it would be really hard to motivate them to finish [E23]”.

Discussion

The aim of this investigation was to explore educators' perspectives on supporting PFSS computer-based intervention for children with SSD within their setting, in order to identify factors which acted as facilitators and barriers to implementing intervention.

Educators' perspectives

Educators were forthcoming in describing both positive and negative aspects of their experiences implementing PFSS within their setting. While their comments described experiences that related specifically to PFSS, their comments may also apply more generally to educators implementing other types of computer-based intervention in their settings. A number of the educators reported prior experience of supporting speech and language therapy in their setting. Their descriptions suggested minimal or no support was provided from a SLT; instead they were asked to implement therapy through scrapbooks and flashcards which were often given to them by children's parents. This situation led to educators not necessarily understanding the purpose or goals of the materials which they were directed to use. These experiences are confirmed by other research reporting that educators and SLTs often have minimal contact. For example, Glover et al. (2015) reported that although teachers and SLTs in their Australian study expressed a strong desire for more collaborative practice, few collaborative practices were currently occurring. Similarly, Baxter et al. (2009) reported in a study of primary schools in England that most frequently teaching staff have never had contact with an SLT, and the most frequent form of contact with an SLT was through telephone contact.

Educators generally viewed the use of PFSS positively because the amount of intervention seemed more concentrated, it was engaging and immersive, and educators could understand the process and support their students effectively. These findings resonate with those of Hartas (2004) who found that intervention agents, such as educators, feel happier when they are able to perform tasks within their professional scope. Computer-

based interventions such as PFSS can allow educators (including teaching assistants) to work in the familiar role of supporting children accessing technology and managing attention and behaviour, while not having to extend into areas of support where they may not feel they have adequate knowledge, training, and/or skills to be effective, such as providing feedback on speech accuracy as identified by Dodd and Barker (1990). This point is particularly important for supporting children with SSD as for such children intervention usually requires a specific set of activities to be completed on a frequent basis that are not relevant to an entire class (Wren et al., 2001). This is in contrast to strategies and activities for children with language difficulties which are used continuously throughout the day, impact on access to learning, and may benefit many children in the setting (Wren et al., 2001). Therefore, the use of computer-based intervention may mark a new type of service delivery where professionals collaborate through effective joint working (Lindsay and Dockrell, 2002), but educators have much higher levels of autonomy in delivery of support than previously possible. This is especially important in settings where educators with minimal levels of training (i.e., teaching assistants and volunteers) are increasingly called upon to support children with diverse needs with minimal training (Cumming and Wong, 2012; Giangreco, 2013). Indeed, in the Sound Start Study, it was often teaching assistants rather than qualified teachers who delivered PFSS.

However, there were some criticisms of the computer-based intervention style. Some educators were unsure of the effectiveness of the PFSS, in contrast some seemed displeased that learning from the program was limited to children enrolled in the research project. These issues were partly related to the nature of the Sound Start Study, designed as a randomised controlled trial to evaluate the benefit of PFSS to children with SSD. This meant that only children with SSD who met study inclusion criteria were selected to participate. However, this also highlights a fundamental difference in the philosophy of educators and SLTs. While educators have the perspective that all children should have equal access to

support, a typical SLT approach is that children with specific areas of difficulty require specific support (Hong and Shaffer, 2015; Tollerfield, 2003).

A number of educators commented on the role of the early childhood setting in supporting intervention for children with SSD, which is an increasingly prominent service delivery option (El-Choueifati et al., 2012). Some educators commented that interventions such as PFSS would be better completed by children at home and outside of the early childhood setting, but at the same time they acknowledged that this would mean children may not be able to access the intervention at all. These comments were usually associated with educators who had difficulty achieving the prescribed number of sessions of PFSS within the days that children were present at preschool. Other educators were very positive about providing speech and language therapy intervention at their setting as it meant that children would be able to access some form of speech and language therapy service, especially children in low socioeconomic situations who were unlikely to access services outside of their setting.

Barriers and facilitators

No clear pattern was identified in the factors that acted as barriers and/or facilitators to educator implementation of computer-based intervention in an early childhood centre. However, the factors identified were in line with previous work describing factors which affect the implementation and sustainability of interventions in schools that include personal factors (e.g., characteristics, attitudes, behaviours, support), organisational factors (e.g., administration, policies, procedures, training, support), and environment (Durlak and DuPre, 2008; Forman et al., 2009).

Factors which acted as facilitators in some situations acted as barriers in others, or at different points in time. For instance, the children's differing abilities to use the laptop and a mouse to complete the PFSS games was initially a barrier for many. However, some children quickly learnt these skills to be able to access PFSS more independently, changing

use of technology from a barrier to a facilitator. Conversely, the novelty of PFSS and the choice of games was initially a facilitator for many children. However, over time the repetition of the same games became a barrier. The lack of clarity around facilitators and barriers across the children, educators, and sites examined in this study point towards the need to consider the interactions between individual attributes, environment, and personal characteristics as outlined in holistic models of health such as the International Classification of Functioning, Disability and Health – Children and Youth (World Health Organization, 2007) and ecological models such as that explored by Bronfenbrenner (1994)

Two barriers in implementation were mentioned by the majority of educators. Firstly, the use of laptop and a mouse by the PFSS program was reported to impede children's access to the program, their independence in using the program and their desire to use the program. The solution to this raised by many educators was changing the program to a touch screen format which could be accessed from a hand-held device. They commented that children intuitively accessed technology in this way and that it required less co-ordination to interact in the program. The second difficulty mentioned by educators related to the implementation of PFSS in keeping with the specified intensity. For the purpose of the research project children were required to play the games four times a week for the 9 consecutive weeks of the intervention phase, which should have taken around 15 minutes per session. Many barriers made achieving the prescribed intensity difficult and in some cases, impossible. These factors mostly related to the time taken to complete sessions and the number of sessions that needed to be completed. This barrier of time is not new. Both McCartney et al. (2011) and Dodd and Barker (1990) noted that limited time for implementation diluted the intensity and in turn the effectiveness of the intervention. However, it also related to children's capacity and willingness to use PFSS, independence in using PFSS, and not wanting to miss out on other activities while completing PFSS. In terms of barriers within the environment, there were policy and philosophy difficulties such as the

early childhood settings' schedules, and logistical difficulties such as the time it took within the day to complete sessions and when sessions could occur during the day, the availability of people who need to be involved (both the educators and the children), and meeting government required staff to student ratios.

Limitations

This research was conducted in the context of a community-based randomised controlled trial to examine the effectiveness of PFSS, which brought with it strict criteria as to the implementation of the intervention in the early childhood centres. These constraints on the implementation of PFSS may have resulted in some of the issues raised by educators and described here such as the lack of support to carry over learning into the centre's program, strict eligibility criteria for participants, and stringent requirements for PFSS dose. As this was a research project rather than a clinical application of the intervention all children received the same intervention at the same time at the same dose level. This placed a burden on the setting and educators, especially sites with multiple children participating, and this may not reflect recommended or feasible implementation in non-research settings. An intervention evaluation, including adherence to implementation protocols and the importance of intervention intensity, has been explored within this trial and is discussed elsewhere (McCormack et al., 2016). Another limitation may have been that the early childhood settings that agreed to participate in the trial were already positively predisposed to engage with SLTs and provide intervention. This may have led to selection bias in that the early childhood settings participating in this study had already demonstrated one of the two stages of implementation examined, that is, adoption of a program and then implementation of that program (Fixsen et al., 2005).

Future Research

Future research regarding computer-based intervention in early childhood settings should consider the perspectives of all stakeholders engaged in the process, not just the

perspectives of educators. While educators' voices are important as the directors of the settings and the staff who are implementing the intervention, the voices of the children, their parents, and staff not directly involved in implementation would provide valuable perspectives into how implementation could be optimised in these settings. While in this study the children's voices were heard through their educators, future research should consider children's perspectives on their intervention experiences directly (Holliday, Harrison and McLeod, 2009; Owen, Hayett and Roulstone, 2004). Future research should also consider the implementation of different computer-based interventions, interventions used within a clinical paradigm, computer-based interventions in different environments, and factors influencing response to intervention and the need for referral to direct speech language therapy services.

Conclusion

Implementation of computer-based intervention within an early childhood setting for children with SSD may be impacted by many barriers and facilitators; personal, environmental and program-specific. Further, the perception of factors as barriers or facilitators was influenced by characteristics of the child, the educator and the setting, such that what was perceived as a barrier in one context could be perceived as a facilitator when working with a different child, or a different educator or in a difference setting. Delivery of speech and language therapy services in early childhood settings needs to take these factors into consideration, and requires collaboration with educators during planning and implementation to design services that best meet the needs of children, educators, parents, and SLTs.

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Conflict of interests

The authors declare that there is no conflict of interest. The authors acknowledge that [author] and [author] developed the PFSS software used in this project; however, they were not directly involved in the implementation of this project, had no contact with participants, and did not participate in data collection or analysis.

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Table 1.

Key roles and responsibilities of educators and the research team

Educator responsibilities	Research team responsibilities
Ensuring that children participated in the required amount of intervention with PFSS (four sessions a week of around 15 minutes duration for nine consecutive weeks)	Identify intervention targets of each child
Monitoring children to ensure they remained on task and completed all games, changes children's goals weekly within the program	Train educators in the use, management, and backup of PFSS
Maintaining records of children's attendance and participation in intervention and backing up PFSS files every week	Answer educator questions and resolve technical and logistic issues
Describing their experiences with the intervention in a phone interview at the conclusion of the intervention	Visit the preschool throughout the intervention to check on intervention progress and record keeping

Table 2

Categories, themes, and subthemes identified in the thematic analysis

Category	Theme	Subtheme	Points
Personal	Children	Child engagement with PFSS	Capacity to complete PFSS games/tasks Participation in PFSS program Awareness of performance Child’s independence
		Child’s inclusion/exclusion experience	Child’s response to inclusion/exclusion
	Peers		
	Educators	Speech and language therapy service provision	Providing speech and language therapy services in the early childhood setting
		Educator engagement with PFSS	Technology and PFSS experiences Speech and language therapist support
		Supporting children’s PFSS use	Technology use Engaging peer participation Encouraging participation
Environmental	Policy and philosophy	Child-centred practice	
		Use of technology	
	Physical environment	Inclusion/exclusion	Physical isolation In the play environment Staffing
	Logistics	Time	Timing of PFSS sessions Time to use PFSS People in the early childhood setting
		Technology	PFSS setup Supporting technology Project specific
Intervention-Specific	PFSS program	PFSS Format	
		Specific PFSS games	
		Duration of games	

Key. PFSS, Phoneme Factory Sound Sorter (Wren and Roulstone, 2013).

Appendix A

Teaching assistant and preschool director interview schedule

- 1) How did using Phoneme Factory Sound Sorter (PFSS) fit into your preschool routine?
 - a) Were there any issues in relation to your preschool policies or processes?
- 2) Can you tell me what it was like to use PFSS?
 - a) What worked well /what did not work so well?
 - b) How did it compare to any other tasks suggested by speech-language therapists?
- 3) How did the children get on using the PFSS?
 - a) What kind of support did you need to give them, if any?
 - b) What worked well for the children/what didn't work so well for them?
 - c) Did they make any comments to you about using it?
- 4) What would make the PFSS better/simpler to use?
- 5) Is there anything else you'd like to discuss?