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Teachers' use of assistive listening devices in inclusive schools

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The objective of this study is to examine factors that can explain teachers' use of assistive listening devices in inclusive schools for pupils with hearing loss (HL). Assistive listening devices, such as teacher-microphones and pupil-microphones, can ensure an enhanced listening environment for such pupils and thus induce a higher level of participation in the teaching. The study included 167 teachers of pupils with HL in fifth through tenth grades. The analyses indicated that factors related to the teachers, pupils, parents and technology influenced the teachers' use of microphones. Teachers with positive attitudes toward the microphones tend to integrate them regularly in classroom communications compared with teachers who are negatively inclined. Frequent use of the microphones also occurred if pupils had severe HL. Furthermore, parents who tend to be highly involved in the children's school performance indirectly affected the teachers' microphone use. Additionally, frequent use of pupil-microphones seems to be dependent of the number of microphones; a high-density of microphones promoted their use.

Keywords: hearing impairments; assistive listening devices; inclusive schools

Introduction

Advances in technology have increased the inventory of available tools and teaching strategies to improve the participation of children with disabilities in educational settings and activities (McGregor and Pachuski 1996). This technology can be important for inclusive schools which are the guiding political vision in Norway; every child has the right to attend a school in their local community, and all teaching must be adapted to the individual's abilities and interests. Participation in education is critical to success, but for many children with disabilities, participation is a constant struggle (Craddock 2006). Classroom noise, rapid discussions, frequent changes in topics, and large numbers of people involved in the conversations prevent in particular children with hearing loss (HL) from hearing, understanding, and participating in the verbal classroom communications that are fundamental activities in schools (Crandell, Flexer, and Smaldino 2005). Assistive listening devices can improve the children's ability to perceive and participate in classroom communication (Luckner and Muir 2001). However, the use of assistive technologies often depends on the teachers' willingness to integrate them into their classroom routines (Luckner and Muir 2001; Wright et al. 2006; Murchland and Parkyn 2010; Craddock 2006; Hemmingsson, Lidström, and Nygård 2009; Skär 2002; Eriks-Brophy et al.

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2006). This reluctance against to use the technology may be caused by of a variety of factors, such as their attitudes towards the equipment or type of equipment. It may also depend on students' degree of HL, because students with mild HL receive less educational support (Most 2004).

The objective of this study is to examine how teachers implement teacher-microphones and pupil-microphones in teaching, and to explore factors that may influence implementation. Few studies are conducted on the experiences with and how they are used, although pupils with HL can apply for various systems free of charge as part of the Nordic countries' disability policies (Ravneberg 2009). A comprehensive understanding of teachers' practices with the technology may improve the interventions and advice provided to schools by specialists.

Research questions

The goal of this research is to examine the factors that promote teachers to regularly integrate assistive listening devices into their classroom routines. The factors explored related to the teachers, pupils, parents, and types of educational and technical interventions. A structural equation model (SEM) was used to examine to what extent these factors can explain the variations in use.

Previous research

Children with HL appear to be well accepted by teachers, and teachers are generally willing to be trained by specialists on appropriate teaching modifications (Lynas 1986; Hyde and Power 2004; Punch and Hyde 2010; Polyclinic 2009). Frequently recommended modifications besides implementing assistive listening devices are to give written information, repeat answers from classmates, speak clearly, and be aware of the students' understanding of the classroom communication (Coniavitis-Gellerstedt 2006). Although, teachers are reported to maintain a positive mindset towards children with HL, the majority of the teachers in Lynas' (1986) study incorporated only minor adaptations. Coniavitis-Gellerstedt (2006) found that 75% to 90% of 1000 teachers of pupils with HL claimed to adjust their teaching when necessary, yet 40% of the microphones supplied were not utilised. Other studies have arrived at similar conclusions; assistive listening devices seem to be used infrequently by teachers (Ludlow 2001; Zabala 1995; Craddock 2006; Bergkvist 2001; Coniavitis-Gellerstedt 2006). Teachers may consider assistive technologies too troublesome to manage, disrupting while teaching, too complex, or uncomfortable to wear (Copley and Ziviani 2004; Heeney 2007; McGregor and Pachuski 1996). According to Heeney (2007), some teachers felt uncomfortable using a sound field system because their voices sound distorted or the microphone headset were improperly adjusted. Frequent technical problems also led to negative attitudes.

Other recommended interventions are to reduce the class size if there are more than 20 pupils in the class and to improve the classroom acoustics (Grønlie 2005). Many pupils also are given special education, and consequently are less taught together with the class (Wendelborg and Tøssebro 2008). In what extent these intervention may affect the teachers' implementation of assistive listening devices are less focused.

Antia (1999) argued that in general, teachers prefer teaching modifications that benefit the entire class. Adaptations specific to children with HL are less acceptable

and less likely to be implemented. The type of technology supplied, may therefore be important; several studies strongly support the implementation of sound field system in all schools, because of the positive implications for all children's academic performance and for teachers' health and teaching (Crandell, Flexer, and Smaldino 2005; Heeney 2007; Rosenberg et al. 1999). The use of loudspeakers is recognised as a method to overcome problems associated with noise, distance, and reverberation in classrooms. Loudspeakers improve the listening environment, thereby allowing more teaching time because of the instruction are repeated less, and the advantages of this technology may promotes its regular use. The number of pupil-microphones also affects their use. Teachers with a high-density of pupil-microphones integrated them more regularly compared with teachers with a low-density of microphones, as the latter situation was too complicated to manage (Rekkedal 2007).

To effectively integrate this technology, teachers must be provided with sufficient information regarding the children's specific impairment and the technical aids supplied to them (Lynas 1986; Antia et al. 2009; Punch and Hyde 2010; Chmiliar 2007; McGregor and Pachuski 1996; Wright et al. 2006; Craddock 2006). Furthermore, they should be involved in the assessment process along with the therapists (Wright et al. 2006). Teachers themselves have stated that a lack of information prevents them from implementing the necessary educational adaptations (Coniavitis-Gellerstedt 2006; Polyclinic 2009). Insufficient funds and limited time may be reasons for why teachers do not receive the necessary training (Punch and Hyde 2010; Chmiliar 2007).

Additionally, the teacher's gender is a possible factor in his/her use of technical aids; compared with their male counterparts, female teachers are described as more involved with their pupils compared to males and are more considerate of the needs of individual pupils (Demetriou, Wilson, and Winterbottom 2009).

Pupils with mild HL are often reported to be ignored because they are believed to have less need for support compared with pupils with severe HL (Convertino et al. 2009; Marschark, Lang, and Albertini 2002). Some studies found that teachers reported that students with mild HL performed more poorly in school compared with students with severe HL, because of a less supportive setting (Most 2004; Wolf 2007). Older pupils are another group who are infrequent users of assistive listening devices (Coniavitis-Gellerstedt 2006; Kent and Smith 2006). The stigma connected to assistive technology is considered a barrier for their use.

Numerous studies have suggested that parental involvement affects children's outcomes above and beyond other factors, such as socioeconomic status and parents' education, which have traditionally been thought to predict a child's academic success (Hill and Taylor 2004; Griffith 1996; Mahoney 2011). However, parents of children with disabilities report that professionals and the schools often disregard their specific requests, although the parents are concerned about their children's academic performance (Lundeby and Tøssebro, 2008). Nevertheless, it is possible that parents' interest in school outcomes can lead teachers to be more attentive towards the pupils, and consequently make necessary teaching modifications, including using assistive technology.

Analysis model

Figure 1 presents a designed and simplified analysis model for ease of understanding and reads from left to right. Use of teacher-microphones and pupil-microphones are

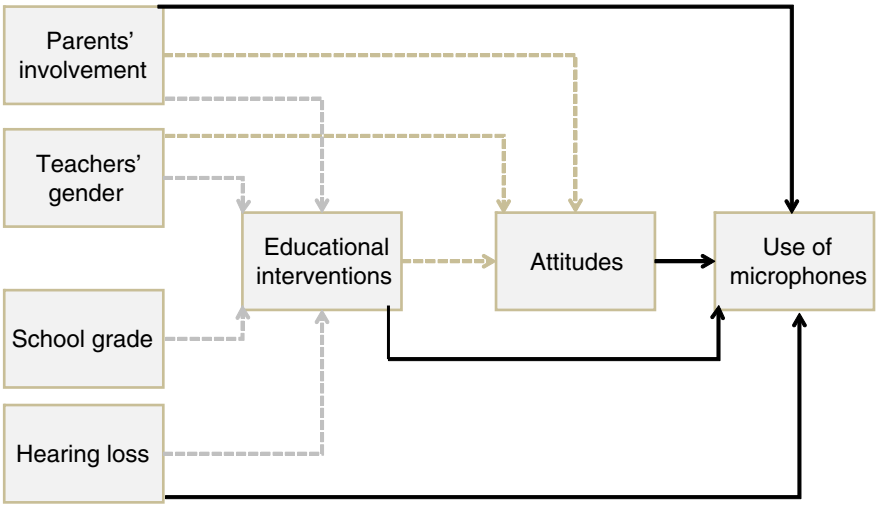

Figure 1. The theoretical model of the interactions between microphones uses and the factors related to the teachers, students, parents, and educational and technical interventions represented by knowledge, class size, participation in classroom lessons, acoustics, loudspeakers, number of pupil-microphones, and errors with the microphones.

the dependent variables. The grey lines correspond to the variables anticipated to have an indirect effect on the dependent variables. Some of these variables are also believed to have direct effects as represented by the black lines in the figure. The independent variables are expected to be correlated.

The teachers were characterised according to gender, their attitudes towards the equipment and knowledge about hearing impairment and the technical aids, whereas the exogenous variables HL and school age represent the pupil factors. The parents were evaluated on their involvement in their child's academic progress and social behaviour.

The teachers' attitudes towards assistive technology are regarded as a critical intermediate variable, because positive attitudes seem to be essential to the successful implementation of assistive technology (Copley and Ziviani 2004; Ludlow 2001; Silverman, Stratman, and Smith 2000; Heeney 2007). Their approaches to and use of microphones was expected related to the following previously defined factors: the characteristics of the teachers, pupils and parents, as well as those of the educational and technical interventions. Based on previous research a hypothesis was that teachers would be positively inclined towards the microphones if they were female (Demetriou, Wilson, and Winterbottom 2009). Furthermore, infrequent use of microphones among adolescents has been reported; and was also anticipated to affect these results. A high degree of knowledge about hearing impairment and the technical equipment was assumed to be a positive predictor, as were parents who demonstrate a high degree of involvement in their children's schooling. If the teachers experienced few technical problems and/or taught small classes, they were expected to be content. Managing the pupil-microphones can be challenging in large classes, whereas use of teacher-microphones may occur irregularly in small classes. Teachers may also consider the use of microphones sufficient to accommodate the pupils' needs and consequently make fewer educational adaptations. Additionally,

the teachers were assumed to be positively disposed towards the microphones if the pupils participated regularly in classroom activities, thereby affecting the teachers' use of assistive technology. All of these factors were expected to impact the implementation of the microphones.

The type of technical equipment, such as loudspeakers and a high-density of pupil-microphones (although the density of microphones was evaluated only with pupil-microphones) were believed to be positively correlated with the use. Classroom acoustics were also important; poor acoustic design exacerbates the problems of noise in modern classrooms and increases the children's difficulties in understanding their teachers (Heeney 2007). Use of microphones was assumed to occur frequently in rooms with poor acoustics to improve the listening environment. Finally, the characteristics of the parents and the pupils were also hypothesised influencing the types of technical and educational interventions offered.

Methods

The participants were Norwegian teachers assigned to pupils with HL who ranged from fifth to tenth grade and were in ordinary schools. The pupils were recruited from twelve Assistive Technology Centres and four National Resource Centres for Hearing Disability. Two counties were excluded because a pilot project was completed in these counties in 2007. Information letters were sent by the centres to the parents to inform them about the survey and to obtain permission to contact the children's teachers. In all, 187 parents consented, resulting in a participation rate of approximately 34%. No data were available for the pupils who did not participate, and it was difficult to perform a non-responder analysis. However, the target group consisted of younger children with HL, a group often subjected to research, and parents may be more ambivalent about allowing them to participate.

Questionnaires and information letters were sent to the 187 teachers approved by the parents and 167 teachers returned the questionnaires, a response rate of 89%. The teachers were offered two response alternatives, either by Internet or on paper, and 80.6% answered via paper. Table 1 presents the distribution of the teachers' gender and age. The majority were females between 31 to 50 years of age. Table 1 shows the distribution of school grades; with the majority of teachers worked with pupils in primary schools (fifth to seventh grade), and a smaller number were in secondary schools (eight to tenth grade).

Table 1. The distribution of teachers' gender, age, and school (%, N = 167).

Males	32.1
Females	67.9
Age	
< 30	10.2
31–50	56.3
> 51	33.5
Primary school	60.3
Secondary school	39.7

Ethical considerations

The study was approved by the Norwegian Social Science Data Services. Questionnaires and a description of the study were sent to the teachers. The teachers were informed of the anonymity of the research and that they could quit the study at any time. It has been reported that teachers endure high stress levels due to demands from administrators, colleagues, and students, which is compounded by work overload (Klassen and Chiu 2010). It may feel overwhelming to also spend time on questionnaires; however, the teachers responded positively, and some teachers remarked that the questionnaires were useful.

Type of equipment

Table 2 presents the number of teachers supplied with teacher-microphones. Approximately 74% of the teachers who received teacher-microphones were also given pupil-microphones. The majority were provided with a high-density of pupil-microphones (e.g. one microphone per one or two classmates), as observed in Table 2. The classmates must be willing to handle these microphones. During classroom conversations, a pupil must press the microphone switch. Furthermore, all microphones must be regularly charged.

Differences emerged between the teachers in the primary and the secondary school regarding the distribution of pupil-microphones. Approximately 80% of the teachers in the primary schools were supplied with pupil-microphones compared with 63% of the teachers in the secondary schools ($\chi^2 = 5.424$, $p = 0.017$). No differences were found between the groups regarding teacher-microphones ($\chi^2 = 0.111$, $p = 0.469$).

Normally, the following three types of sound transmission systems are supplied; microphones connected to loudspeakers, microphones in combination with inductive loop systems, or microphones in combination with FM systems, as shown in Table 2. The latter two systems may further be connected to loudspeakers. Differences emerged between the classrooms with loudspeakers and those without in terms of the density of pupil-microphones ($\chi^2 = 8.005$, $p = 0.004$). Approximately 76% of the classrooms with no loudspeaker systems were supplied with a high-density of

Table 2. Use of assistive listening devices (%, N = 167).

Have teacher-microphones	
Yes	90.5
No	9.5
Number of student microphones	
One microphone per more than five classmates	14.3
One microphone per five classmates	3.6
One microphone per four classmates	11.6
One microphone per three classmates	8.0
One microphone per two classmates	47.3
One microphone per one classmates	15.2
Type of sound transmission system	
Loud speaker only	49.7
Inductive loop with or without Loudspeaker	29.8
FM with or without loudspeaker	20.5

pupil-microphones, whereas 49% of those with loudspeakers had a high-density of microphones.

Approximately 56% of the teachers reported that they always used teacher-microphones during teaching and classroom conversations, 30% reported that they almost always used them, and 14% used them sometimes or seldom. The usage of pupil-microphones was lower; only 17% of the teachers reported always using them, 45% used them almost always, and 38% used them sometimes or seldom.

Measures

The survey questions were designed based on the literature described above and on a previous pilot project. The dependent variable 'use of teacher-microphones' was measured with the question; 'how often do you use microphones when: (1) you teach and speak to the entire class; and (2) you have class discussion/conversation ('never,' 'seldom,' 'sometimes,' 'almost always,' or 'always'). The two items were combined into one factor with a Cronbach's alpha of 0.576, which is less than ideal. A similar question and response alternatives measured the second dependent variable 'use of pupil microphones.' The pupils' microphone usage was evaluated with the following categories: (1) classmates ask or answer questions during class; (2) classmates have class discussions/conversations; (3) classmates ask or answer questions during lessons together with other classes; and (4) classmates are performing or reading. The four items were combined into one factor with a Cronbach's alpha of 0.804.

Four variables were related to characteristics of the teachers. A five-item questionnaire assessed the teachers' 'attitudes towards teacher-microphones'; (1) the microphone is impractical to wear; (2) the microphone is too much to control/handle; (3) it is difficult to switch the microphone on and off during the lesson; (4) the students tend to concentrate more when the microphone is used; and (5) the microphone is used even when the student is absent ('totally disagree,' 'disagree,' 'neither agree nor disagree,' 'agree,' and 'totally agree'). Principal component analysis confirmed one factor, and a Cronbach's alpha of 0.726 was satisfactory. The variable 'attitudes towards pupil-microphones' had similar response alternatives as to the teacher-microphone, and the following statements were evaluated; (1) it is easy for pupils to use the microphones correctly; (2) the microphones hinder pupils' spontaneity; (3) the microphones structure/discipline the pupils; (4) it is difficult to motivate the pupils to use the microphones; (5) the microphones are in use even if the particular pupil is absent; and (6) the microphones are too much to control/handle. Principal component analysis indicated one dimension, and the Cronbach's alpha of 0.744 was acceptable. Two questions measured teachers' 'knowledge'; (1) how much knowledge do you have about hearing impairment ('have little or no knowledge,' 'have some knowledge but need to learn more,' and 'have enough knowledge'); and (2) How well do you know the microphone system ('I am able to handle the system but unable to fix simple errors, such as lack of antennas or power supply,' and 'I have good knowledge and am able to fix simple errors, such as lack of antennas or power supply'). The Cronbach's alpha of only 0.441 for the two questions was less than ideal. However, the variable was treated as one factor to obtain a continuous variable. Finally, the teachers' gender (0 = male, and 1 = female) was treated as a dichotomous variable.

Two variables related to the pupils. HL was based on a measurement used in Hendar's study (Hendar 2008), and is presented in Table 3. The variable was transformed into a dichotomous variable (0 = hear without hearing aids, 1 = hear

Table 3. The distribution of the pupils' HL (%, N = 167).

Can hear speech without hearing aid at a distance of one metre	58.9
Can hear speech with hearing aids/cochlea implant at a distance of one metre	30.4
Cannot always hear speech with hearing aids/cochlea implant at a distance of one metre	10.2
Cannot hear speech with hearing aids/cochlea implant at a distance of one metre	0.6

with hearing aids/cochlea implant), as was the pupils' 'school grade' (0 = secondary school, and 1 = primary school). The teachers evaluated the variable 'parents' involvement' with the following questions; to what extent are you satisfied with parents' involvement in the following settings: (1) the pupil's academic performance; and (2) the pupil's social performance ('to no degree,' 'to a minor degree,' 'to some degree,' 'to a high degree,' or 'to a very high degree'). The two items were converted to one factor with a Cronbach's alpha of 0.889.

Three variables were related to the equipment and four variables to the educational interventions. Use of loudspeakers was treated as a dichotomous variable (0 = no, and 1 = yes). Table 2 shows the 'number of pupil-microphones' per pupils. The statement 'there are often some errors with the (teacher-/pupil-) microphones,' had response alternatives similar as to those for the attitudes towards teacher-microphones.

The variable 'educational adaptations' was adapted from the Conivatis-Gellerstedt study (2006) and consisted of the following seven items; how often do you give: (1) introduce new information, concepts, and words written on paper or blackboard; (2) visualise the lecture with concrete pictures; (3) give individual instructions or preparation beforehand; (4) pay attention to the student's understanding; (5) repeat classmates' answers; (6) place the pupil so he/she can see both classmates and teachers; and (7) speak more clearly ('never,' 'seldom,' 'monthly,' 'weekly' and 'daily'). Principal component analysis indicated two factors, however the Cronbach's alpha appeared unsatisfactory for the two factors, whereas a Cronbach's alpha of 0.775 for all items was acceptable.

'Participation' in teaching was measured with by hours of special education outside the classroom ('3–4 hours daily,' '1–2 hours daily,' '3–4 hours weekly,' '1–2 hours weekly,' '2–3 hours monthly,' and 'less'). 'Class size' was a continuous variable where the number of pupils varied from 7 to 72. Classroom 'acoustics' was measured with the response alternatives 'extremely poor acoustics,' 'poor acoustics,' 'good acoustics,' 'extremely good acoustics,' and 'unsure.'

Analysis

Version 18.0 of the SPSS (SPSS Inc., Chicago, IL, USA) software package, along with AMOS 18, was used for the statistical analysis. Statistical significance was set at $p = 0.05$. Chi-square tests for independence were performed to compare the differences in obtaining pupil-microphones for the teachers in primary and secondary schools and teachers with and without loudspeakers. A principal component analysis was carried out to evaluate data reduction for the variables 'attitudes towards teacher-microphones and pupil-microphones.' Cronbach's alpha was computed to estimate the internal consistency of all of the instruments used.

To examine the assumptions of the theoretical structural equation model (SEM), bivariate regression analyses of the dependent and independent variables were conducted, followed by multiple regression analyses. AMOS was performed in conjunction with the SEM analyses. The assumption of the SEM analyses was, unfortunately, not supported. Only exogenous variables may be dichotomous in an SEM analysis. Almost all of the endogenous variables used here were continuous, except from the dichotomous variable 'loudspeakers,' which was treated as an endogenous variable in the analysis of the teacher-microphones. However, the multiple regression analyses indicated that 'loudspeakers' significantly affected 'attitudes towards teacher-microphones' (Beta $=0.451$, $p<0.001$) and 'use of teacher-microphones' (Beta $=-0.219$, $p<0.01$).

Data screening and collinearity diagnostics

Data screening revealed skewed distributed data concerning the use of teacher-microphones and pupil-microphones. Although the distributions were negatively skewed, SEM analyses were completed for both variables. A structural analysis of the collinearity diagnostic for the variables included in the SEM analyses indicated no collinearity for the teacher-microphones variable (tolerance: 0.84 to 0.95; VIF: 1.04 to 1.18). The result of the Durbin–Watson test was well within the boundaries for acceptance (Durbin–Watson $=1.96$), and interpretation residuals gave no reason for concern (Cook's distance <1). No collinearity was found concerning pupil-microphones (tolerance: 0.83 to 0.92; VIF: 1.08 to 1.19), and the result of the Durbin–Watson test was well within the boundaries for acceptance (Durbin–Watson $=1.87$). The interpretation residuals gave no reason for concern (Cook's distance <1). The two intermediate variables, 'attitudes towards teacher-microphones' and 'attitudes towards pupil-microphones' had satisfactory normal distributions.

Reliability and validity

Internal consistency measured through Cronbach's alpha was acceptable for the questions used, except for 'use of teacher-microphones' and 'knowledge.' Other options for measuring reliability, such as performing a test-retest were deemed unrealistic.

No standardised tests were used, although they are preferable and may improve the construct validity. The concept of attitudes towards microphones was composed based on secondary literature and a previous pilot project. However, Cronbach's alpha proved satisfactory and may indicate an acceptable conceptual validity. Two less reliable variables investigated were 'classroom acoustics' and HL. These variables were measured imprecisely, but the pilot project had shown that not all parents had access to an audiogram.

The internal validity seems satisfactory, and a causal connection was found between the dependent and independent variables. However, the difficulties determining the cause and effect may be a threat to the internal validity. Whether the variables reflect the past or the present is an important issue. Almost all of the personal and all of the intervention variables are considered to reflect the past. The dependent variables 'attitudes' and 'use of microphones' represent the present;

consequently the causality between the variables is not quite clear. Additionally, the causality between errors and the use of pupil-microphones is unclear.

Results

Initial analyses

To prepare the SEM analyses, bivariate regression analyses were first conducted. All the independent variables, which included the educational/technical interventions and the characteristics of the teachers, pupils and parents, were analysed with the two intermediate variables 'attitudes towards teacher-microphones and pupil-microphones' and the two dependent variables. The independent variables with significant effects were subsequently included in the multiple regression analyses, and the variables with significant effects in any of the multiple regression analyses were included in the SEM analyses.

The variables with significant bivariate relationships to 'attitudes towards teacher-microphones' included the following: knowledge, loudspeakers, errors, gender, and parents' involvement. The multiple regression analysis indicated that all of the variables except 'errors' became significant predictors and these variables were included in the SEM analysis.

The variables with significant bivariate effects on the use of teacher-microphones were 'attitudes towards teacher-microphones,' 'knowledge,' 'educational adaptation,' 'HL' and 'parents' involvement.' Only the variables 'attitudes towards teacher-microphones' and HL became significant in the multiple regression analysis and were included in the SEM analysis.

Similar to the results of the teacher-microphones analysis, 'errors' and 'knowledge' were significant predictors for 'attitudes towards pupil-microphones.' Additionally, 'school grade,' 'number of pupil-microphones,' and 'acoustics' exhibited significant effects. All of the variables except 'school grade' contributed significantly in the multiple regression analysis. 'School grade' was nevertheless included in the SEM analyses because the variable significantly influenced some of the educational interventions. 'Acoustics' was excluded from further analyses because 11.6% of the respondents answered 'unsure.'

The variables 'attitudes towards the pupil-microphones' and 'HL' had bivariate effects on the use of pupil-microphones. Moreover, the findings were significant for 'knowledge,' 'number of pupil-microphones' and 'errors.' All of these variables were included in the SEM analysis. No bivariate associations were found between the microphones and 'participation in classroom activities' or 'class size,' and these variables were excluded from further analyses.

Factors directly affecting the microphone use

The initial theoretical model (Figure 1) resulted in unsatisfactory fit indices, i.e. an unsatisfactory agreement between the reproduced and the existing covariance matrix. Modifications based on the theoretical considerations and suggested modifications made by AMOS produced the modified SEM shown in Figure 2 for the teacher-microphones and Figure 3 for pupil-microphones. The model fits were acceptable. The chi-square (v2-test) yielded results that were not significant, indicating that there were no significant differences between the modified theoretical model and the

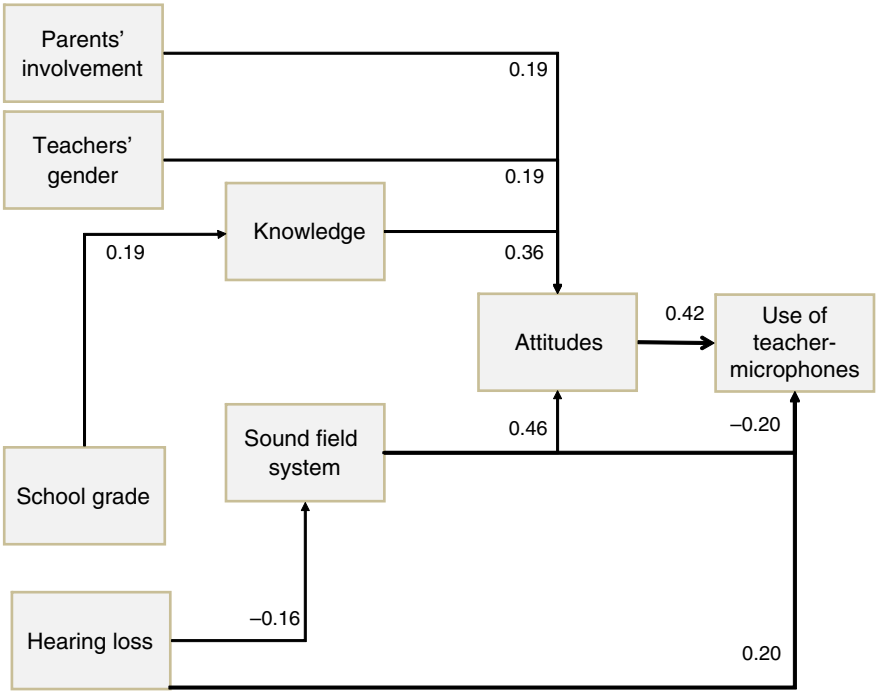

Figure 2. The modified structural equation model of the relationship between the use of teacher-microphones and the factors related to the teachers, pupils, parents, and technical and educational interventions.

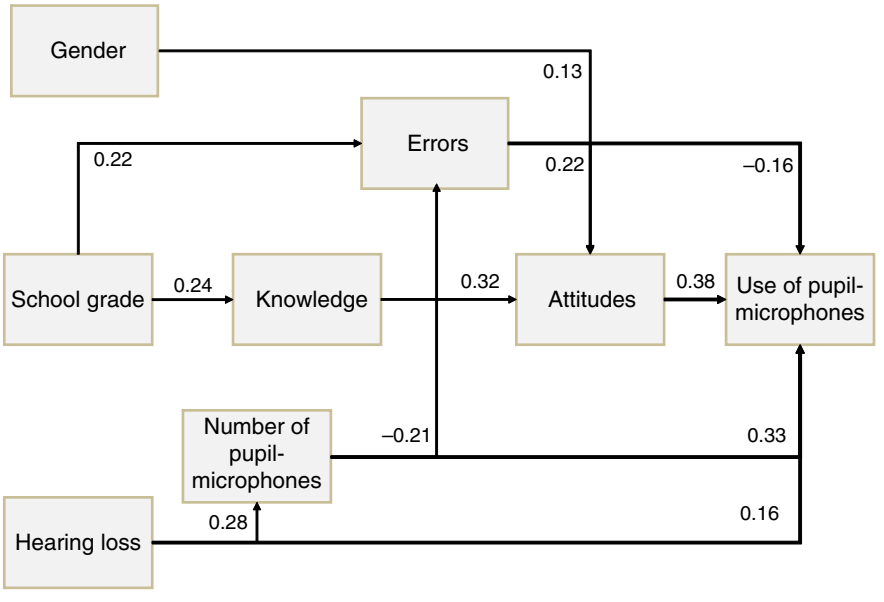

Figure 3. The modified structural equation model of the relationship between the use of pupil-microphones and the factors related to the teachers, pupils, and technical and educational interventions.

empirical models based on the data. The root mean square error of approximation (RMSEA) was 0.04 for Figure 2 and 0.02 for Figure 3; a REMSEA under 0.05 is considered to be an acceptable fit. The goodness of fit indices (CFI/IFI = 0.975; TLI = 0.939) of Figure 2 and (CFI/IFI = 0.992; TLI = 0.983) of Figure 3 were all over 0.9, which is the threshold value for a satisfactory model fit.

Figures 2 and 3 present the standardised beta coefficients for the use of teacher-microphones and the use of pupil-microphones and are to be read from left to right. The thick lines represent the variables with direct effects on the dependent variable 'use of microphones' which appears on the right side of the figure. The other lines represent the variables with indirect effects on microphone utilisation.

The analysis indicates that 'attitudes towards the microphones' and 'HL' directly affect the use of teacher-microphones (Beta = 0.42, 0.20) and pupil-microphones (Beta = 0.38, 0.16). The teachers tended to consistently use teacher-microphones and pupil-microphones if they were positively inclined towards using the equipment or worked with pupils with severe HL. The educational and technical variables differed in their direct effects on usage of teacher-microphones and pupil-microphones. 'Loudspeakers' is associated with use of the teacher-microphones (Beta = − 0.22). Although the use of loudspeakers appears to be non-significant in the bivariate regression analyses, when controlled for other variables the SEM analysis indicates that use of loudspeakers negatively affects the teacher-microphones usage. Accordingly, loudspeakers appear to lead to reduced utilisation of teacher-microphones rather than frequent utilisation as has been assumed. 'Number of pupil-microphones' and 'errors' (Beta = 0.33, −0.17) are related to the use of pupil-microphones. A high-density of microphones appears to promote regular use. Frequent technical problems negatively impact the use of pupil-microphones.

Factors indirectly affecting the use of microphones

The other independent variables indirectly affect use of microphones though the intermediate variables. 'Knowledge' was associated with the attitudes towards both teacher-microphones (Beta = 0.36) and pupil-microphones (Beta = 0.32). Use of loudspeakers (Beta = 0.46) positively influenced the attitudes towards teacher-microphones. The personal characteristic of the teachers' gender' is related to both teacher-microphones (Beta = 0.19) and pupil-microphones (Beta = 0.13). Female teachers seem more satisfied with the microphones than male teachers. A positive approach to the teacher-microphones is further associated with high parental involvement in the children's school performance (Beta = 0.19).

The exogenous variable 'school grade' interfered with the educational and technical interventions. As shown in Figure 2 and Figure 3, 'school grade' appears to be associated with 'knowledge' for both teacher-microphones (Beta = 0.19) and pupil-microphones (Beta = 0.24). The teachers in the secondary school tend to report less knowledge about hearing impairment and the technical aids. Frequent errors with the pupil-microphones (Beta = 0.22) also influence the teachers' attitudes. HL is associated with the type of technical equipment supplied. Pupils with severe HL (Beta = − 0.16) tend to use loudspeakers less and to frequently be supplied with a high-density of pupil-microphones (Beta = 0.28) as presented in the figures.

Table 4 presents the different variables' standardised total effects on one another regarding the teacher-microphones. The total effect is the combination of the direct effect and indirect effects through other variables. The bottom row presents the

Table 4. The total effects that the variables in Figure 2 have on one another (standardised beta coefficients).

	Loudspeakers	Knowledge	Parents' involvement	Hearing loss	School grade	Teachers'gender	Attitudes
Loudspeakers	–	–	–	−0.16	–	–	–
Knowledge	–	–	–	–	0.19	–	–
Attitudes	0.45	0.36	0.19	−0.07	0.07	0.19	–
Use of teacher-microphone	−0.03	0.15	0.08	0.20	0.03	0.08	0.42

dependent variable, and the columns indicate the independent variables. Each column should be read from top to bottom. Because 'loudspeakers' had a strong positive effect on attitudes, the total negative effect on use of teacher-microphones became nearly zero (Beta = −0.03). The adjusted total effect of 'HL' (Beta = 0.20) is the same because of the variable's negative effect on 'loudspeakers.' 'Knowledge' acquired an indirect effect (Beta = 0.15) through the variable attitudes. 'Parents' involvement' affected to some degree, as seen in Table 5. The independent variables explained 40% of the variance in the attitudes towards teacher-microphones, and 19% of the variance in the use of teacher-microphones.

Table 5 presents the variables' standardised total effects on the use of pupil-microphones. The adjusted total effect of the number of pupil-microphones (Beta = 0.34) became slightly higher. HL (Beta = 0.26) exhibited a higher total effects because of the variable's direct and indirect effects on usage. 'Knowledge' (Beta = 0.12) acquired an indirect effect similar as to the teacher-microphones. The adjusted total effect of 'errors' (Beta = −0.07) became approximately zero. The independent variables explained approximately 18% of the variance in the attitudes towards pupil-microphones and approximately 32% of the variance in the use of pupil-microphones.

Discussion

The present investigation of the teachers' implementation of microphones to pupils with HL in inclusive schools aimed to examine to what extent teachers integrate microphones into their classroom routines and to explore factors that can influence the implementation of microphones. Based on secondary research, it was hypothesised

Table 5. The total effects that the variables in Figure 3 have on one another (standardised beta coefficients).

	Knowledge	Number of pupil-microphones	Errors	Hearing loss	School grade	Attitudes
Knowledge	–	–	–	–	0.24	–
Number of pupil-microphones	–	–	–	0.28	–	–
Errors	–	−0.21	–	−0.06	0.22	–
Attitudes	0.32	−0.05	0.23	0.01	0.12	–
Use of pupil–microphones	0.12	0.34	−0.07	0.26	0.01	0.38

that factors related to the teachers, pupils, parents, and educational and technical interventions would explain the variations in the teachers' use.

A major finding is the difference between the use of teacher-microphones and pupil-microphones. Few teachers report always implementing pupil-microphones and a relatively large group implement them occasionally. The pupil-microphones involve several participants and are consequently more challenging for the teachers to control and handle compared with their own microphones, which can explains the low results. Most teachers (56%) report always using teacher-microphones: however the rate was lower than in the study by Heeney (2007), in which 63% claimed to consistently implement a sound field system for most teaching sessions. His study evaluated the effect of sound field system in an intervention group compared to a control group, which may have lead to a higher use. The majority of the teachers (86%) report almost always or always using the microphones, which is higher than that found by Coniavitis-Gellerstedt (2006), in which only 60% of the teachers reported implementing teacher-microphones when necessary. The findings here indicate that the teachers, to a large extent, seem willing to integrate teacher-microphones into their teaching, but are less able to integrate pupil-microphones.

The importance of positive attitudes

A key explanation of frequent use appears to be the teachers' attitudes towards the microphones. If the microphones exhibited positive effects, were easy to manage, and were straightforward to use for both the teachers and the classmates, the teachers appeared to integrate both consistently. Other studies also point to teachers' attitudes towards assistive technologies as central factors (Copley and Ziviani 2004; Hemmingsson, Lidström, and Nygård 2009; Craddock 2006), which this current study seems to support. Consequently, factors that can promote positive attitudes are important issues. As argued in the introduction section, the teachers' knowledge, the parents' involvement and the type of interventions were believed to be central dimensions to the teachers' attitudes towards microphones.

Knowledge about the hearing impairment and the technical aids as expected influenced attitudes and indirectly influenced the use of microphones. The majority of the teachers appear informed about hearing problems, although 44% of the teachers had never participated in courses arranged by the National Resource Centres, which may explain why numerous teachers reported needing additional information. Participating in such courses several times significantly improved the teachers' knowledge in contrast to never participating or participating at on only one occasion. Participation in courses outside the schools requires economic resources, which may explain why few teachers attended the courses. Most of the teachers also seem to be informed about the technical equipment, yet only 47% knew how to fix simple errors. In particular competency in using the technical equipment seems to lead to fewer problems with the pupil-microphones, which in turn promotes to positive attitudes. Accordingly, there is a need for systematic information concerning the technical equipment and hearing impairment. Such information improves the teachers' understanding of the need for teaching interventions (Lynas 1986; Antia et al. 2009; Punch and Hyde 2010; Chmiliar 2007; McGregor and Pachuski 1996; Wright et al. 2006; Craddock 2006), and therefore encourage positive attitudes towards and frequent use of the equipment.

Gender signalled a difference in the teachers' attitudes; female teachers appear to be more comfortable with the microphones than male teachers. The male teachers also seem less willing to make educational adaptations compared with the female teachers. 'Educational adaptations' was not related to the use of microphones, but because a gender effect also occurred here, this possible difference should be noticed. The reasons for these results are difficult to interpret. To a certain degree, this outcome may be linked to the findings of Demetriou, Wilson, and Winterbottom (2009), where female teachers were reported to focus more on individual students' needs.

Interestingly, positive attitudes towards the teacher-microphones also were found if parents were highly involved in the children's school performance, which indirectly affected the use of microphones. It appears that those teachers participated more often in the information courses compared to the teachers with less involved parents. The parents may require that the school prioritise sending teachers to these courses; accordingly the teachers gain the necessary competence. The parents' influence here seems to be of importance, although many parents to children with disabilities claim that they are not being listened to (Lundeby and Tøssebro 2008).

Another influential factor associated with attitudes is the students' school age. Frequent errors with the pupil-microphones and the tendency of poor knowledge about hearing impairment among the teachers in the upper grades demonstrate that the adolescent students seem to be a group at risk. In addition, few of the secondary school teachers report participating in courses. The schools' economic situation is one reason mentioned. Other explanations may be related to the teachers' working situation; because marks or grades are introduced at the secondary school level, the teachers must spend more time on formal evaluation (Bru et al. 2010), and consequently may put a lower priority on participating in the courses. Furthermore, the teachers may not consider HL as a grave disability. Other reasons are connected to the adolescent's concerns of a stigma or their experiences with pupil-microphones. Fewer adolescents appear to be supplied with pupil-microphones compared with the pupils in the primary school. The adolescents may reject using it or resist using it frequently when starting at a new school or in new classes, as the technology signals a disability (Scherer 2002). Microphones are visible devices and they demand that persons other than the individual with HL actively use them. The microphones may be considered by classmates to be too bothersome to use, and additionally, not all classmates use them correctly; accordingly the adolescents may prefer not to introduce the microphones to new classmates. The classmates' attitudes towards the microphones are an issue that should be further explored.

The importance of the pupils' hearing loss

The pupils' degree of HL also affected the microphone use as assumed. Pupils with mild HL tend to be an at-risk group because in these cases the teachers tend to use the microphones irregularly. The teachers might assume that pupils with mild HL do not require consistent use of microphones, even though poor listening conditions in the classrooms may create considerable difficulties for these students too (Antia et al. 2009). Those pupils were also supplied with equipment that was inconsistently implemented during teaching. Consequently, degree of HL is an essential underlying factor for understanding the teachers' approaches to and usage of microphones, and

confirm that the degree of disability impacts teachers' praxis, as other studies have found (Convertino et al. 2009; Marschark, Lang, and Albertini 2002).

The importance of proper equipment

A third essential factor affecting microphone usage is related to the type of equipment; a low-density of pupil-microphones resulted in infrequent use. Few microphones per classmate seemed to be too complex for the teachers to administer. Teaching situations where several classmates share one microphone demands distribution and handling of the microphones between the classmates, which takes time and disrupts the pupils' spontaneity, whereas with a high-density, they are easily accessible and may not disrupt communication in the same way as low-density. A previous study found that in cases with a low-density of microphones, they are implemented only in structured lessons, such as a reading presentation (Rekkedal 2007), which is in line with the current finding. Access to high-density of microphones therefore seems to be required for regular integration of pupil-microphones.

The effect of the presence of loudspeakers is somewhat difficult to interpret. It was found to positively affect the teachers' attitudes, but was negatively related to microphone use. This finding is the opposite of prior expectations of a positive relationship; however, the total effect of the loudspeakers system became nearly zero. The direct negative effect seems to have a specific reason; less frequent use of the loudspeakers occurred during classroom discussions/conversations. Few teachers with this system tended to use pupil-microphones or were given a high-density of microphones, which may explain the infrequent use of teacher-microphones in this setting. However, more teachers used the sound field system when the specific pupil was absent compared to the teachers without this system; this confirms that interventions that are of advantageous for all pupils will be implemented regularly. To a certain extent this supports Antia (1999), who states that teachers make more use of modifications that improve the learning environment for all students. However, the sound field system did not seem to promote more frequent use compared to the other systems when the specific pupil was present.

Conclusions

Teachers' attitudes towards microphones appear to be a major factor affecting their use. Positive attitudes seem to generate a consistent integration of the microphones. Because high degrees of knowledge positively affected attitudes, this subject is of importance. Although, many teachers reported having been trained to use the equipment, few had satisfactory knowledge. Moreover, the majority of the teachers report needing further information about hearing impairment. The reasons for insufficient knowledge among the teachers should be further examined. Nevertheless, there seems to be a need for systematic and supplementary information about the technical equipment and hearing problems because of the positive influence this has on the teachers' attitudes and thereby the implementation of the microphones.

The analyses indicate four pathways to the use of microphones. The most essential pathway appears to be the pupils' degree of HL; having severe HL seems to lead to frequent use, and additionally they were supplied with equipment that was frequently implemented. The second pathway seems to be the pupils' school age; the

teachers in the secondary schools appear to have less knowledge and to experience frequent errors with the pupil-microphones, which indirectly lead to negative attitudes towards the microphones and to infrequent use. A third pathway was the parents' involvement; the teachers who considered the parents highly involved in their child's schooling appear to be positively inclined towards the microphones, and this indirectly indicated frequent implementation of the microphones. The teachers' gender indicates a fourth pathway because of their different attitudes towards the implementation of microphones and their use of educational adaptations.

Pupils with mild HL, who attend secondary school, and/or whose parents are less involved seem to be at-risk groups and professionals should therefore be attentive to those pupils. Because all of the teachers who used pupil-microphones also used teacher-microphones, all of the variables are essential to understanding the implementation of assistive listening devices. However, further research is necessary to confirm these pathways.

Limitations

The participation rate of the teachers in this survey was high; however, care should be exercised in generalising these findings to the total population of teachers because of the low participation rate of pupils. There was a particular focus on specific dimensions, which included factors concerning the teachers' gender and knowledge and technical factors such as the type of equipment and technical faults. Other factors may also have explanatory power, such as the degree of cooperation between teachers, different teaching methods and aspects concerning the benefits of loudspeakers on teachers' health.

Although the terms 'predictors' and 'pathways' are used the causal directions of the pathways should be interpreted with caution. Many of the findings appear to be as predicted, however further research is required.

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