Modifying the Classroom Environment to Increase Engagement and Decrease Disruption with Students Who Are Deaf or Hard of Hearing

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The goal of this study was to examine the effect of physical modifications on the academic engagement and disruptive behavior of Deaf or Hard-of-Hearing students in self-contained classrooms. Three classrooms at a school for the Deaf were modified after consultation with the classroom teachers. The modifications of the classroom environment included changes in seating arrangements, classroom organization, visual stimulation, and acoustic quality. A multiple-baseline design was used to examine the effects of the intervention on the frequency of student academic engagement and disruptive behaviors. Results show a functional relationship between the physical environment and both an increase in levels of academic engagement and a decrease in levels of disruptive behavior. Teachers maintained the majority of modifications after the study ceased. Social validity ratings by the teachers indicated high acceptability of the intervention. Limitations and practical implications for future research are discussed.

Classroom physical environments can influence the way students behave. The physical arrangement and features of the classroom environment, such as seating arrangements, lighting, and organization, can influence students' behavior and attention to academic tasks (Evans & Lovell, 1979; Fullerton & Guardino, 2010; Guardino & Fullerton, 2010; Schilling & Schwartz, 2004). For Deaf or Hard-of-Hearing (DHH) students in particular, visual or auditory distractions, poor lighting, obstruction of line of sight, and seating near doors or windows with high traffic are among the classroom features that can influence academic engagement (Dye & Bavelier, 2010).

Behavioral academic engagement includes involvement in classroom academic tasks, such as being on-task, following teacher directions, and participating in class discussion, as well as the absence of behaviors disruptive to learning (Fredericks, Blumenfeld, & Paris, 2004). Academic engagement is inversely related to disruptive behavior—in other words, as academic engagement increases, disruptive behavior decreases (Lane, Smither, Huseman, Guffey, & Fox, 2007). Researchers have reported that academic engagement is related to achievement (Finn, Pannozzo, & Voelkl, 1995) and school attendance (Connell, Spencer, & Aber, 1994). For DHH students specifically, classroom participation is related to achievement (Antia, Sabers, & Stinson, 2007; Long, Stinson, & Braeges, 1991). Although academic engagement can be influenced by a number of student and school factors (Trussell, 2008), one factor that is comparatively simple to control is the classroom physical environment. The purpose of this research was to examine whether modifications of the physical environment increase students' academic engagement and decrease their disruptive behavior.

Few data are available on the extent of academic engagement and disruptive behavior in classrooms of DHH students. DHH students may exhibit disruptive behavior in the classroom because they have additional disabilities that make it difficult for them to focus on

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academic tasks or because they are prone to visual or auditory distractions. The Gallaudet Research Institute (2011) indicates that almost 40% of students who are DHH have an additional disability, including attention deficit disorders, learning disabilities, or emotional problems. Students with these additional disabilities are likely to exhibit disruptive behaviors in the classroom (Kelly, Forney, Parker-Fisher, & Jones, 1993; Meadow & Trybus, 1985).

DHH students may also be prone to visual distractions, leading to a reduced ability to attend to relevant aspects of the classroom and negatively affecting the ability to focus on academic tasks. Visual distractibility may be related to an acute sense of peripheral vision, leading to high distractibility (Bavelier, Dye, & Hauser, 2006; Chen, Zhang, & Zhou, 2006; Dye, Baril, & Bavelier, 2007; Neville & Lawson, 1987; Proksch & Bavelier, 2002; Visual Language and Visual Learning Science of Learning Center, 2011). Dye, Hauser, and Bavelier (2008) describe the connection between visual demands and attentiveness in DHH students:

> With respect to attentional allocation, problems may arise when there is a conflict between the demands of the environment and the default allocation of resources. For example, in structured learning environments, such as classrooms, the deaf child's attention has to be focused upon an instructor or an interpreter. When there are sources of visual distraction in the periphery, then a deaf child may appear to be inattentive as their attention is constantly being drawn towards those peripheral events (p. 7).

Similarly, DHH students may have problems with auditory distractions. Environments with excessive background noise and reverberation make listening and learning difficult for the student who is attempting to access spoken language and focus on the lesson presented by the teacher or on peer discussion (Crandell & Smaldino, 2000). A noisy environment may have a negative impact on the ability of DHH students to remain academically engaged (Nelson & Soli, 2000). Thus, visual and auditory aspects of the physical environment may be particularly important to control in classrooms for DHH students.

Classroom Environments and Student Behavior

Classroom physical environment can affect learning by changing patterns of teacher–student interaction and by reducing distractions and "downtime" (Trussell, 2008). For example, certain kinds of seating arrangements can facilitate student interaction but can also distract students during individual work. Classrooms cluttered with furniture can result in students constantly bumping into each other and create an environment where disruptive behavior is likely to occur. A disorganized classroom, where teachers and students need to hunt for materials, can reduce instructional time and increase the opportunities for students to engage in behavior that disrupts classroom learning. The physical environment can affect the ability of the teacher to move around the classroom and make contact with students, thereby increasing student engagement in the classroom activity. As mentioned previously, excessive auditory and visual stimuli can distract students and reduce their focus on academic tasks. Unfortunately, research on the effects of classroom physical environments on student behavior is scanty and much of the cited research was conducted more than 30 years ago. Physical modifications that have been studied include (a) student seating, including the designation of space for students' personal supplies, (b) positioning of the teacher's desk, (c) the use and organization of materials, (d) lighting, and (e) classroom acoustics and noise.

Student seating. Changing the classroom seating is one of the more obvious and easier changes to make to the classroom environment. Several researchers have noted how changing the seating arrangement has affected student behavior (Hood–Smith & Leffingwell, 1983; Proshansky & Wolfe, 1974; Visser, 2001; Wheldall & Olds, 1987; Zifferblatt, 1972). An early descriptive observational study by Zifferblatt (1972) indicated that grouping student desks together encouraged student socialization but had a negative effect on student academic engagement. A case study by Hood–Smith and Leffingwell (1983) found that a seating arrangement that created a common area in the center of the room between two groups of rows and that also provided students with more individual work space resulted in

an overall increase in academic engagement during class work periods.

Classroom seating needs to be arranged such that students can engage in individual work and participate in group work. Zifferblatt (1972) observed two classrooms, which he designated "satisfactory" and "difficult" based on students' behavior and engagement in academic activities. He reported that the satisfactory classroom had separate areas designated for independent and group work; in the difficult classroom, both group and independent work were conducted at the students' seats, which were arranged in clusters. He noted that the teacher made far fewer comments about students' behavior in the satisfactory than in the difficult classroom.

Guardino and Fullerton (2010) worked with a classroom teacher to rearrange the classroom physical environment by creating distinct individual versus group work spaces, providing personal space for individual belongings, and rearranging the classroom furniture to reduce distractibility. After the classroom was modified, academic engagement increased by approximately 42%. Unfortunately, although disruptive behavior decreased, the reduction was not stable. One of the reasons for the variation in disruptive behavior was that the modifications were used inconsistently and not always as intended. For example, the chair bags (bags hung from the students' chairs to store belongings) became a catchall rather than a place for essential classroom supplies needed throughout the day, indicating that some teachers and students may need guidance on the use of physical spaces within the classroom in order to minimize disruptive behavior.

There is no research providing evidence of the kind of seating and classroom arrangements that are most beneficial for DHH students. In self-contained classrooms with students who use sign language, teachers often utilize a horseshoe or circular seating arrangement because it allows the students to see each other when communicating. In a review on research on the visual distractibility of deaf students, Dye, Hauser, and Bavelier (2009) suggest that the best seating arrangement for students with a hearing loss is one that is consistent and presents minimal distractions.

Positioning of the teacher's desk. Based on the observations of the difficult and satisfactory classrooms,

Zifferblatt (1972) noted that when the teacher's desk was in a central position from which students could be easily observed, the teacher was more likely to sit at the desk than to interact with the students. Alternatively, when the teacher's desk was inaccessible, the teacher was more likely to spend time interacting with the students. The more time a teacher spends engaged with students, the better the student outcomes (Ezrailson, Kamon, Loving, McIntyre, 2006; Middlecamp, 2005; Reeve, Jang, Carrell, Jeon, & Barch, 2004). Although there is no research specifically on the relationship between the placement of the teacher's desk and the teacher's interaction with DHH students, one would expect that any physical arrangement that increases teacher–student interaction would likely lead to increased student academic engagement.

Organization of materials. Students in classrooms where materials are organized and accessible have fewer disruptive behaviors than those in classrooms where materials are disorganized and in disarray (Goodman & Pendergrass, 2001; Gump, 1974; Trussell, 2008; Weinstein, 1977). Weinstein (1977) found that when materials and class supplies were organized and visible within centers, children increased their appropriate use of these centers. With all students, including DHH students, a well-organized classroom is likely to result in reduced downtime and, therefore, more engaged time. Disorganized materials might also be a source of visual distraction to DHH students.

Lighting. Student's behaviors can be affected by too much or too little environmental lighting. Visser (2001) observed a classroom of students with emotional behavior disorders and reported, as had previous authors (Evans & Lovell, 1979; Proshansky & Wolfe, 1974; Weinstein, 1979) that too much light creates a "dazzling" on white boards and students' desks, which becomes a visual distraction. Because many DHH students primarily use their vision to communicate, sufficient lighting and control of excessive lighting is important and is likely to increase attention and academic engagement. Appropriate lighting is also necessary for those students who supplement audition with speech reading (Kaderavek & Pakulski, 2002).

Acoustics and noise. It is likely that a noisy learning environment affects students' ability to understand

teachers and to focus on their work (Choi & McPherson, 2005; Proshansky & Wolfe, 1974; Robinshaw, 2007; Sorkin, 2000). There is evidence that young listeners and students with learning disabilities have difficulty understanding sentences in noise (Bradlow, Kraus, & Hayes, 2003; Nelson & Soli, 2000), although research with typically hearing students has not always shown that noisy conditions negatively affect reading or writing performance (Slater, 1968; Weinstein & Weinstein, 1979). For students with hearing loss, the level of background noise in a classroom, the signal-to-noise ratio, and reverberation time can be crucial factors in their ability to understand spoken language (Crandell & Smaldino, 2000; Nelson, Soli, & Seltz, 2002) and, therefore, affect their ability to focus on instruction. Acoustic modifications that can be incorporated into the physical environment include putting sound-absorbent materials in the classroom (Bednarczyk, Alexander-Whiting, & Solit, 1994; Luetke-Stahlman, 1998; Robinshaw, 2007). Reconfiguration of the classroom environment so that students are located far from equipments that emit high levels of background noise will also help increase speech-to-noise ratio (Bess, 1999).

Justification for This Study

There is a dearth of research to provide sufficient evidence that physical modifications in classrooms actually make a difference in student behavior. Observational studies of single classrooms (Hood-Smith & Leffingwell, 1983; Proshansky & Wolfe, 1974) or professional insight (Fitt, 1974) can provide direction to establish hypotheses for future research but do not provide evidence for practice. Much of the cited research was conducted several decades ago, and few of these studies used control groups. As early as 1979, Weinstein noted that one of the major problems faced by researchers is the difficulty of matching the experimental and control groups across classrooms and schools due to student factors that might influence academic engagement and disruptive behavior. Teachers' instructional styles are also likely to differ and influence student academic engagement (Brophy & Good, 1986). Thus, when researchers examine the effects of classroom physical environments on student behavior, they face

various threats to both internal and external validity because the students and instructors vary greatly from setting to setting.

Single-case designs offer an alternative to group designs and allow researchers to examine the effect of interventions without the need for control groups, as each case provides its own control (Kratochwill et al., 2010). The single case can be a single individual or a group of individuals, such as a classroom. A multiple-baseline design allows the researcher to compare the data obtained during baseline (business-as-usual) with data obtained during intervention. The onset of the intervention is staggered in time across several cases in order to control for confounding variables such as time or maturity. Because each case provides its own control, to show a causal relationship between the independent and dependent variables, the researcher needs to show that the dependent variable changes, in each case, only after the onset of the intervention (Horner et al., 2005; Kazdin, 1982; Kratochwill et al., 2010). Typically, single-case design requires repeated measurements of the dependent variable.

A multiple-baseline design is particularly important when researching low-incidence disabilities such as deafness because it allows researchers a method to address the challenges of small sample sizes and sample heterogeneity (Bullis & Anderson, 1986). Single-case design studies alleviate the problem of sample size, while providing interventions that are applicable to classroom settings, are responsive and flexible to individual student and teacher needs, and solve internal, external, and social validity issues (Horner et al., 2005; Kratochwill et al., 2010).

An important part of any intervention study is to establish the social validity of the intervention (Horner et al., 2005). The purpose of social validity is to examine the acceptability of an intervention, particularly for those affected by it (Schwartz & Baer, 1991). Educational interventions that are imposed by a researcher are unlikely to be maintained, because they may not be feasible or do not meet the needs of the school or classroom setting. As early as 1978, Wolf suggested that consumers needed to validate the work of researchers on three levels: the significance of the goals, the social appropriateness

of the procedures, and the social importance of the effects. Thus, classroom interventions need to be acceptable to the teacher and fit the culture and routines of that particular classroom. In the case of this study, particularly a "one-size-fits-all" approach to changes in classroom physical modifications would be unlikely to be effective. Teachers needed to be able to select the modifications that were the best fit for the physical space, teaching style, and routines of their own particular classrooms.

The purpose of this study was to examine the effects of environmental modifications on the academic engagement and disruptive behavior in classrooms of DHH students. The specific research question was as follows: Is there a functional relationship between the classroom physical environment, student academic engagement, and student disruptive behavior? A secondary purpose of this study was to examine whether individual consultation with teachers about physical classroom modifications specific to teachers' needs (rather than a one-size-fits-all set of physical modifications) would result in high social validity and maintenance of the environmental modification after the study ceased.

Method

The study used a multiple-baseline design across classrooms to answer the research questions. For purposes of this study, modification to the classroom environment was defined as physical changes to the classroom that included rearrangements of furniture, lighting, acoustics, or materials. Student academic engagement was defined as productive on-task behavior, both passive and active. Student disruptive behavior was defined as behaviors that interrupt student academic engagement.

Participants and Settings

Participants for this study included three elementary teachers from a school for the Deaf in the southwestern region of the United States. After receiving an announcement from the principal regarding the study, these three teachers volunteered to be participants. All three teachers were hearing. Teachers 1 and 2 were female and Teacher 3 was male. Teacher 1 was a long-term substitute teacher, who inherited her classroom with all of

its belongings for 5 months and had no previous teaching experience prior to placement in this classroom. Teachers 2 and 3 had more than 20 years of experience teaching Deaf students and had occupied the same classrooms for 9 and 12 years, respectively.

The communication philosophy of the school is American Sign Language (ASL) immersion and all instruction is presented in sign language. All observations and interviews were conducted within the classroom setting. All three classrooms had students ranging in age from 9–11 years. Classrooms 1, 2, and 3 had a total of 4, 5, and 5 students, respectively. In Classroom 1, all of the students had significant intellectual disabilities in addition to deafness; all students in this classroom had fine motor delays and two had vision impairments. In the other two classrooms, approximately half of the students had diagnosed behavior, attention, and hyperactivity issues. Because the classroom was the unit of analysis for this study, no identifying data were obtained on individual students.

Instruments

An observation system was designed to measure academic engagement and disruptive behavior. A social validity measure was used after the intervention ceased.

Observation of academic engagement. The following behaviors were documented as academic engagement:

1. Passive engagement was documented as any behavior where the student was a productive member of the classroom without active participation. Passive engagement included listening and attentively watching the teacher during lesson delivery. Watching the teacher was defined as sustained eye contact.

2. Active engagement was documented as any physical behavior where the student was a productive member of the classroom. Active engagement included raising his/her hand, working independently (writing, using a calculator, and using manipulatives), answering a question, working with another child on the assigned task, and following the teacher's directions (Downer, Rimm-Kaufman, & Pianta, 2007; Lane et al., 2007). Students who were not engaged either passively or actively were documented as unengaged.

Observation of disruptive behavior. The following behaviors were documented as disruptive:

1. Speaking or signing without permission was documented when a student engaged in conversation with a peer while the teacher was engaged in individual or whole group instruction.
2. Getting out of seat was documented when the student left the seat without prior permission from the teacher and caused distractions to other students or interrupted the teacher by having to be redirected to the seat.
3. Making unwanted physical contact was documented when a student touched a peer or adult without receiving prior permission to do so or played with or manipulated objects without permission.
4. Not following directions was documented when the student did not respond to the teacher's initial request or when the teacher repeated a request two or more times, thus interrupting the flow of the classroom lesson.
5. Making loud noises was documented when the student made noises that disrupted the teacher or disturbed students who wore assistive hearing devices (implants or hearing aids). Disruption was noted when either a peer or teacher requested the student to stop making the noise. Noises included banging on the table or desk or using objects to create disruptive noises.

Academic engagement and disruptive behavior were measured by direct observation using a partial-interval measurement system. Each 20-min observation session was divided into 20 one-minute intervals for recording academic engagement and 40 thirty-second intervals for recording disruptive behavior. Academic engagement and disruptive behaviors were scored and noted as either present or absent for the entire classroom. To record academic engagement, observer(s) did a visual sweep of the classroom at the end of each 1-min interval and noted the total number of students not academically engaged. A percentage score for academic engagement per observation session was calculated by adding the total number of intervals in which all students were engaged and dividing it by the total number of observed intervals (20), then

multiplying by 100. To record disruptive behavior, the observer noted whether any student engaged in any disruptive behavior during each 30-s interval. A percentage score for disruptive behavior per observation session was calculated by adding the number of intervals in which disruptive behavior occurred and dividing it by 40 (the total number of intervals observed), then multiplying by 100.

Interobserver Agreement Reliability

The researcher and research assistant—a doctoral candidate—conducted observations in the target classrooms prior to baseline until 85% agreement was obtained between observers. Once 85% agreement was obtained, baseline data collection commenced. To ensure that observers maintained a high level of agreement, interobserver agreement (IOA) data were recorded for 38% (11 of 29 sessions) of baseline observations, 36% (13 of 36 sessions) of intervention observations, and 22% (two of nine sessions) of the follow-up observations. The IOA data for academic engagement was calculated by dividing the number of intervals in agreement by the total possible number of intervals (20), then multiplying that sum by 100. IOA for disruptive behavior was calculated by dividing the number of intervals in agreement by the total possible number of intervals (40), then multiplying that sum by 100. Agreement for academic engagement and disruptive behavior averaged 87% and 93%, respectively.

Social Validity

Social validity data were collected to determine the acceptability of the intervention. We used two tools—the Classroom Modification Questionnaire (CMQ), designed by the first author; and an interview with the teacher—both administered at the end of the study. The postintervention interview of the teacher was conducted after the teacher completed the CMQ. The interview provided the teachers the opportunity to elaborate on their personal experience as a participant in the study, strengthening the social validity of the research project.

CMQ design. The CMQ included 10 questions regarding the teacher's perception of the effectiveness of the intervention, likeliness to recommend the

intervention to other teachers, and overall satisfaction with the study. Each question is rated on a 5-point Likert scale, with a score of 1 indicating dissatisfaction and a score of 5 indicating complete satisfaction with the intervention. Scores on this instrument can range from 10 to 50, with a high score indicating higher acceptability of the intervention.

Postintervention interview. The postintervention interview provided the teachers with the opportunity to share aspects about their experiences during the intervention and after the study. The interview consisted of 10 questions prompting the teachers to explain what they liked best, what they would change if they were to participate in the study again, which modifications were most helpful, and which modifications they would recommend to other teachers. Postintervention interviews ranged in length from 20 to 40 min.

Procedures

This study took place across three phases: (a) baseline data collection, (b) intervention that included teacher consultation and physical changes in the classroom, and (c) follow-up observations.

Phase 1: Baseline Data Collection

In Phase 1, the researcher conducted initial consultation interviews with the teachers, took photos of the classroom (without students) to document classroom arrangement prior to the intervention, and collected baseline data on academic engagement and disruptive behavior. During this initial consultation, the researcher asked the teacher to specify the areas in the classroom where disruptive behaviors most frequently occurred, the types of disruptive behaviors that occurred throughout the school day, and the times of the academic school day when disruptive behavior was highest to conduct the 20-min observation sessions. Once the 20-min observation time was agreed upon, the researchers collected data at this designated time throughout the study. The duration of each interview was approximately 10–15 min. Baseline data were collected through direct observations of students in classrooms. Observations in each classroom lasted 20 min and were usually conducted during math and language arts lessons. On occasion, classrooms were observed when teachers were transitioning from math and language arts to an art project, silent reading, or snack accompanied with a lesson.

Phase 2: Implementation of the Intervention

Intervention began when there was a stable baseline of six data points in Classroom 1. The researcher and teacher consulted together regarding the most reasonable, feasible, and likely effective classroom modifications to make based on the type of disruptive behaviors reported and documented in Phase 1. Several classroom environment modifications based on previous research were discussed with the teachers. These modifications included, but were not limited to, the following: changing the seating arrangement, decreasing stimuli, changing the lighting, organizing materials, clearing and controlling pathways, creating individual versus group work areas, rearranging the teacher's desk, and introducing aromas and background colors. Teachers' choices of modifications were based on their needs as well as their students' needs. Modifications that were discussed with the teachers are described in Table 1, which also shows the modifications that were chosen by each teacher. Over the course of one weekend day, Teacher 1 and the researcher made the modifications to Classroom 1. After modifications were complete, the researcher took pictures of Classroom 1 without students present. As necessary in a multiple-baseline-across-settings design, baseline data continued to be collected across Classrooms 2 and 3 during intervention with Classroom 1.

When data showed a positive treatment effect in Classroom 1, the intervention process began for Classroom 2. A positive treatment effect was noted when a trend in the opposite direction of baseline data occurred with low variability. Therefore, when a decrease in the frequency of disruptive behavior and increase in academic engagement occurred over at least 3 days in Classroom 1, the researcher began the consultation and intervention process with Teacher 2. When data in Classroom 2 showed an effect over at least 3 days, the researcher began the consultation and intervention process with the teacher of Classroom 3. Modifications that were made in each classroom are presented in Table 1. Modifications in Classrooms 1, 2, and 3 took 3, 4, and 4 hr to complete, respectively.

Table 1. Classroom modifications chosen by each teacher

Possible modifications	Teacher 1	Teacher 2	Teacher 3
Altered the seating arrangement	X	—	—
Decreased or changed placement of stimulating visuals	X	X	X
Changed the lighting	X	X	X
Cleared pathways between students and high-trafficked areas	—	X	X
Made a clear distinction between individual versus group activities	X	—	—
Organized areas by adding shelves, labels, or cubbies	X	X	X
Faced students away from doorways and windows, and partially or completely covered windows	X	X	X
Increased airflow	X	—	—
Created personal space to promote ownership (cubbies, labeled shelf space, and desks)	X	X	—
Addressed acoustic quality in the classroom by eliminating objects that produce background noise and/or adding sound-absorbing items	—	X	—
Added carrels to promote individual work/privacy	X	X	X
Placed barriers and/or partitions in the classroom to influence where attention would be drawn	X	—	—
Added aroma–lavender scent to promote a calming, soothing environment	X	X	—
Added objects to simplify teachers' implementation of lessons (shelves under lesson table, easel for floor lessons, and rolling chair)	X	X	X

Phase 3: Follow-up

After the intervention phase, the researcher returned once a week for 3 weeks to collect follow-up data in all three classrooms. This follow-up procedure was intended to measure the degree to which there were sustained reductions in disruptive behavior and increases in academic engagement and also to note whether the classroom modifications were continued. During the follow-up phase, each teacher completed the CMQ and engaged in an interview with the researcher to evaluate the social validity of the research project.

Treatment Integrity

The degree to which each teacher implemented the designated modifications was assessed in two ways. First, the author and the research assistant independently verified, in three separate sessions, that the teacher implemented at least 90% of the modifications agreed upon in the consultation session and recorded on the classroom modification checklist. If the modification was in place and being used, then the researcher would mark it with a check mark. If the modification was not in place or was not being utilized, it would receive a zero. The total number of modifications implemented was divided by the total number of modifications agreed upon and then multiplied by 100 to get a treatment integrity percentage score. Second, the researcher took "before" and "after" pictures of the classroom to record that changes in the environment had occurred.

Data Collection Procedures

The dependent variables (academic engagement and disruptive behavior) were measured by direct observation using a partial-interval measurement system for each 20-min observation session. The researcher and a research assistant (a doctoral student in special education) completed the data collection during the same teacher-designated 20-min observation session throughout the study. Academic engagement and disruptive behaviors were scored as either present or absent for each classroom as described earlier.

Results

Figure 1 shows the baseline, intervention, and follow-up data for all three classrooms. The data points represent the percentage of academic engagement and disruptive behavior per observation session. Because each classroom was considered a single case, we analyzed the data at the classroom level. We systematically examined the variability, level, trend, immediacy of effect, and overlap, as suggested by Kratochwill et al. (2010). We completed the following: (a) visual analysis and split-middle trend line analysis, (b) a calculation of means, medians, and standard deviations for each phase, (c) a comparison of the median differences between baseline and intervention phases, and (d) an examination of the percentage of nonoverlapping data points (PND) between phases. Tables 2 and 3 show the descriptive statistics (means, standard deviations, medians, and ranges) of the three classrooms for disruptive behavior and academic engagement across all three phases of the study. Scores are shown as a percentage of total intervals observed.
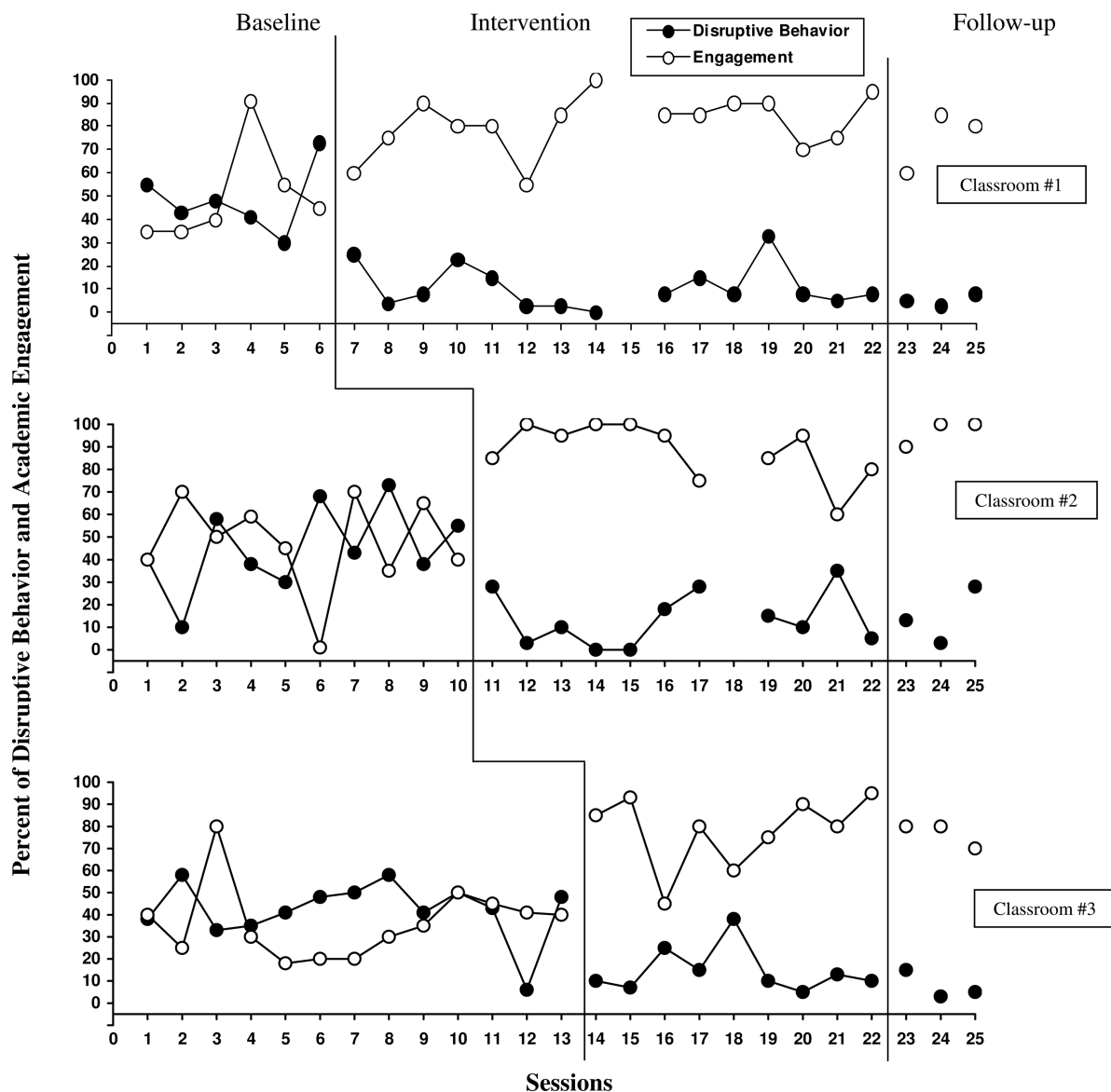

Figure 1   Academic engagement and disruptive behavior during baseline, intervention, and follow-up.

Table 2 Mean, standard deviation, median, and range of academic engagement across classrooms

Classroom	Baseline (%)	Intervention (%)	Follow-up (%)
Classroom 1			
Mean (SD)	50 (21)	81 (12)	75 (13)
Median	43	85	80
Range	35–91	55–100	60–80
Classroom 2			
Mean (SD)	48 (21)	88 (13)	97 (6)
Median	48	95	100
Range	1–70	60–100	90–100
Classroom 3			
Mean (SD)	37 (17)	78 (16)	77 (6)
Median	35	80	80
Range	18–80	45–95	70–80

Table 3 Mean, standard deviation, median, and range of disruptive behavior across classrooms

Classroom	Baseline (%)	Intervention (%)	Follow-up (%)
Classroom 1			
Mean (SD)	48 (15)	11 (9)	5 (3)
Median	46	8	5
Range	30–73	0–33	3–8
Classroom 2			
Mean (SD)	45 (19)	14 (12)	15 (13)
Median	42	6	13
Range	10–73	0–28	3–28
Classroom 3			
Mean (SD)	42 (13)	15 (10)	8 (6)
Median	43	10	5
Range	6–58	5–38	3–15

Classroom 1

Academic engagement. Baseline academic engagement data for Classroom 1 were fairly stable with the exception of Data point 4. During this session, the students were engaged in free time rather than the typical lesson and work period. The level of academic engagement was in the midrange (30–70%), with a slightly increasing trend. Rate of academic engagement increased immediately after the intervention began and stayed within a high range (75–100%). The intervention data were stable with a flat trend throughout the remainder of the intervention. The median rates for academic engagement increased by 42 percentage points, whereas the standard deviation decreased by 9 percentage points between baseline and intervention phases. The

follow-up data showed academic engagement remained high with an upward, moderately stable trend. The PND for academic engagement was .06% because of one low data point (Session 4). If Session 4 were to be disregarded, the PND for academic engagement was 100%.

Disruptive behavior. The disruptive behavior data for Classroom 1 were fairly stable during baseline, with the exception of the last data point prior to intervention, which showed a drastic increase in disruptive behavior. Using a split-middle trend line analysis, the baseline data revealed a moderately high level of disruptive behavior with a slightly decreasing trend. Once intervention began, disruptive behavior immediately decreased and displayed moderate stability with a flat trend. The median rates for disruptive behavior decreased by 37 percentage points between the baseline and intervention phases. The follow-up data for disruptive behavior showed a low rate with a stable flat trend. An examination of Figure 1 shows that the level of disruptive behavior in Classroom 1 changed from a moderately high rate (30–70%) during baseline to a low rate (0–30%) during intervention conditions. During follow-up conditions, a low rate of occurrence continued. Classroom 1 had one overlapping data point between baseline and intervention phases for disruptive behavior. The PND for disruptive behavior was 93.3%.

Classroom 2

Academic engagement. The baseline academic engagement data for Classroom 2 showed low stability, with a midrange (30–70%) level and a slightly decreasing trend. Immediately after the intervention, the rate of academic engagement increased and remained in the high-range level with a slightly decreasing trend. The median rates for academic engagement increased by 47 percentage points between baseline and intervention phases. Follow-up data revealed a high level with a stable upward trend, indicating an increase in academic engagement. The PND for academic engagement was 91.6%, showing a highly effective intervention.

Disruptive behavior. In Classroom 2, disruptive behavior during baseline was moderately stable, within the midrange level (30–70%), and with an increasing trend. The rate of disruptive behavior decreased

immediately after the intervention began. During the intervention, disruptive behavior was moderately stable in the low range with a slightly increasing trend. The median rate for disruptive behavior in Classroom 2 decreased by 38 percentage points between baseline and intervention phases. Follow-up data revealed that the level of disruptive behavior was moderately stable, with a slightly decreasing trend at a low level (0–30%). Fifty percent of the disruptive behavior data points between baseline and intervention phases overlapped because of one low data point (Session 2) in baseline. Without this data point, the PND for disruptive behavior was 91.6%.

Classroom 3

Academic engagement. Baseline academic engagement data for Classroom 3 were stable with the exception of Data point 3. During baseline, the level of academic engagement was in the low range, with a slightly increasing trend. The rate of academic engagement increased immediately after the intervention began and stayed within the middle to high range. Academic engagement during intervention was stable, with a flat trend. The median rates for academic engagement increased by 45 percentage points between baseline and intervention phases. Follow-up data revealed a stable level of academic engagement in the high range (70–80%). PND between baseline and intervention was 44.4% because of one high data point (Session 3) during the baseline phase. Without this data point, the PND for academic engagement was 88.8%.

Disruptive behavior. In Classroom 3, disruptive behavior data during baseline were stable within the midrange level, with a flat trend. The rate of disruptive behavior decreased immediately after the intervention began and stayed moderately stable in the low range, with a slightly decreasing trend throughout the remainder of the intervention. Median rates for disruptive behavior decreased by 33 percentage points between baseline and intervention phases. Follow-up data showed a sustained low level (0–20%) of disruptive behavior. The data for Classroom 3 indicated a trend similar to that of the other three classrooms; disruptive behavior decreased immediately after the intervention began and remained at a stable low level during the follow-up phase. Overlapping data for disruptive behavior in Classroom 3 showed a PND of 11.1% between baseline and intervention phases because of one low data point (Session 12) during baseline when the teacher showed a video instead of conducting a typical lesson. Without this data point, the PND for disruptive behavior was 88.8%.

Treatment Integrity Data

At the end of each session, each observer recorded whether the teacher maintained the original classroom modifications. For each session, treatment integrity was obtained by adding the number of modifications maintained by the teacher and dividing this figure by the total number of modifications agreed upon during the consultation. The mean of the three session scores constituted the average treatment integrity percentage. The average treatment integrity for Classrooms 1, 2, and 3 was 96%, 98%, and 90%, respectively. Treatment integrity was verified by examining the pictures of the classrooms preceding and following the intervention.

Social Validity Data

Each teacher completed the CMQ at the end of the study. The highest score obtainable on the CMQ was 50, indicating complete satisfaction, and the lowest score was 10, indicating no satisfaction. Teachers 1, 2, and 3 scored 47, 42, and 46 respectively, indicating a high level of satisfaction with the intervention. All three teachers indicated that the intervention helped at least half of their students decrease disruptive behavior and increase academic engagement. The teachers agreed that they would continue to use the modifications as well as implement additional strategies. They rated the intervention as minimally to "not at all" disruptive. In addition, all three teachers reported that they would "definitely" recommend this intervention and that it would benefit other teachers. Only one teacher was uncertain as to whether the modifications increased academic performance; the other two teachers perceived that at least one student's academic performance had increased because of the intervention.

Discussion

The goal of this study was to determine whether there is a functional relationship between the intervention (physical modifications to the classroom environment) and the dependent variables (student academic engagement and disruptive behavior). Horner et al. (2005) state that, "experimental control is demonstrated when the design documents three demonstrations of the experimental effect at three different points in time" (p. 168). In this study, a functional relationship was established between the changes in the classroom environment and the targeted student behaviors. The data in Classroom 1 showed an immediate stable change in level and a trend in the opposite direction of baseline data for both dependent variables, demonstrating a functional relationship between the classroom environment and the dependent variables. The functional relationship was validated by subsequent and similar changes in the second and third classrooms, meeting the recommended three demonstrations needed to show an experimental effect. The data from this study also confirm the inverse relationship between disruptive behavior and academic engagement demonstrated by other researchers (Downer, Rimm-Kaufman, & Pianta, 2007; Lane et al., 2007; Paine, Radicchi, Rosellini, Deutchman, & Darch, 1983) and extends findings of the inverse relationship to a population of DHH students including those with various disabilities.

This research suggests that with proper and careful classroom arrangement, teachers may be able to increase student engagement and, consequently, academic achievement. Epstein (1981) stated,

> "We have only begun to understand how school and classroom structures influence different student outcomes, and much research is needed before teachers will be able to purposefully select combinations of classroom structures to maximize achievement, attitudes, and other goals of schooling." (p. 104)

Changes in the classroom arrangement were comparatively simple and included modifying the seating arrangement, organizing materials, and reducing visual distractions. Students with a hearing loss are challenged by visually distracting stimuli; many have disabilities related to attention and behavior deficits (Glenn, 1988; Kelly, Jones, Moulton, Verhulst, & Bell, 1993; Kluwin,

1985; Meadow & Trybus, 1985; Samar, Parasnis, & Berent, 1998). Students who have attention deficits and behavioral disabilities in addition to deafness may have greater challenges in environments that are visually distracting and disorganized. The effects of the reduction in visual stimuli were noted by the teachers in the postintervention interviews. The teacher in Classroom 1 noted, "The (disruptive) behavior has definitely been reduced because the environment has been changed. I think it was in part because of the black backgrounds, reducing stimuli, and (providing) individual space."

One of the key features of this study was that the researcher and the teachers worked in partnership to determine the modifications needed. In order to demonstrate a robust relationship and the social validity of an intervention, the researcher must encourage change without forcefully making change occur because imposed change has generally low social validity (Richards et al., 1999). In the present study, the teachers desired a change in their classroom environments; the researcher made modifications after consultation with each teacher. Consequently, modifications could be tailored to individual teaching styles and student needs.

Limitations

This study was conducted in a single educational context. The research was conducted at a school with a small number of students per classroom and only included three teachers. Future research is needed to determine whether the functional relationship between the physical environment and the variables academic engagement and disruptive behavior is also found in different educational settings and classroom contexts. Because all modifications to a classroom were made at one time, it was not possible to gauge the effect of any single modification. Furthermore, it was difficult to determine the minimum modification needed to effect change. Researchers have yet to determine whether the whole is greater than the sum of its parts because they have not examined the effects of implementing the modifications incrementally (Evans & Lovell, 1979; Fullerton & Guardino, 2010; Guardino & Fullerton, 2010; Hood-Smith & Leffingwell, 1983).

Another limitation of this research is that data were only obtained on student behaviors. Teacher behavior

and teacher–student interaction may be other potential variables that are influenced by the physical environment. Future research should examine how teacher behaviors are influenced by the classroom physical environment, and how, in turn, changed teacher behaviors influence student behaviors.

Implications for Future Practice

The implications include classroom characteristics, time commitment, individualization of modifications, alterations to the modifications, and teachers' use of modifications.

Classroom characteristics. Martin (2006) noted that the "architectural facility" is the overall framework of the school or classroom and may not be easily modified. However, the "arranged environment" within that framework is established by the teacher and influences student behaviors. Clearly, certain features of the classroom cannot be changed, such as size of the classroom or placement of windows, doors, or ductwork. However, space within the classroom can be arranged to enhance engagement. For DHH students particularly, classroom arrangements that allow for organization and access to materials can reduce visual clutter and thus reduce visual distractions. The use of carrels or partitions can reduce visual and auditory distraction during individual work; whereas for group work, desks can be arranged facing away from doors and windows.

Time and effort. Teachers who consider making modifications to their classrooms must consider the time needed to modify the classroom. The total time to complete the modifications was approximately 3.5 hr per classroom. Although for purposes of the research, the classroom modifications were completed within one weekend, in practice, teachers need not be confined by this time frame. The cost of making the modification was approximately $500 per classroom; thus, the dedicated time per classroom is a minimal investment to obtain positive changes in student behavior.

Individualization of modifications. An important aspect of the study was the individual consultation leading to modifications suited to each teacher's needs. In some cases, after the modifications were made, the teacher requested additional changes to better suit the needs of his or her learners. Individualization and continual adaptations of the modifications probably contributed to the maintenance of high academic engagement and low disruptive behavior during the follow-up. However, individualization also requires flexibility and modification over time.

Minor modifications may need to be made to accommodate unexpected challenges. For example, in Classroom 1, desks were added for each student during the initial modification. After using the desks for a period of 3 days, Teacher 1 requested that the desks be stabilized because the students had a hard time staying still and, consequently, were constantly moving their desks. The need for alterations points out the necessity of continually working with the teachers until the physical modification is satisfactory. Modifications that are not satisfactory are unlikely to be used.

Teachers' use of modifications. Although all modifications were agreed upon by the teacher prior to the intervention, the teacher(s) did not always use the modification in the same manner. For example, one teacher took down the carrels after the first day of the intervention and was not seen using them for the remainder of the study. In contrast, another teacher instructed her students on how to set up the carrels so they could use them at their discretion. Interestingly, all three teachers reported in their interviews that the carrels were the most helpful in encouraging academic engagement for their students. Their opinions were validated by the data because in Classrooms 1 and 3, when the teachers used the carrels, the level of disruptive behavior was lower and academic engagement higher than on days when the carrels were not used.

Practitioners should understand the implications of the effects of the classroom physical environment on student behavior. Physical modifications can be the first step to increase desirable student behaviors prior to more intrusive interventions.

Implications for Future Research

Findings from this study suggest that the physical environment can have an influence on student academic engagement and disruptive behavior. Because

the research was conducted only in self-contained classrooms with four to five students who have hearing loss, it will be desirable to expand the research to other settings for these students, such as general education or resource classrooms. General education classrooms, because of the numbers of students and the presence of multiple adults, often have many more auditory and visual distractions than self-contained classrooms. Changes to these classrooms may benefit not only students with a hearing loss but also other students in the classroom. Resource classrooms often have students working on different tasks; service professionals often enter and exit with students, possibly creating a highly distractible environment. Researchers could examine physical arrangements in these settings to reduce visual and auditory distractions. Replication of this study in different classroom settings and with larger groups of students will help to validate the current findings and increase the generalizability to a larger population and to different settings, such as inclusion classrooms and itinerant teacher work areas (Barger-Anderson, Domaracki, Kearney-Vakulick, & Kubina, 2004).

Students with hearing loss are frequently served by itinerant teachers, who pull out these students for individual instruction that may occur in poor physical conditions such as hallways, the corner of the classroom, or crowded offices. Further investigation of how these physical environments affect student behavior and engagement may assist in increasing effectiveness of itinerant services and persuading school administrators to dedicate space to the itinerant teacher.

Future research should also consider addressing the students' perception and feelings about their classroom environment. Dixie (2007) suggests asking students how they feel about the classroom environment to establish a sense of ownership and caring for the classroom. Students may suggest ideas for the classroom environment, which are not apparent to the teacher but may nonetheless help reduce disruptive behaviors or increase academic engagement.

Investigation of the parents' perception of their child's behavior and attitude after the modifications may be of interest. In addition, addressing whether the modifications affect student achievement is of great value to both researchers and practitioners. These are important factors to consider to further understand how the environment affects student behavior and engagement. Further research is needed to validate the current study as well as to explore other areas of interest and need in classroom modification research.

Conflict of Interest

No conflicts of interest were reported.

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