Learning via Direct and Mediated Instruction by Deaf Students

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Four experiments investigated classroom learning by deaf college students receiving lectures from instructors signing for themselves or using interpreters. Deaf students’ prior content knowledge, scores on postlecture assessments of content learning, and gain scores were compared to those of hearing classmates. Consistent with prior research, deaf students, on average, came into and left the classroom with less content knowledge than hearing peers, and use of simultaneous communication (sign and speech together) and American Sign Language (ASL) apparently were equally effective for deaf students’ learning of the material. Students’ self-rated sign language skills were not significantly related to performance. Two new findings were of particular importance. First, direct and mediated instruction (via interpreting) were equally effective for deaf college students under the several conditions employed here. Second, despite coming into the classroom with the disadvantage of having less content knowledge, deaf students’ gain scores generally did not differ from those of their hearing peers. Possible explanations for these findings are considered.

Over the past several decades, there has been a change in the face of deaf education. Legislation such as National Law 118/71 in Italy and Ley Orgánica 10/2002 de Calidad de la Educación in Spain has sought to improve equity and access for individuals with disabilities. In the United States, Section 504 of the Rehabilitation Act of 1973 prohibited discrimination against people with disabilities, who are otherwise qualified, in any program receiving federal funding, including academic institutions. The Education for All Handicapped Children Act (PL 94–142), passed in 1975, assured free and appropriate public education for children with disabilities. Largely as a consequence of such legislation, the number of deaf students in integrated or “mainstream” classrooms has increased dramatically.

At the postsecondary level, more than 31,000 deaf and hard-of-hearing students currently are enrolled in educational institutions in the United States. This number is up 15,000 over the past 10 years (National Center for Education Statistics, 1999), and the current number is still most likely an underestimate, as perhaps 3%-4% of college students may have an undisclosed hearing loss (Richardson, Long, & Woodley, 2004). Almost 50% of all 2- and 4-year postsecondary institutions in the United States have identified themselves as serving at least one deaf or hard-of-hearing student, and among larger colleges and universities, this number rises to around 95%.

PL 94–142, the Americans with Disabilities Act, and related legislation has resulted in the availability of a variety of alternative communication methods, including sign language, in order to provide deaf students with access to classroom instruction. However, little empirical attention has been given to how much language deaf students actually understand in the classroom or how learning is affected by their language fluencies (seemingly an essential piece of information if the underlying goals of such legislation are to be

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Language fluencies also tend not to be considered at the postsecondary level, where there is an implicit assumption that students with hearing loss can gain full access to classroom communication through either instructors’ spoken language or provided support services (e.g., sign language interpreting, real-time text). This article examines the extent to which sign language, either directly from an instructor or via a sign language interpreter, provides deaf students in integrated college classrooms with access to communication comparable to that available to their hearing classmates (see Marschark, Leigh, et al., 2006, for consideration of real-time text).

In asking whether deaf and hard-of-hearing students can be successful in mainstream classrooms (a question answered in the affirmative), Antia (2007) discussed the need for high-quality sign language interpreting in settings that include deaf students. She noted that simply having an interpreter in the classroom “does not guarantee full access to instruction” (p. 1). Antia described several difficulties associated with learning via sign language interpreting including students not being able to attend to two different sources of visual information, classroom pacing, and the situation of interpreters who are less than fully qualified being confronted by the multiple conversations and interruptions natural to large mainstream classes (Jones, 2005; Marschark, Sapere, Convertino, & Seewagen, 2005a; Sapere, LaRock, Convertino, Gallimore, & Lessard, 2005; Schick, Williams, & Bolster, 1999). Despite the ever-increasing number of deaf students in integrated classes, our knowledge about the extent to which interpreting and other support services provide them with true access to education remains unclear (Harrington, 2000; Lang, 2002).

The notion of “access” for deaf students here actually consists of two related issues. External to the student is the question of whether sign language interpreting or any other means of instruction can fully or sufficiently capture and communicate an instructor’s content and meta-instructional information. Internal to the student, but clearly in interaction with the first issue, is the question of whether any particular student has the background knowledge, conceptual structure, and learning tools to make effective use of that which is communicated (Hauser, Lukomski, & Hillman, in press; Marschark, Convertino, & LaRock, 2006). Language fluency is also part of this issue, as many deaf and hard-of-hearing children start school lacking fluency in either signed or spoken language (see Marschark & Wauters, in press, for discussion).

The experiments presented here provide comparisons of direct and mediated instruction for deaf students under several conditions in an effort to control, if not measure, the comparability of information communicated through the two modes. Marschark et al. (2005; Experiment 2) provided one demonstration that highly qualified interpreters can communicate the content of a college-level lecture with sufficient accuracy and completeness to allow skilled signers to score near ceiling on a subsequent test. In that experiment, lectures were presented either via direct instruction (spoken) or via interpreting (signed without audio) to hearing sign language interpreters. Scores on a posttest that covered the content of the lecture did not differ between the two conditions (93% and 90%, respectively). Experiment 1 of that study, in contrast, found deaf students’ mean performance with the same materials (but with audio available) to range from 50% to 80%, whereas hearing students’ performance ranged from 84% to 94% in corresponding conditions (controlling for differences in prior knowledge).

Several other studies have demonstrated that deaf students’ performance in interpreted educational settings is relatively modest. Fleischer (1975) and Murphy and Fleischer (1977) examined deaf college students’ comprehension of lectures communicated via interpreting (American Sign Language [ASL]) versus transliteration (signing with English word order but with characteristics of ASL) and obtained no differences due to instructional mode. Although neither study compared such mediated learning to direct instruction for either deaf students or hearing students, mean comprehension scores for the deaf students ranged only from 42% to 59%. Another comparison of interpreting and transliteration by Livingston, Singer, and Abramson (1994) yielded scores ranging from 49% to 94% across various conditions, with an overall mean score of 62%. Among college students who had seen an interpreted lecture, those who were designated as ASL oriented showed a significant
advantage relative to those who were designated as oriented toward English-like signing. A reliable advantage was not obtained for transliteration of the lecture by the students who were designated as oriented toward English-based signing, however, and when a narrative presentation rather than a lecture was interpreted, neither comparison was reliable.

Jacobs (1977) presented deaf and hearing college students with “high-quality” transliteration of lectures via university interpreters. Deaf students scored significantly lower than hearing students on written multiple-choice tests, averaging 69% across the six lectures. This compared to an average score of 83% by the hearing students who received the lectures via direct instruction. In experiments reported by Marschark, Sapere, Convertino, Seewagen, and Maltzen (2004), deaf and hearing college students saw lectures accompanied by either interpreting or transliteration. Regardless of whether the multiple-choice posttests were written or signed, deaf students scored from 60% to 75% across conditions, significantly lower in each case than the 85%-90% obtained by hearing peers. Marschark et al. (2005a) examined the effects on learning of student–interpreter familiarity and interpreters’ experience in postsecondary classrooms. They obtained results comparable to the earlier findings, as deaf students’ mean posttest scores ranged from 69% to 70%, whereas those of hearing students ranged from 85% to 88%, even when they statistically controlled for prior content knowledge.

The above-mentioned findings that deaf students learning via mediated instruction obtain less information from classroom presentations than their hearing peers are not restricted to settings using instruction via sign language interpreting. Studies by Jelinek Lewis and Jackson (2001); Marschark, Leigh, et al. (2006); and Stinson, Elliot, Kelly, and Liu (in press) obtained similar results when deaf high school and college students were presented with real-time text in the classroom. Interestingly, Marschark, Leigh, et al. (2006, Experiment 3) found that Australian deaf students aged 12–16 years scored no higher when geography lessons were presented directly by a deaf teacher (using Auslan) than when they were presented via real-time text or both the direct instruction and the text simultaneously. That result contradicted the accepted wisdom (at least among interpreters and interpreter trainers, e.g., Davis, 2005; Winston, 2005) that direct instruction, particularly if provided by a deaf instructor, would be superior to mediated instruction.

Kurz (2004) compared direct and mediated instruction for deaf students under controlled conditions. Deaf students in sixth to ninth grade each saw six science lessons, three given by a hearing science teacher with an interpreter (mediated instruction) and three by a deaf science teacher (direct instruction). Lessons and instructional mode were counterbalanced across participants. Test scores indicated that students learned significantly more of the content in two of the six lessons when they were given via direct instruction. Analyses by student indicated that of the 19 students, 2 learned relatively more overall via interpreting, 10 learned more via direct instruction, and 7 showed no difference in learning in the two conditions. Although these results suggest an advantage for some deaf students’ learning via direct instruction, the deaf teacher’s lectures in Kurz’s study were almost twice as long as the hearing teacher’s interpreted lectures. The finding of Marschark, Leigh, et al. (2006; Experiment 3) that direct instruction from the deaf teacher did not differ from mediated instruction via real-time text, in contrast, entailed presentations from the same person and of identical length because the within-participants design involved groups of students receiving instruction in all three conditions in the same classroom at the same time (counterbalanced over lectures). In short, what limited evidence is available suggests that mediated and direct instruction may not differ much in overall effectiveness for deaf students, all other things being equal. The following experiments were intended to further examine this issue.

Experiment 1

Experiment 1 explored the possibility that relative to previous studies, deaf students’ classroom learning might benefit from direct instruction, particularly by a deaf teacher. Such a superiority might result from more fluent communication than might otherwise be the case (Lang, McKee, & Conner, 1993), deaf teachers’ having a better understanding of how deaf
students think and learn (Marschark, Convertino, et al., 2006), or deaf students’ greater motivation (Stinson & Walter, 1997) when taught by a deaf teacher. More importantly, the experiment examined whether mediated learning involving an interpreter is inherently inferior to direct instruction, as suggested by Davis (2005), Winston (2005), and others. In particular, it addressed the question of whether previous studies in which deaf students did not learn as much as hearing peers in interpreted settings were the result of the reduced fidelity of information when it passed through an intermediary between instructor and student. Here, a deaf university instructor gave a lecture intended for both deaf and hearing students. For the deaf students, this represented direct instruction, whereas sign-to-voice interpreting for the hearing students represented mediated learning. The situation was thus parallel to prior studies in which hearing instructors’ spoken lectures represented direct instruction for hearing students but mediated learning (via voice-to-sign interpreting) for deaf students. The primary manipulation was the nature of interpreting provided to the hearing students. If mediated instruction is inherently inferior to direct instruction, deaf students should perform better, or at least no worse, than hearing students.

Method

Participants. The experiment involved four groups of students: one containing 22 deaf students and three containing 20, 22, and 24 hearing students. All students were enrolled at Rochester Institute of Technology (RIT). RIT includes the National Technical Institute for the Deaf (NTID) as one of its eight colleges, but deaf participants came from all RIT colleges. Students were recruited via flyers and personal contacts and were paid for their participation. All the deaf students reported depending on sign language as their primary mode of communication. Eleven of the 22 reported using hearing aids regularly; none had cochlear implants.

Design and procedure. A 30-min lecture on schizophrenia was provided by a Deaf university professor who works in the area of neuroscience and clinical psychology. An instructor in RIT’s College of Liberal Arts, he had recently won the university award for excellence in teaching given to new faculty. He was accustomed to teaching mixed classes of deaf and hearing students and used primarily ASL in the classroom, supported by a designated interpreter who provides voice interpreting for hearing students. The lecture, intended for nonmajors in psychology, was interpreted by three different interpreters: (a) the instructor’s designated interpreter, who was highly familiar with the instructor and the lecture content; (b) an interpreter deemed by interpreting services managers to be of comparable skill and experience but who was unfamiliar with either the instructor or the lecture content; and (c) a new interpreter who had just graduated from the NTID interpreter training program. The new interpreter was one of the top students in her graduating class but had relatively little classroom experience with voice interpreting and was not familiar with either the instructor or the lecture content.

The lectures and the interpretation were digitally recorded and presented using life-sized video projection, following the demonstration by Marschark et al. (2005) that live and projected lectures led to comparable levels of learning by both deaf and hearing students. Students viewed the lectures in small groups in a regular RIT classroom. In this and subsequent experiments, students, interpreters, and instructors were told only that the experiments concerned deaf and hearing students’ learning in the classroom.

In collaboration with the instructor, 20 multiple-choice questions, each with four alternative answers, were created for use as posttest questions. In this and the subsequent experiments, questions on the multiple-choice tests included primarily factual information (recall), but some required inferences. In the latter case, care was taken to avoid “remote” inferences, ensuring that the answers to the questions were easily discerned from the information provided by the instructor. After preparation of the tests, they were always vetted to ensure that they contained the information necessary to answer all the questions, and modifications were made where necessary. In this experiment, 10 of the questions were selected for use as a content-specific pretest of prior knowledge and were administered prior to the lecture. Immediately
following the lecture, all three groups completed the 20-question posttest.

All deaf students completed a communication questionnaire adapted from the NTID Language and Communication Background Questionnaire (LCBQ). NTID employs the LCBQ rather than face-to-face communication interviews to obtain information on student language skills because it is more efficient and has been found to correlate approximately 0.80 with interview assessments. The questionnaire was not intended as a definitive assessment of student language skills but provided estimates sufficient for the present purposes. In particular, analyses reported below used students’ responses, on a 1–5 Likert-type scale, to two questions: “Please rate your skill in understanding ASL” and “Please rate your skill and understanding signed English (no voice).” The meanings of both “ASL” and “signed English” were elaborated for the deaf students, ensuring that they understood that the former was not a precise term and that the latter did not refer to Seeing/Signing Exact English but to English-based signing.

Results and Discussion

Unless otherwise indicated, all and only those results presented in this and subsequent experiments were significant at the .05 level. Post hoc comparisons all used Bonferroni tests, a method based on the Student’s $t$ statistic but which adjusts significance levels for multiple comparisons. Unless otherwise noted, all analyses were conducted using the percentage of correct responses.

Consistent with prior studies, all three groups of hearing students scored higher than the deaf students on the pretest indexing prior content knowledge, yielding a significant effect of group in a one-way analysis of variance, $F(3, 84) = 5.98$, $MSe = 211.64$ (Table 1). A similar analysis of the posttest scores also yielded a significant effect of group, $F(3, 84) = 8.90$, $MSe = 236.66$. Post hoc tests indicated that hearing students who saw the lecture interpreted by the two experienced interpreters scored significantly higher (87% and 83%) than the deaf students (67%). Posttest scores of the hearing students who were supported by the new interpreter (69%) did not differ from those of the deaf students.

These analyses would appear to indicate that hearing students who saw a lecture mediated by a skilled interpreter learned more of the content than did the deaf students, even though the latter received direct instruction from the deaf instructor. However, the posttest results could reflect the fact that the hearing students knew more about the content material than their deaf peers prior to the lecture, at least as indexed by the pretest. Two additional analyses therefore examined learning while eliminating effects of prior knowledge. In the first, an analysis of covariance was conducted in which posttest scores served as the dependent variable and pretest scores as the covariate. This yielded a significant effect of group, $F(3, 83) = 6.60$, $MSe = 204.08$. Post hoc tests revealed that when prior knowledge was controlled, hearing students who received the lecture via the instructor’s designated interpreter scored higher than the deaf students, but there were no other significant differences among the groups (Table 1).

A second means of examining learning independent of prior knowledge involved the calculation of gain scores. These were obtained by subtracting performance on the pretest from performance on the same 10 questions when they were repeated on the

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means (SDs) of pretest, posttest (controlling for prior knowledge), and gain scores* in lecture from deaf instructor in Experiment 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Students</td>
</tr>
<tr>
<td>Direct instruction</td>
<td>Deaf</td>
</tr>
<tr>
<td>Dedicated interpreter</td>
<td>Hearing</td>
</tr>
<tr>
<td>Skilled interpreter</td>
<td>Hearing</td>
</tr>
<tr>
<td>New interpreter</td>
<td>Hearing</td>
</tr>
</tbody>
</table>

*Gain score = pretest items appearing on the posttest (raw scores) minus pretest score.
posttest ("old" items). Overall, scores on the old posttest items increased 29% from the pretest. A one-way analysis of variance using gain scores as the dependent variable yielded a significant effect of group, $F(3, 83) = 11.13$, $MSe = 305.54$. The hearing students who received an interpretation from the new interpreter had significantly lower gain scores than deaf and hearing students in the other groups, none of which differed significantly from each other (power = 0.825; Table 1).

Experiment 1 thus yielded two important findings. First, it indicated that mediated learning does not necessarily disadvantage learning, at least when skilled interpreters are involved. Hearing students who saw a lecture voiced by a skilled interpreter scored as well or better than deaf peers who received the same lecture directly from a deaf instructor. A new, relatively inexperienced interpreter voiced for the deaf instructor well enough that hearing students learned as much as deaf students who received direct instruction, but this is not the kind of "level playing field" we are seeking. Second, with the exception of the condition involving the designated interpreter, comparisons involving gain and posttest scores controlling for prior knowledge failed to reveal the usual significant advantage for hearing students over deaf students in learning from a college-level lecture. This was true even though the deaf students entered the classroom with less content knowledge than their hearing peers, as indexed by the pretest.

One possible explanation for the lack of a significant difference in gain scores was that students were taught by a deaf instructor who perhaps was able to overcome (or side step) deaf students' potential disadvantages in the classroom by virtue of his own experiences. Having a deaf instructor also offers a social–emotional–intellectual link between the instructor and the deaf students, involves someone who understands "how deaf students think" (Marschark & Wauters, in press) and may contribute to greater motivation on the part of the deaf students (Stinson & Walter, 1997). Alternatively, the key may lie in having accessible direct instruction, independent of the instructor's hearing status (Lang et al., 1993).

The deaf college students in the present experiment rated their sign language skills quite highly. On the 5-point scale from no skill to excellent, the mean rating for ASL comprehension was 4.41 ($SD = 0.67$), and the mean rating for comprehension of English-based signing was 4.05 ($SD = 1.13$). Correlational analyses, however, indicated no significant relationships between those self-rated skills and either posttest scores, $r_{s(21)} = .06$ and .27, respectively, or gain scores, $r_{s(21)} = .002$ and .42, respectively, all $ps > .05$. It thus appears unlikely that language fluency, per se, accounts for these results (see comparable results in Marschark, Leigh, et al., 2006, with regard to real-time text, and Marschark et al., 2005, with regard to performance of "oral" vs. "signing" students).

A related explanation for the apparent success of the deaf students here concerns to another difference between this experiment and previous studies (Jacobs, 1977; Livingston et al., 1994; Marschark, Leigh, et al., 2006; Marschark et al., 2005a; Murphy & Fleischer, 1977). In almost all the previous experiments examining deaf students' learning via sign language interpreting compared to hearing classmates, lectures were given by mainstream hearing instructors with only limited, if any, experience teaching deaf students. In addition to the instructor in Experiment 1 being deaf, this was the first time that we used a skilled and experienced teacher of deaf students who could fully appreciate and accommodate differences between them and hearing learners sharing the same classroom (Marschark, Convertino, et al., 2006). Previous studies by Marschark and colleagues all used peer-nominated, high-quality instructors, but they were instructors of hearing students who only occasionally encountered deaf students in their classes. Information about teacher quality was not available for the other studies reviewed above. Experiment 2 further, therefore, explored the issue of direct and mediated instruction while extending our research to include a more diverse population of deaf students.

**Experiment 2**

Using a design that involved direct instruction for deaf students and interpreting for hearing students, Experiment 1 suggested that mediated learning via interpreting does not necessarily create a disadvantage in the classroom. Our pedagogical goal, however, is to improve learning by deaf students in integrated
settings, where deaf instructors are extremely rare. Experiment 2 therefore sought to clarify the results of Experiment 1 by having lectures presented by hearing instructors experienced in teaching deaf students and able to communicate directly with both them and hearing students.

Because of the mix of students who use sign language and spoken language in NTID classrooms, instructors frequently use simultaneous communication (spoken English and sign together, SC) for the purposes of direct instruction. That mode of communication was used in this experiment as well. Although it has been pointed out that SC does not fully represent either ASL or English grammar (Marmor & Petitto, 1979), studies that have examined classroom learning have indicated that in the hands of a skilled user, SC can be as effective as other forms of communication at middle school through college levels (e.g., Cokely, 1990; Hyde & Power, 1992; Newell, 1978). Quinsland and Long (1989), for example, compared deaf college students’ classroom learning when an instructor either signed for himself using SC or used interpreters designated as “skilled” or “unskilled” based on their certification with the Registry of Interpreters of the Deaf. As in the present Experiment 1, Quinsland and Long found that students learned significantly more content with a skilled interpreter relative to an unskilled one, but there was no difference between direct instruction via SC and instruction via a skilled interpreter. In the present experiment, use of SC also offered the advantage of providing for a comparison group of hearing students because it is as accessible to them as it is to deaf students.

Learning of lecture content by deaf and hearing students was examined here in conditions where instructors presented their lectures either in spoken language, with voice-to-sign interpreting for deaf students, or using SC. Lectures given via spoken language created conditions of direct instruction for both hearing and deaf students who use spoken language but mediated (interpreted) instruction for deaf students who use sign language. Lectures involving SC created conditions of direct instruction for both hearing and deaf students, regardless of deaf students’ preferred mode of communication.

Method

Participants. Twenty-four deaf and 12 hearing RIT students participated in the experiment. Twelve of the deaf students were designated “signing students,” based on LCBQ responses, indicating that they learned to sign early in life and had used it through all or most of their educational careers. The other 12 deaf students either did not know sign language or were new to it, reporting that they depended on spoken communication throughout all or most of their educational careers. Although the term “oral” is a misnomer for students who primarily use spoken language, it is less cumbersome than the alternatives and is used here to refer to this latter group. Ten of the 12 oral students reported using hearing aids regularly; the other two had cochlear implants and reported using them consistently. Four of the signing students reported using hearing aids regularly. Three others had cochlear implants, although only two indicated that they used them consistently. All participants were recruited via flyers and personal contacts; they were paid for their participation.

Design and procedure. Two hearing NTID instructors developed brief, introductory, college-level lectures. Each instructor was recorded twice: once presenting their lecture via SC and once via spoken language only. One lecture, given by a mathematics instructor, was on the “Golden Section.” The other lecture, given by an information technology instructor, was on the programming language Visual Basic. Although adult learners of sign language, each instructor had been teaching deaf students for more than 20 years, had been recommended for their excellent communication skills and had won the university’s award for teaching excellence by senior faculty. The single interpreter had more than 20 years’ experience in college-level classrooms and provided students with the standard RIT interpreting for integrated classes (i.e., English word order with characteristics of ASL). In addition, with a background as an oral interpreter, he provided clear spoken language mouth movements throughout his transliterations.

The procedure was similar to Experiment 1, but each student received two lectures, one in each
instructional mode. Pretests and posttests were constructed as in Experiment 1, except that pretests contained 9 questions and posttests contained 18. After the test on the first lecture, students completed the communication questionnaire and then received the second lecture. Students saw the life-sized, video-projected lectures in a mock classroom containing only one or two students at a time. The essential design was thus 3 (group: signing deaf students, oral deaf students, hearing students) × 2 (lecture content) × 2 (instructional mode: SC or spoken/interpreted); the latter two factors were within participants. Order of presentation (both lecture content and instructional mode) was balanced across sessions.

Results and Discussion

Preliminary analyses indicated no significant effects of presentation order (either lectures or instructional mode) on either pretest or posttest scores, and that factor is not considered further. Analyses of pretest performance involved a 3 (group) × 2 (lecture content) analysis of variance in which lecture content was within participants. There was both a main effect of lecture, \( F(1, 38) = 4.81, \text{MSe} = 0.03 \), as students scored higher on the mathematics pretest than the programming pretest, and a main effect of group, \( F(2, 38) = 4.91, \text{MSe} = 0.05 \). The group effect reflected higher pretest scores by the hearing students than either group of deaf students, although only the difference between the hearing students and the signing students was significant (Table 2). Because of these differences in prior knowledge, analyses of posttest scores involved analyses of covariance, using pretest performance to control for prior content knowledge.

Posttest scores for the two lectures were analyzed separately, using 3 (group) × 2 (instructional mode) analyses of covariance because of the incomplete blocks design (students received lectures in both instructional modes, but the lectures had different content/instructors). For the programming lecture, this analysis revealed a marginal effect of group, \( F(2, 29) = 3.24, \text{MSe} = 0.02, p = .054 \), but neither the effect of instructional mode, \( F(1, 29) = 2.55 \), nor the Instructional Mode × Group interaction, \( F(2, 29) < 1 \), was significant. The marginal group effect reflected the fact that oral deaf students scored somewhat lower than signing deaf students, who performed somewhat lower than the hearing students, but none of the post hoc tests were significant.

For the mathematics lecture, the analysis of posttest scores revealed a significant effect of group, \( F(2, 29) = 9.45, \text{MSe} = 0.02 \), and a reliable Group × Instructional Mode interaction, \( F(2, 29) = 3.56 \), but no main effect of instructional mode, \( F(1, 29) = 1.37 \). The group effect reflected the fact that, overall, hearing students scored significantly higher than oral deaf students, whereas the signing and hearing students did not differ. The interaction derived from the oral and signing deaf students’ performing equally well in the spoken/interpreted lecture, but not as well as the hearing students, whereas when the instructor signed for herself, the oral students scored below both the signing students and the hearing students, who did not differ (perhaps due to a ceiling effect; Table 2).

As in Experiment 1, it was expected that gain scores would provide a more sensitive measure of content learning under the different conditions. A 3 (group) × 2 (instructional mode) analysis of variance using gain scores (old posttest items minus pretest) on the programming lecture as the dependent variable yielded only a significant effect of instructional mode,

<table>
<thead>
<tr>
<th>Condition</th>
<th>Oral students</th>
<th>Signing students</th>
<th>Hearing students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming lecture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.46 (0.13)</td>
<td>0.38 (0.19)</td>
<td>0.64 (0.22)</td>
</tr>
<tr>
<td>Posttest</td>
<td>0.62 (0.29)</td>
<td>0.68 (0.12)</td>
<td>0.85 (0.17)</td>
</tr>
<tr>
<td>Signed (SC)</td>
<td>0.09 (0.20)</td>
<td>0.35 (0.11)</td>
<td>0.18 (0.20)</td>
</tr>
<tr>
<td>Gain</td>
<td>0.66 (0.11)</td>
<td>0.79 (0.18)</td>
<td>0.88 (0.11)</td>
</tr>
<tr>
<td>Interpreted</td>
<td>0.33 (0.14)</td>
<td>0.39 (0.15)</td>
<td>0.31 (0.19)</td>
</tr>
<tr>
<td>Mathematics lecture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.57 (0.21)</td>
<td>0.51 (0.23)</td>
<td>0.67 (0.20)</td>
</tr>
<tr>
<td>Posttest</td>
<td>0.82 (0.14)</td>
<td>0.93 (0.03)</td>
<td>0.96 (0.07)</td>
</tr>
<tr>
<td>Signed (SC)</td>
<td>0.24 (0.16)</td>
<td>0.44 (0.17)</td>
<td>0.28 (0.17)</td>
</tr>
<tr>
<td>Gain</td>
<td>0.78 (0.13)</td>
<td>0.78 (0.13)</td>
<td>0.97 (0.03)</td>
</tr>
<tr>
<td>Interpreted</td>
<td>0.37 (0.17)</td>
<td>0.37 (0.29)</td>
<td>0.37 (0.22)</td>
</tr>
</tbody>
</table>

*Gain score = pretest items appearing on the posttest (raw scores) minus pretest score.*
$F(2, 30) = 5.82, MSe = 0.03$, as gain scores were greater in the interpreted instruction condition than in the direct instruction condition. An analysis of variance on the gain scores for the mathematics lecture yielded no significant effects, all $F$s < 1, $MSe = 0.041$ (Table 2).

Correlational analyses again were used to examine relations between self-reported communication skills and performance. Posttest and gain scores in direct and interpreted instruction conditions were considered separately, together with rated ASL comprehension, rated comprehension of English-based signing, and preferences for sign versus speech as a mode of instruction in the classroom (all 5-point scales). There were no significant correlations between performance and communication skills among either the oral or the signing students.

Three important findings emerge from these results. First, and most importantly, scores of deaf students who signed did not differ from those of hearing students in these lectures, as indexed by both posttest and gain scores. These findings contrast with previous studies but are consistent with Experiment 1. Second, for students who typically use sign language in educational settings, instruction via interpreters or teachers signing for themselves generally resulted in comparable levels of performance as indexed by gain scores. In other words, mediated learning does not appear inherently inferior to direct instruction for deaf students in any broad sense (cf. Davis, 2005; Winston, 2005). Third, scores of deaf students who rely on spoken language, and have done so throughout their educational careers up to the college level, did not surpass those of students who use sign language in the classroom (see Marschark et al., 2005, for similar results). Students who rely on spoken language did not do as well as either the signing deaf students or the hearing students, overall, despite the fact that they had access to both the instructors’ speech and the clear mouthing from the interpreter in a quiet classroom. Moreover, although SC is sometimes maligned as a “fractured” communication mode, it is revealing that performance did not seem to be compromised for deaf students who relied on the signing or hearing students who relied on the spoken message.

**Experiment 3**

The findings from the first two experiments demonstrate that deaf students can learn as much via sign language interpreting in the classroom as their hearing peers can through direct instruction, at least as indexed by instructors’ multiple-choice tests. These results contrast with previous studies involving mediated learning, which uniformly have found deaf students to perform below the levels of their hearing peers. It could be argued, however, that Experiment 2 did not provide an optimal academic context for signing students because the instructors were using simultaneous communication (Cokely, 1990; Johnson, Liddell, & Erting, 1989; Marmor & Petitto, 1979). Because of the frequency with which SC is used in lieu of sign language interpreting in the education of deaf students of all ages, Experiment 3 examined whether deaf college students’ learning is disrupted by skilled-signing hearing instructors who voice when they sign. It apparently did not do so in Experiment 2, which compared hearing students and deaf signers; Experiment 3 asked whether results would be similar when teachers used SC versus ASL (i.e., without voice). The caveat of using instructors who are skilled in SC is important here because previous studies that have done so (e.g., Cokely, 1990; Newell, 1978; Quinsland & Long, 1989) have demonstrated comparable levels of learning with SC as with other modes of instruction, whereas studies that have used less skilled users (e.g., Marmor & Petitto, 1979) have shown the sign code to be relatively impoverished relative to the speech code (although Marmor and Petitto did not evaluate the effectiveness of communication).

In Experiment 3, two hearing instructors each provided lectures once using SC and once using ASL. Both instructors were adult learners of sign language, and referring to their voice-off sign language production as ASL is more a relative distinction rather than an indication that the investigators can be confident of the quality of the ASL grammar or appropriateness of sign selection. The signed lectures appeared to include more characteristics of transliteration than the lecture of the deaf instructor in Experiment 1, but they were more ASL like than the transliterations of
the lectures provided by the interpreter here and in Experiment 2.

Method

Participants. Thirty-two deaf students participated in this experiment, all of whom identified themselves as signers. They were drawn from the same population as those in the previous two experiments and were paid for their participation. The two instructors were senior RIT faculty members teaching in the college of NTID. One lecture, signed without voice, was obtained from the mathematics instructor who participated in Experiment 2. It was the same Golden Section lecture that she had produced in SC and spoken language, and it was taped in the same session as the other two lectures. Another pair of lectures was obtained from an instructor in the same department as the information technology instructor in Experiment 2 and who also had won the university teaching award for senior faculty. His lecture was on using Microsoft Excel.

Design and procedure. The procedure was identical to that in Experiment 2. Each of the deaf students saw one lecture in SC and one in ASL, with counterbalancing across small testing groups. No hearing students were involved in this experiment. Pretests contained 9 questions and posttests contained 18.

Results and Discussion

Preliminary analyses indicated no significant effects of presentation order on either pretest or posttest scores, and that factor is not considered further. Analyses of pretest performance involved a one-way analysis of variance in which lecture content was within participants. The main effect was not significant, \( F(1, 31) = 3.53, \text{MSe} = 0.02 \), and so subsequent analyses did not require controlling of prior knowledge.

Given the nature of the incomplete blocks design, simple \( t \) tests were used for the remaining analyses, and the results are easily stated. There were no significant differences in performance between students who received a lecture in SC from one instructor or the other or between students who received ASL from one instructor or another. More importantly, using either posttest or gain scores as the dependent variable, there were no significant differences between ASL and SC for either instructor (all \( ts < 1.0 \); Table 3). Simply put, there was no evidence that SC interfered with deaf students’ learning. Although a null effect, this finding is consistent with a variety of previous studies involving high school and college populations (e.g., Cokely, 1990; Newell, 1978; Quinsland & Long, 1989). It also replicates Experiment 2, in which SC produced gain and posttest scores (controlling for prior knowledge) that did not differ for signing deaf and hearing students.

Correlations examining possible relations of self-rated skill in SC and “sign language (without voice)” with posttest and gain scores for both SC and ASL conditions yielded no significant coefficients. This experiment thus indicates that the methodology of Experiment 2 was not biased against deaf students’ performance using SC. Still, there are other conditions that need to be evaluated before it seems safe to conclude that mediated instruction does not put deaf students at a disadvantage in mainstream settings.

Experiment 4

The findings obtained in Experiments 1–3 indicate that even if they come into the classroom with less

<table>
<thead>
<tr>
<th>Condition</th>
<th>( M ) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming lecture</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.51 (0.16)</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
</tr>
<tr>
<td>ASL (no voice)</td>
<td>0.76 (0.14)</td>
</tr>
<tr>
<td>Gain</td>
<td>0.39 (0.19)</td>
</tr>
<tr>
<td>Simultaneous communication</td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>0.33 (0.14)</td>
</tr>
<tr>
<td>Mathematics lecture</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.44 (0.18)</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
</tr>
<tr>
<td>ASL (no voice)</td>
<td>0.84 (0.12)</td>
</tr>
<tr>
<td>Gain</td>
<td>0.32 (0.19)</td>
</tr>
<tr>
<td>Simultaneous communication</td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>0.24 (0.12)</td>
</tr>
</tbody>
</table>

Note. ASL = American Sign Language.  
*Gain score = pretest items appearing on the posttest (raw scores) minus pretest score.
content knowledge than their hearing peers, deaf students can make comparable gains when they are taught via sign language interpreting or direct instruction. There are still remaining questions about the relative effectiveness of mediated (interpreted) instruction, however, because no one has compared hearing students’ learning under conditions of direct versus mediated instruction, nor have we seen a comparison of direct and interpreted instruction for deaf students using the same materials. The difficulty inherent in developing an experiment with the latter design is reflected in the study by Kurz (2004), described earlier.

Kurz (2004) sought to compare the effectiveness of direct and interpreted instruction by having the deaf and hearing teacher (with interpreter) use prepared scripts. The teachers collaborated on preparation of their presentations, but students’ prior knowledge was not evaluated in any way that allowed calculation of gain scores. Most importantly, even if the lessons provided by the two teachers covered the same material, the fact that direct instruction from the deaf teacher took almost twice as long as the interpreted instruction by the hearing teacher indicates that their presentations were rather different. The length difference cannot be attributed solely to the fact that individual signs take more time to produce than words, as Bellugi and Fischer (1972) showed that the use of inflections, classifiers, and other devices in ASL results in a rate of information production comparable to that of spoken English. It appears more likely that the deaf instructor, recognizing the needs of the deaf students, used more repetition, gave lengthier or more detailed explanations, and provided more explicit statements rather than depending on students to make inferences (Marschark & Wauters, in press).

In Experiment 4, we sought to eliminate earlier confounds and examine how much deaf and hearing students learn when they receive instruction from teachers who have native fluency in their shared languages, a situation not fully satisfied in Experiments 1–3 or any previous studies. We also sought comparisons of learning using the same material. After considering a variety of alternatives with differing strengths and weaknesses, we chose to use only a single instructor, a native-signing hearing child of deaf parents who has a mathematics background, routinely teaches mathematics to deaf students, and works as a certified sign language interpreter.

The instructor created two lectures, each of which he presented in both ASL and spoken English. The ASL version of a lecture represents direct instruction for deaf students, and its (voice) interpreted version represents mediated instruction for hearing students. The spoken English version of a lecture represents direct instruction for hearing students, and its (signed) interpreted version represents mediated instruction for deaf students. By having the instructor provide two lectures, we created a within-participants design in which each student received lectures by both direct and mediated instruction from the same instructor, and across participants, the materials were as close as possible to identical. Fully recognizing that presentation of the same content in ASL and English might still make for some differences, the fact that both lectures were produced by the same individual seemed likely to minimize them (see below).

Method

Participants. Twenty-two deaf students and 20 hearing RIT students from the same population as the previous experiments were paid for their participation. The deaf students were selected from among those who consider themselves signers. The senior interpreter had worked in college-level classrooms for more than 20 years and has near-native ASL skills according to deaf and hearing colleagues.

Design and procedure. As described above, the hearing mathematics instructor was a native user of ASL who uses it regularly in the classroom. He was requested to create two lectures of approximately 15–20 min in length. One of his lectures described the discovery of calculus; the other was about the mathematical accomplishments of Pythagoras. He was videotaped while presenting each lecture, once in ASL and once in spoken English. The two lectures were recorded on different days, but both versions of each lecture were recorded in the same session. The instructor re-recorded one of the English lectures to make it closer
to the ASL version (at his request). He had been instructed to try to keep all the lectures the same length while covering the same material in the two versions of each lecture. The actual lengths of the generated lectures, timed continuously from the beginning of the first utterance to the end of the last, were Pythagoras signed, 16 min 53 s; Pythagoras spoken, 13 min 5 s; calculus signed, 15 min 35 s; and calculus spoken, 14 min 8 s. For the purposes of this experiment, the signed and spoken lectures were assumed to be of comparable lengths, at least relative to the 100% difference in the comparable conditions of Kurz (2004).

Each student saw two lectures: one signed by the instructor with sign-to-voice interpreting for hearing students and one spoken by the instructor with voice-to-sign interpreting for the deaf students. Lectures, versions, and their order of presentation were balanced over the multiple testing of small groups. As in the other experiments, each lecture was preceded by a test of prior knowledge (six questions) and followed immediately by a posttest (12 questions) that included the pretest questions. The students completed the communication questionnaire between the two lectures.

Results and Discussion

Preliminary analyses indicated no significant effect of lecture order, and that factor is not considered further. Analyses of pretest performance involved a 2 (hearing status) × 2 (instruction mode: mediated vs. direct) × 2 (lecture: calculus vs. Pythagoras), in which the latter two factors were within participants. An analysis of variance indicated that there was a significant effect of hearing status, $F(1, 38) = 19.70$, MSe = 423.16, as the deaf students demonstrated less prior knowledge about the content of the lectures than the hearing students (Table 4). There was also a main effect of lecture, $F(1, 38) = 22.89$, MSe = 473.23, as students demonstrated more prior knowledge about the content of the calculus lecture than the Pythagoras lecture on the pretest.

Because of differences in deaf and hearing students’ prior knowledge, posttest scores were analyzed using an analysis of covariance and the same design as the analysis of the pretest scores; pretest scores for the two lectures were the covariates. A main effect of hearing status was obtained, $F(1, 36) = 6.95$, MSe = 427.20, as the hearing students outscored their deaf peers in all conditions (0.80 vs. 0.65, overall), even when prior knowledge was controlled. This effect was qualified by significant interactions of instructional mode by lecture, $F(1, 38) = 8.95$, and hearing status by instructional mode by lecture, $F(1, 38) = 5.13$. As can be seen in Table 4, for the calculus lecture, hearing students obtained identical scores with mediated and direct instruction, whereas deaf students performed better with direct instruction than with interpreted instruction. For the Pythagoras lecture, scores were higher overall for both groups compared to the calculus lecture, and both groups performed somewhat better with direct instruction than with interpreted instruction. Nevertheless, there was not a significant main effect of instructional mode nor a significant hearing status by instructional mode interaction, both $F$s(1, 36) < 1.

Gain scores were calculated by subtracting scores on the six pretest items from scores on the six old

<table>
<thead>
<tr>
<th>Condition</th>
<th>Deaf students</th>
<th>Hearing students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.41 (0.23)</td>
<td>0.69 (0.20)</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct instruction</td>
<td>0.67 (0.19)</td>
<td>0.74 (0.13)</td>
</tr>
<tr>
<td>Mediated instruction</td>
<td>0.56 (0.22)</td>
<td>0.74 (0.17)</td>
</tr>
<tr>
<td>Gain scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct instruction</td>
<td>0.37 (0.22)</td>
<td>0.18 (0.32)</td>
</tr>
<tr>
<td>Mediated instruction</td>
<td>0.11 (0.31)</td>
<td>0.15 (0.26)</td>
</tr>
<tr>
<td>Pythagoras lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.27 (0.19)</td>
<td>0.38 (0.21)</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct instruction</td>
<td>0.74 (0.17)</td>
<td>0.92 (0.06)</td>
</tr>
<tr>
<td>Mediated instruction</td>
<td>0.57 (0.15)</td>
<td>0.88 (0.16)</td>
</tr>
<tr>
<td>Gain scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct instruction</td>
<td>0.45 (0.21)</td>
<td>0.53 (0.27)</td>
</tr>
<tr>
<td>Mediated instruction</td>
<td>0.39 (0.26)</td>
<td>0.62 (0.18)</td>
</tr>
</tbody>
</table>

Note. ASL = American Sign Language.

*Gain score = pretest items appearing on the posttest (raw scores) minus pretest score.
posttest items. They were analyzed using analyses of variance and the same design as the analysis of posttest scores. Consistent with Experiments 1–3, there was no significant difference in overall gain scores for deaf (0.33) versus hearing (0.37) students, $F(1, 38) < 1$, $MSe = 730.33$. There was, however, a significant Hearing Status $\times$ Lecture interaction, $F(1, 38) = 5.40$, $MSe = 619.11$, as hearing students gained significantly more than deaf students on the Pythagoras lecture (0.58 vs. 0.42), $t(40) = 2.15$, but gains of the two groups did not differ on the calculus lecture (0.17 vs. 0.22), $t(40) = 0.58$.

Correlational analyses were used to examine relations between self-reported communication skills and performance. Posttest and gain scores in direct and interpreted instruction conditions were considered separately for each lecture, together with self-ratings of ASL comprehension skill and English-based signing comprehension skill. The only significant coefficient was that between self-rated ASL skill and gain scores for the Pythagoras lecture, $r(41) = .46$, the lecture in which deaf students made the greatest gains. The lack of any consistent relations between communication skills and performance in this and the previous experiments, however, caution against drawing any conclusions from that single significant correlation coefficient.

**General Discussion**

The purpose of this study was to examine deaf students’ classroom learning in light of several previous studies that had consistently demonstrated them to learn less than hearing peers in mainstream settings where they received instruction through sign language interpreting (e.g., Jacobs, 1977; Marschark et al., 2004, 2005a). All four of the experiments described here replicated earlier findings, indicating that deaf college students, on average, come into classrooms with less knowledge than their hearing peers and leave the classroom with less knowledge in terms of scores on content-specific tests. The present experiments also indicated, however, that deaf students nonetheless can learn (proportionately) just as much as their hearing classmates under at least some conditions. Although there was some variability over instructors and lecture content with regard to posttest scores, both that measure and absolute gain scores indicated that content learning was largely independent of whether instruction is mediated by an interpreter or provided directly from an instructor who shared the students’ primary language.

In contradicting frequent claims that direct instruction should be superior to mediated instruction, these findings may indicate that the quality of instruction for deaf students is more important than mode of communication per se, as long as it is accessible. The situation may be one in which deaf students’ learning is more sensitive to instructional quality than is learning by hearing peers due to the academic challenges that they bring to the classroom (e.g., in reading, metacognition, memory, and problem solving; Hauser et al., in press; Marschark & Wauters, in press). Although highly skilled instructors and interpreters have been used in prior studies, it may be that the college-level instructors involved in this study had exceptional teaching skills beyond their familiarity with the academic abilities and diverse learning styles of deaf students.

Alternatively, such findings may be more specifically tied to deaf students’ receiving instruction from university instructors who are experienced and skilled in teaching deaf students or those who have experience with more other diverse student populations. Previous studies comparing learning by deaf and hearing high school and college students have involved mainstream hearing teachers with relatively little experience teaching deaf students or similar groups (Jacobs, 1977; Marschark et al., 2004, 2005a; Marschark et al., 2005). As a result, they would not be expected to have much familiarity with or experience in accommodating deaf students’ knowledge, learning styles, or their academic strengths and needs relative to hearing students. More generally, Detterman and Thompson (1997) argued that effective methods for educating any special population cannot be optimized until we better understand individual differences and the cognitive abilities underlying learning and until educators develop specific and realistic goals for such students.

If any of these hypotheses provide a convenient summary of the present results, the findings do not
speak to the issue of how instructors without experience with special populations can be educated or supported sufficiently so that deaf students in their classes can make gains of the sort demonstrated here. The results of Experiments 1 and 4, involving junior faculty members, suggest that many years of experience may not be necessary, but it is unclear whether an instructor who only occasionally finds a deaf student in his classroom can be tutored sufficiently to adjust his teaching materials and methods to accommodate such students. We have suggested elsewhere (Marschark, Sapere, Convertino, & Seewagen, 2005b) that interpreters might be able to provide this important link, but questions about the appropriateness of this solution, given interpreters' current training and the philosophy underlying interpreting as a profession, remain to be resolved (Seal, 2004).

The present experiments, together with studies described earlier involving both interpreting and real-time text support for deaf students in integrated classrooms, also leave open, more general questions concerning the relative effectiveness of integrated classrooms for deaf and hard-of-hearing students. Clearly, many deaf students succeed in mainstream K-12 classrooms (Antia, 2007; Marschark et al., 2005b). Less information is available concerning students in integrated postsecondary settings, although deaf students enrolled in the colleges of RIT other than NTID (i.e., classrooms with both deaf and hearing students) recently have been graduating at a higher rate than their hearing peers (Hurwitz, 2007).

It is important to note that none of the experiments described above found deaf students' performance to be at chance levels (25%), or even close. Rather, the deaf students' scores on multiple-choice tests typical of college classrooms fell below those of hearing peers by 10%–20%, levels comparable to the previous studies reviewed here that included both deaf and hearing students. This study goes further, however, indicating that comparable performance of deaf and hearing students is possible in integrated college classrooms using sign language interpreting as well as direct instruction by teachers who sign for themselves. The extent to which these findings depend on the quality and experience of the instructors, interpreters, or students involved in the present experiments remains to be determined. At the very least, the present findings indicate that deaf college students are not destined to lag behind hearing classmates and that there are a variety of communication alternatives that can be effective in providing them with sufficient access to classroom instruction to allow them to succeed academically.

Funding

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Notes

1. Such settings are sometimes referred to as “inclusive” or “mainstream” when they include K-12 classrooms, even if those terms have slightly different meanings. In the present context, “integrated” and mainstream are used interchangeably, referring to classrooms (usually at the college level) that include both deaf and hearing students, with appropriate support services for the former.

2. Communication protocols in NTID classrooms are typically decided by students.

3. Testing for this experiment was conducted during the first 2 months of the academic year to avoid oral students' becoming too familiar with sign language.

4. Marschark, Rhoten, and Fabich (2007) reported findings, indicating that deaf college students with and without implants did not differ in performance in studies of this sort.

5. Although most NTID faculty periodically have their ASL skills evaluated through the Signed Communication Proficiency Interview, the levels obtained from those evaluations are confidential and were not available to the investigators.

References


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