Deaf and Hard-of-Hearing Students’ Solving of Arithmetic Word Problems

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Abstract

There has been limited research into the intersection of language and arithmetic performance of deaf and hard-of-hearing students although previous research has shown that many of these students are delayed in both their language acquisition and arithmetic performance. This study examined the performance of deaf and hard-of-hearing students in South-East Queensland, Australia, in solving arithmetic word problems and also examined the strategies that they used. It was found that solution of word problems was similar for deaf and hearing students, but that deaf students’ were delayed in solving word problems. The results confirm other studies where deaf and hard-of-hearing students are delayed in their language acquisition and this impacts on their capacity to successfully undertake the resolution of arithmetic word problems. Study conclusions stress greater use of direct teaching of analytic and strategic approaches to addressing arithmetic word problems.
Deaf Students’ Solving of Arithmetic Word Problems

Research examining deaf and hard-of-hearing students’ achievements in mathematics has chiefly concentrated on their skills in operations and number. These studies have generally concluded that there is no central cognitive basis for major differences documented in mathematical performance between deaf and hearing students and that achievement differences that are observed are the result of a combination of linguistic, procedural and experiential delays for the deaf students. Increasingly in these studies, it would seem the role of language on mathematics comprehension is being recognised for both hearing (Wood, Wood, Griffith & Howarth, 1986; Zevenbegen, 2000, 2002) and deaf (Luckner & McNeill, 1994; Serrano Pau, 1995; Titus, 1995; Wood et al., 1986) students.

Extending beyond lexical and syntactic difficulties to more complex configurations, problems of an everyday nature involving the use of linguistic forms applied to arithmetic concepts and strategies have been found to cause significant difficulty for deaf students (Daniele, 1993; Serrano Pau, 1995; Luckner & McNeill, 1994; Wood et al., 1986). However, the nature of the relationship between language and mathematics understanding and performance for deaf students has still not been established in any significant detail.

In examining and theorizing the effects of language on the resolution of mathematical tasks Wood et al. (1986) argued that the linguistic characteristics of mathematical problems create difficulties for both hearing and deaf students. They contend that both deaf and hearing students are often able to do the arithmetic of questions such as “How many minutes between 10.40 a.m. and 1.20 p.m.?” (p. 157) but deaf students (particularly) experience difficulties in transforming the words of the problem into a workable mathematical format. Wood et al. (1986) conclude that the role of language delay (especially with more complex syntax) is critical to understanding the delays in performance of deaf students as opposed to earlier “deficit” models; i.e., that deafness in and of itself causes a cognitive deficit that accounts for an inability to solve problems.

Specific studies of the relationship between language and mathematics have been evident in the study of “everyday” word problems. Using Riley, Heller and Greeno’s (1983) classification of word problems (as “change”, “compare” and “combine” forms, described below) and research reported by Del Campo and Clements (1986), it is clear that the wording of arithmetic tasks has a significant effect on the successful completion of those tasks. Even where the arithmetic is simple and involves addition and subtraction of two numbers where the sum is less than ten, many students in the upper primary years can experience difficulty solving them (Lean, Clements & Del Campo, 1990).

Some researchers (Wood et al., 1986; Serrano Pau, 1995; Frostad, 1996) have claimed that while deaf students consistently show delays in comparison with their hearing peers in arithmetic problem-solving, there is no simple or direct relationship established between these delays and the students’ linguistic and experiential deficits, or with their degree of hearing loss. Serrano Pau (1995) studied deaf students’ problem solving ability using “change”, “compare” and “combine” problems in order to examine their problem-solving abilities in relation to their reading comprehension levels. While Serrano Pau acknowledged that the relationship between reading comprehension and problem solving ability was important, he found that ineffective problem solving strategies largely based upon the strategies taught by teachers and adopted by the students were also relevant in their poor performance. Other reports also suggest that the
ineffective problem solving strategies adopted by deaf students are largely based upon on the strategies taught by teachers (Luckner & McNeill, 1994).

Luckner and McNeill (1994) identified three learner capabilities relevant for deaf students when considering linguistic aspects of mathematics. These were intellectual skills, including a knowledge of the concepts and rule structures relating to the problem solving task, organized information in the form of appropriate schemata to enable an understanding of the problem, and cognitive strategies that allow the learner to select the relevant information and strategies necessary to the problem’s solution. They confirmed that deaf students have difficulties in relation to arithmetic problem solving and it is important to identify ways to assist deaf students to develop organizational and procedural skills if their arithmetic problem solving strategies are to be improved.

In summary, researchers have claimed that while deaf and hard-of-hearing students consistently show delays in comparison with their hearing peers in arithmetic problem-solving, there is no simple or direct relationship established between these delays and the students’ linguistic and experiential deficits or their degree of hearing loss (Wood et al., 1986). Indeed, Wood et al. go so far as to suggest that what is clear from the research is that deaf and hard-of-hearing students as a group have a greater variability in their performance on mathematical tasks than the general student population. In consequence, the present study sought to examine the performance of deaf and hard-of-hearing students on arithmetic word problems with a procedure that offered some comparison to previous studies of hearing students and particularly, to examine the deaf students’ use of linguistic information and cognitive strategies.

Method

This research reports on a project that examined deaf and hard-of-hearing students’ performance solving arithmetic word problems. As previous studies have not considered the procedural strategies used by such students in solving arithmetic word problems, this project investigated the following questions:

1. How do deaf and hard-of-hearing students compare with their hearing peers in developing the ability to solve arithmetic word problems?
2. Are there identifiable strategies used by deaf and hard-of-hearing students when attempting to solve arithmetic word problems?

Using the research instrument developed by Lean, Clements and Del Campo (1990) and their data for hearing students as a comparison base, this project investigated the strategies used and outcomes achieved by deaf and hard-of-hearing students in Queensland schools when solving arithmetic word problems.

Sample. Seventy-four moderately to profoundly deaf students in the South-East Queensland region (from both mainstream and special education settings) were tested on arithmetic word problems and a selected group was interviewed about how they worked through the problems presented. The students had all been ascertained to be in need of special support because of hearing impairment, whether in regular classes with itinerant teacher support or in special units in regular schools. All had mastered basic number facts (i.e., basic addition and subtraction facts to 100) and had basic English competency skills as determined from school records and teacher judgements. Comparable numbers of boys and girls participated in the study and students did not have other significant or uncorrected impairments. In some cases, the sample size for a particular grade level was low due to the number of students enrolled in the particular year level.

INSERT TABLE 1 ABOUT HERE
The task. The arithmetic word problems were those developed by Heller and Greeno (1978) and later used in both Australia and Papua New Guinea with hearing students by Lean, Clements and Del Campo (1990). As in the Lean et al. and the Serrano Pau (1995) studies, three types of questions — “change”, “combine” and “compare” — were used. All questions involved additive or subtractive strategies with numbers where the sum was less than ten.

Riley, Greeno and Heller (1983) identified three arithmetic problem types based on the types of action needed to be undertaken in the resolution of the problem. These problem types are:

- “Change” questions which involve a process whereby there is an event that alters the value of the quantity, e.g., “Peter had 3 oranges. Michelle gave him 2 more oranges; how many oranges does Peter have now?”
- “Combine” questions which relate to static situations where there are two amounts. These are considered either as separate entities or in relation to each other, e.g., “Sarah has 4 oranges; Michelle has two oranges; how many oranges do they have altogether?”
- “Compare” questions which involve the comparison of two amounts and the difference between them, e.g., “Ben has 5 oranges; Alice has 2 more oranges than Ben; how many oranges does Alice have?”

The questions can then be divided into subcategories depending on the position of the unknown quantity within the problem. For example, “John has 2 buckets. Eric has 6 buckets. How many more buckets than John does Eric have?” versus, “Gina has some boxes. Ken has 3 boxes. Gina has 1 more box than Ken. How many boxes does Gina have?” Further distinctions in the questions need to be noted. For Change questions, the direction of change causes distinct characteristics in the questions as change may be increasing or decreasing, and hence require different actions. For Compare questions, the relationship between the sets (more or less) is a further variable affecting the question. As a result, there are 14 distinct word problems (De Corte & Verschaffel, 1991). The questions range in levels of difficulty and produce substantially different correct response rates depending on the question type and the variations within those types (De Corte & Verschaffel, 1991; Lean et al., 1990).

Procedure. The study involved two phases. Phase One consisted of a test which deaf and hard-of-hearing students in South-East Queensland completed. The survey consisted of the 24 word problems developed by Lean et al. (1990; provided in Tables 2-4) and used a pencil-and-paper format. The implementation of the test was supervised by a trained research assistant (a teacher of the deaf experienced in mathematics teaching) in conjunction with the classroom teacher. This phase provided base-line data to compare deaf and hard-of-hearing students’ performance against the hearing student population in the Lean et al. Study and is reported in detail elsewhere (Zevenbergen, Hyde & Power, 2001). From the data collected through the test, a six students a each grade level were selected (to represent school settings—mainstream and special education—of the deaf and hard-of-hearing group studied) and interviewed to provide data on the strategies they used to solve the word problems.

Phase Two thus consisted of interviews in which students were encouraged to use a “think aloud” strategy to describe their attempts to solve the tasks. The interviews were videorecorded and were undertaken with a trained research assistant who was fluent in signed English (the communication used for students in special education
settings) and experienced also in oral communication with deaf and hard-of-hearing students.

The analysis of the text transcripts was conducted using a content analysis procedure outlined by Silverman (1993). This procedure essentially identifies the major lexical items used across syntactic forms in the text of respondents and examines and confirms these across successive transcripts. For example, most of the students associated the phrase “less than” as “take away” (subtract) in their transcripts and similarly, when using the term “gave”, they interpreted this as subtraction. Some problems that had greater syntactic complexity and that used less familiar terms (e.g., two sentences describing the participants in the problem and their mathematical relationship, followed by a question referring to one of the participants—“How many did she have at the start?”) produced varied lexical and mathematical responses as the students were unsure how the participants in the problem related to each other in an operational sense, how the numerals in the problems associated with the particular participants or were confused by phrases such as “at the start”. The responses offered provided indicators of the problem-solving strategies used, features of the language used or understood, of cognitive strategies and of mathematical reasoning.

Results
The overall results could not be analysed for statistical significance due to the small sample size available in each year/grade level in the study and the difficulty of direct statistical comparison with the original Lean et al. data (particularly in relation to the different “Grade” level descriptions given for deaf students in our special school settings in comparison to those provided for students in regular school placements). Further, due to the broader grade range (1–12) used in this Queensland study and the Lean et al. Victorian study (1–7), data comparison was only possible for the primary school years. What can be observed, however, are the specific trends that emerged from the responses. Overall, the trends confirm other research in that the successful performance of deaf and hard-of-hearing students is delayed in comparison with their hearing peers, and that the complexity of the word problems creates similar demands and hence trends in performance for deaf and hard-of-hearing students as they do for hearing students.

In the tables below, data are shown for the same sets of questions used in the Lean et al. (1990) study.

INSERT TABLES 2, 3 AND 4 ABOUT HERE

The responses of these deaf and hard-of-hearing students confirm the trends that have been noted in similar studies of word problems involving such students. Students respond to the complexity of the word problem that varies depending on the syntax of the question and the operation to be undertaken—either addition or subtraction in this study. In the Compare questions, the complexity of the word problem generally increases as the tasks appear in descending order in Table 2. This makes it possible to examine the students’ capacities to deal with increasing syntactic and cognitive demands in the word problems where the nature of the operational relationship between the participants may be more or less clear in the linguistic expression.

Similar trends in the delay in correct responses by deaf and hard-of-hearing students are evident in the Change and Combine question comparisons at the grade levels. Again there is a delay in the proportion of correct responses offered by deaf and hard-of-hearing students when compared with the responses offered by the students in the Lean et al. study.
The results reflect generally the students’ better performance on the Change problems than on the Combine and (particularly on) the Compare problems. Older (high school age) students appeared to perform better than younger (elementary school) students. As hard-of-hearing and deaf students age and have greater experience with school, English and mathematics, they seem better able to respond more effectively to the questions, thereby suggesting a “delay” rather than “deficit” explanation of their the ability to respond correctly to the word problems. A more detailed analysis and discussion of these data derived from Phase 1 of the study, is reported in Zevenbergen, Hyde and Power (2001).

For all items, however, student performance was influenced by the linguistic expression involved. These influences were further examined in Phase 2 of the study and are described below.

Decontextualised problems. These tasks involve manipulation of mathematical symbols in a manner that is not embedded in a "real" context. For example, “What is the sum of 4 and 3?” or, “What number is 2 more than 4?” The linguistic component of some of these problems still created significant problems for many of the deaf students. The term “twice” was particularly difficult, with many of the students asking what the term meant. While some students below Grade 6 were able to offer the correct response, they were not able to justify their answer logically (except in one case), and could not transfer their knowledge of “twice”, indicating that they did not have a strong understanding of this term. These items appeared to be the most difficult for the students. The linguistic and conceptual complexity of “twice” was problematic for most students, but equally difficult was deciding the need for the division rather than multiplication to arrive at the correct answer. Many students transferred their knowledge of “twice” as being a process of doubling.

The concept of “less” was also particularly difficult for the students. At the decontextualised level where the binary oppositional terms of “more” and “less” are used, there were fewer students able to respond correctly to the item where the relational term “less” was integral to the item. Further through the tasks, students misconstrued items using the term “less” in a number of different ways. In the Compare tasks that ask which number is two less than three, some students took the use of “less” to connote subtraction and were able to respond correctly, in spite of their appearing not to understand the task. However, most students saw the task as a comparative one in which they had to identify which was the lesser in value of 2 or 3. The signifier “than” seemed to be not understood or used as many of the students did not know the word or its role in the sentence, resulting in the frequent misinterpretation of the task as being “which is more, 3 or 4?”.

Similar difficulties were experienced where students could not interpret the subtle use of “is”, so that they regularly interpreted a question such as “5 is 1 more than which number?” as being “5 and 1 more is which number?” . A similar reliance on the use of “more” and “less” to mean respectively “addition” and subtraction” appears to produce errors for the students.

Contextualised Word Problems. These problems place the mathematical manipulation in an everyday context. For example, in a quasi-social context: “If Mary has 4 apples and Peter has 3 apples, how many apples do they have together?” or, “If Simon makes 4 cakes and Jenny makes 2 more than Simon, how many does Jenny make?”

Where the problems were stated simply and in order of operation, there was a greater likelihood of the deaf students being able to offer correct responses. The actions
involved in the tasks (giving and taking) provided strong contextual cues for the students as to the appropriate operation. Difficulty arose when the indefinite “some” came into the word problems. Not only was the amount missing but it also produced confusion as to the appropriate operation to be undertaken. Where the non-stated amount came at the original line in the task, the students experienced great difficulty in making sense of the task. In those items, where there is a lack of a definitive amount, students were confused as to the requirements of the task (to find how many were there at the beginning). The students searched for key words (such as “lost”) to offer some cues as to what they might need to do. In one item where something was “lost” students took this as a cue for subtraction. Where the first line was ambiguous, many students seemed to ignore it and saw it as having no relevance to the task. They then proceeded to operate on the numbers given, using the cues they could extract from the text of the task.

Items with Compare tasks proved to be difficult due to the structure of the last sentences that required a comparison to be made and a difference noted. As with the other decontextualised tasks, students were at risk of interpreting the task as one that asks which is the bigger or smaller quantity and naming that quantity or interpreting the “more” or “less” in the wording to signify addition or subtraction.

Discussion and Conclusion

As described, an inherent study restriction was the low number of students available from this regional population and consequently the low numbers of students represented at each grade level. This made statistical inter-grade comparisons and comparison with the original 1991 data of Lean et al. difficult. In addition, students in the special education settings were, at times, ascribed to class levels based on the teacher’s judgement of their achievements and could not at all times be equated to the grade levels described for students in regular class programs. A number of issues and conclusions are, however, possible.

The performance of these students is essentially similar to those reported by Wood et al. (1986) for deaf students in the UK and for the Australian hearing students reported by Lean et al. (1991)—a difference being that the deaf students in the present study were delayed in comparison to the reported performances of hearing students. Further, the data collected in this project support the notion that the specificity of language used in mathematics—or more specifically, arithmetic word problems, creates difficulties for deaf students. Their difficulties were based on the variability of syntactic expression in the word problems, lack of knowledge of key terms and on passive forms of expression in some problems.

Many of the deaf students relied on a top-down approach to comprehending the tasks, seemingly accepting that they would not understand everything that was written. Relying on this reading strategy, they attempted to use their understanding of what they identified as key words and apply this knowledge to construct the meaning of the tasks. The over-generalisation of the meaning of some key words resulted in many incorrect responses. With their restricted understanding of semantics, deaf students are often compelled to rely on fragments of sentences (a lexical “strategy”) to make sense of that to which they can gain access. The complex semantics of English in the word problems and the lack of redundant and supportive information found in arithmetic word problems hinders the capacity of deaf students to make sense of the tasks, and hence their capacity to offer correct responses.

For example, as reported by Kelly, Lang and Mousley (in press), the present results support the “consistency” hypothesis proposed by Lewis and Mayer (1987) in
which deaf students were said to be more likely to misunderstand a relational statement and commit an error of reversal when an arithmetic problem was not consistent with the with the statement’s relational term (e.g., being required to add when the relational term was “less than”) (Kelly, Lang & Mousley, in press). In some ways this may be a feature of English which, with its high level of redundancy and syntactic variability, can lead to a degree of unpredictability in the language when used in arithmetic word problems.

An interesting follow up with signing deaf and hard-of-hearing students might be to examine the use of Auslan (or other natural sign languages) in the mathematics development of deaf children. A natural sign language may be more capable of using space (for example, in describing the positional relationships between the elements of or participants in an arithmetic word problem), the direction of movement of operational elements of a problem (such as John “giving” something to Mary) and emphasis (for example, forms of stress or focus on the actual key words in a problem) more effectively than spoken or signed English, while at the same time providing iconicity for many sign/lexical representations of task components or actions.

In addition, it would seem appropriate if there was greater use by teachers of direct teaching of specific language-related and meta-cognitive strategies for addressing arithmetic word problems. As summarized by Marschark et al. (2002), deaf students may not have the broad knowledge and experience to "strategically apply [their] knowledge spontaneously" (p. 125). In referring to deaf students’ lack of meta-cognitive skills these authors suggest "that their teachers may take a more concrete and focused approach to problem solving, hoping that their students will have a clear understanding of a particular strategy" (p. 132). Kelly, Lang and Pagliaro (in press) point out that in their study of deaf students the majority of mathematics teachers appeared to emphasise drill and practice type problems over “true” problem solving approaches. Further, the teachers tended to avoid teaching the deaf students “analytical strategies while focusing primarily on understanding the particular problem goal and pertinent problem information” (p. 7). This can restrict deaf and hard-of-hearing students’ capacities to address new or less familiar problems and force them to rely on the features of the range of problems for which they have instructional experience.

There could be significant benefit if fewer assumptions were made of learning transfer from a limited number of problems examined in the classroom and greater generalisation and “situating” of arithmetic problems in a more extensive range of social, cultural or vocational contexts for deaf students. Although some limited examination of this aspect was attempted in the “contextualised” analysis described above, this approach to the study of learning and performance proposed by Vygotsky (1986) and reported by Cobb and Bowers (1999) holds further promise for a better understanding of the development of competence in mathematics by deaf students. That is, situating problems in more real world social and vocational contexts could enhance the potential for deaf students to develop more analytic and strategic problem solving proficiencies.

In summary, the deaf and hard-of-hearing students were shown to be delayed in comparison to their Australian hearing peers in attempting the arithmetic problems used in the present study. While this confirms the findings of several previous studies, an analysis of the cognitive and linguistic strategies used by the deaf students has assisted in revealing a number of the procedures used by these students in attempting the problems. These suggest that the students’ application of their restricted understanding of the syntax and semantics of English may be a particular difficulty represented in the over use of some solution strategies, and that more “situated”, authentic approaches to problem solving could be used by teachers to expand the experiential, linguistic and strategic
competence of deaf students in addressing arithmetic word problems recognising that teachers, when using such an approach, should be aware of the extra layers of complexity created by such tasks. These have been alluded to in this report.
References


Author Note

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<table>
<thead>
<tr>
<th>Grade</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
<tr>
<td>No.</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td>6</td>
<td>15</td>
<td>7</td>
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</table>
Table 2
Percentage Correct of Compare Questions across Grades *

<table>
<thead>
<tr>
<th>Compare Questions</th>
<th>Grades 1</th>
<th>Grades 2</th>
<th>Grades 3</th>
<th>Grades 4</th>
<th>Grades 5</th>
<th>Grades 6</th>
<th>Grades 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>John has 2 buckets. Eric has 6 buckets. How many more buckets than John does Eric have?</td>
<td>18.2</td>
<td>8.3</td>
<td>33.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>38</td>
<td>53</td>
<td>60</td>
<td>78</td>
<td>85</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>Nick has 2 cups. Sarah has 7 cups. How many cups less than Sarah does Nick have?</td>
<td>27.3</td>
<td>33.3</td>
<td>33.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>34</td>
<td>42</td>
<td>61</td>
<td>72</td>
<td>88</td>
<td>93</td>
<td>96</td>
</tr>
<tr>
<td>Gina has some boxes. Ken has 3 boxes. Gina has 1 more box than Ken. How many boxes does Gina have?</td>
<td>50</td>
<td>85.7</td>
<td>50</td>
<td>54.5</td>
<td>83.3</td>
<td>83.3</td>
<td></td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>59</td>
<td>66</td>
<td>74</td>
<td>85</td>
<td>84</td>
<td>93</td>
<td>94</td>
</tr>
<tr>
<td>Jo has some dolls. Pat has 5 dolls. Jo has 2 dolls less than Pat. How many dolls does Jo have?</td>
<td>50</td>
<td>36.4</td>
<td>16.6</td>
<td>33.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>41</td>
<td>57</td>
<td>49</td>
<td>66</td>
<td>80</td>
<td>88</td>
<td>92</td>
</tr>
<tr>
<td>Bill has some trucks. Tina has 5 trucks. Tina has 2 trucks more than Bill. How many trucks does Bill have?</td>
<td>16.6</td>
<td>25</td>
<td>45.5</td>
<td>25</td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sam has some marbles. Sarah has 6 marbles. Sarah has 2 marbles less than Sam. How many marbles does Sam have?

<table>
<thead>
<tr>
<th>Lean et al. Hearing Student data</th>
<th>41</th>
<th>42</th>
<th>54</th>
<th>69</th>
<th>77</th>
<th>82</th>
<th>84</th>
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<td></td>
<td>0</td>
<td>33.3</td>
<td>33.3</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>33.3</td>
</tr>
</tbody>
</table>

| Lean et al. Hearing Student data | 17 | 43 | 43 | 56 | 64 | 69 | 67 |

* Note: hearing student data are in italics
Table 3
Percentage Correct of Change Questions across Grades *

<table>
<thead>
<tr>
<th>Change Questions</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grades</td>
</tr>
<tr>
<td>Barbara had 2 eggs. Dan gave Barbara 1 more egg. How many eggs does Barbara have now?</td>
<td>Grades</td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>90</td>
</tr>
<tr>
<td>Jack has 4 pens. Dianne took 3 of Jack’s pens. How many pens did Jack have then?</td>
<td>Grades</td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>90</td>
</tr>
<tr>
<td>Jeff had 3 bananas. Carmel gave Jeff some more bananas. Jeff then had 5 bananas. How many bananas did Carmel give Jeff?</td>
<td>Grades</td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td>48</td>
</tr>
<tr>
<td>Anna had five books. Tom took some of Anna's books. Then Anna only had 2 books left. How many of Anna's books did Tom take?</td>
<td>Grades</td>
</tr>
<tr>
<td>Lean et al: Hearing Student data</td>
<td>76</td>
</tr>
</tbody>
</table>
Paul had some pencils. His father gave him 2 more pencils. Then he had 5 pencils. How many pencils did Paul have at the start?

* Lean et al: Hearing Student data

|        | 0 | 0  | 25 | 28.6 | 36.4 | 50 | 58.3 |

Sally has some pictures. She lost 2 of her pictures. Then she had 3 pictures. How many pictures did she have at the start?

* Lean et al. Hearing Student data

|        | 0 | 0  | 0  | 36.4 | 42.9 | 45 | 50  |

* Note: hearing student data are in italics
Table 4 Percentage Correct of Combine Questions across Grades *

<table>
<thead>
<tr>
<th>Combine Questions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>David has 2 dogs and Jim has 4 dogs. How many dogs do they have altogether?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Note: hearing student data are in italics</td>
<td>66.6</td>
<td>83.3</td>
<td>100</td>
<td>100</td>
<td>90.9</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Helen has 3 ribbons. Lyn also has some ribbons. Helen and Lyn have 7 ribbons</td>
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<tr>
<td>altogether. How many ribbons does Lyn have?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>27.3</td>
<td>25</td>
<td>66.6</td>
</tr>
<tr>
<td>* Note: hearing student data are in italics</td>
<td>45</td>
<td>63</td>
<td>69</td>
<td>71</td>
<td>75</td>
<td>85</td>
<td>82</td>
</tr>
<tr>
<td>Lean et al. Hearing Student data</td>
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