DOCUMENT RESUME


| | | |
|---|---|---|
| ED 440 501 | | EC 307 790 |
| AUTHOR | Kelly, Ronald R.; Mousley, Keith | |
| TITLE | Deaf and Hearing Students' Transfer and Application of Skill in Math Problem Solving. | |
| PUB DATE | 1999-03-00 | |
| NOTE | 14p.; Paper presented at the Annual Conference of the Association of College Educators for the Deaf and Hard of Hearing (25th, Rochester, NY, February 26-March 1, 1999). | |
| PUB TYPE | Reports - Research (143) -- Speeches/Meeting Papers (150) | |
| EDRS PRICE | MF01/PC01 Plus Postage. | |
| DESCRIPTORS | *College Students; *Deafness; Higher Education; *Mathematical Applications; *Mathematics Achievement; Mathematics Skills; *Reading Ability; *Word Problems (Mathematics) | |



ABSTRACT

This study compared the ability of college students with deafness and typical college students to transfer and apply their math computation and problem-solving skills to similar problems presented under different conditions. Thirty-seven students with deafness and 12 hearing students were given 30 math problems to solve that were presented under graphic and word conditions. The problems were matched for similarity and difficulty for the two conditions. The results showed that both groups of students were comparable in transferring and applying their math skills to solve the varied problem sets within the graphic condition and the first problem set of the math word problems. When comparing performance between the graphic and word conditions, the data show that the hearing students performed consistently across both conditions. In contrast, the problem-solving performance of the students with deafness was not consistent across the graphic and word conditions. A comparative analysis with respect to reading abilities showed that students with deafness with reading levels at the 9.3 grade level or higher performed significantly better on more complex and difficult word problems when compared to those in the 7th and 8th grade reading range. (CR)

# Deaf and hearing students' transfer and application of skill in math problem solving

Ronald R. Kelly
Department of Research
Center for Research, Teaching, & Learning

and

Keith Mousley
Department of Science and Mathematics

National Technical Institute for the Deaf
Rochester Institute of Technology
Rochester, New York 14623-5604



Ronald R. Kelly, Ph.D.
Department of Research
Center for Research, Teaching, & Learning
National Technical Institute for the Deaf
Rochester, Institute of Technology
52 Lomb Memorial Drive
Rochester, New York 14623-5604

Telephone: (716) 475-6802
E-mail: rrkncp@rit.edu
Fax: (716) 475-5693

Kelly, R. R., & Mousley, K. Deaf and hearing students' transfer and application of skill in math problem solving. Paper presented at the 25th Annual Conference of the Association of College Educators for the Deaf and Hard of Hearing, February 26 - March 1, 1999 in Rochester, NY.

# Abstract

This research examined the ability of deaf and hearing college students' to transfer and apply their math computation and problem-solving skills to similar problems presented under different conditions. Four classes of deaf students enrolled in NTID math classes and a comparison group of hearing college students were given math problems to solve that were presented graphically and in word problem format. The problems were matched for similarity and difficulty for the two conditions. The results showed that both the deaf and hearing college students were comparable in their performance to transfer and apply their math skills to solve the varied problem sets within the graphic condition and the first problem set of the math word problems. When comparing performance between the graphic and word conditions, the data show that the hearing college students performed consistently across both conditions. In contrast, the deaf college students' problem solving performance was not consistent across the graphic and word conditions. A comparative analysis with respect to reading abilities showed that deaf students with reading levels at the 9.3 grade level or higher performed significantly better on the more complex and difficult word problems when compared to the deaf students grouped by 8$^{th}$ and 7$^{th}$ grade reading ranges. While the performances of the deaf students in the 7$^{th}$ and 8$^{th}$ grade reading ranges were nearly the same, the higher level deaf readers' problem solving performance across both the graphic and word problem conditions approximated that of the hearing comparison group. Finally, the problem solving performance of both hearing and deaf college participants was influenced by the increase in problem complexity and difficulty.

Deaf and hearing students' transfer and application of skill in math problem solving

## Introduction

This research examined deaf and hearing college students' transfer and application of their math computation and problem solving skills to similar problems presented under two different conditions – a visual condition in which the problems were presented graphically and a word problem condition. Problem solving is the identification and application of previous experience, knowledge, and skills that result in solutions to problems (Biehler & Snowman, 1997). A successful problem solver must be able to recognize similarities between a current problem and previous problem experiences, as well as identify the relevant information within the problem necessary to develop a correct solution. Transfer of learning refers to when students independently apply previously learned knowledge and problem-solving skills to similar but new situations. The ability to transfer learning is the hallmark of independent learners and problem solvers. Similar to problem solving skills, developing the ability to transfer learning is not intuitive or automatic. "If you want transfer, teach for transfer" (Biehler & Snowman, 1997, p. 389).

Historically, "specific transfer" was used to distinguish transfer that occurred due to specific similarities between two tasks from "general transfer" that involves the use of the same cognitive strategies (Ellis, 1978). More recently, Salomon and Perkins (1989) further elaborate specific and general transfer as *low-road transfer* and *high-road transfer*. Low-road transfer refers to a situation in which a previously learned skill is nearly automatic in retrieval and application to a similar task. For example, a student is demonstrating low-road transfer when they have mastered skills such as addition, subtraction, and multiplication and correctly use them without prompting in a variety of different problem situations to arrive at correct solutions. For example, if students have demonstrated their mastery in calculating the surface area of two-dimensional objects, and without prompting, they can use their previously learned skill to calculate the total surface areas of multidimensional objects, then they are exhibiting low-road transfer of their skills. To develop one's ability to use low-road transfer, it is necessary to have repeated practice with varied materials in different settings. High-road transfer involves formulating rules for one task and applying them to related tasks. It involves a conscious effort to formulate a rule, analogy, or strategy in order to make connections between two or more tasks. Salomon & Perkins (1989) refer to this thoughtful process of formulating and applying a general rule to different looking, but similar tasks as *mindful abstraction.* It also requires repeated opportunities and practice to develop.

Within the context of low-road transfer, this study examined between subjects (deaf and hearing college students) transfer of learning performance on similar math problems within and across the graphic and word conditions. Other variables examined were performance relative to increased difficulty within each condition and the influence of reading levels on deaf students' problem solving performance. The specific research questions were:

1. Are there any differences between deaf and hearing college students in their ability to transfer and apply their computation and math solving skills to similar problems within the graphic or word problem conditions, as well as between the two conditions?

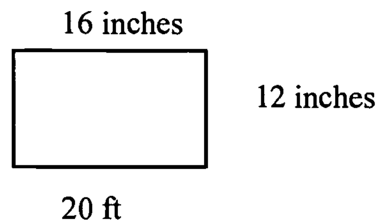
2. Do reading levels of deaf college students influence their problem solving performance for either the graphic or word conditions?

3. Does increasing the complexity of the problems similarly influence the problem solving performance of both the deaf and hearing college students for either the graphic or word conditions?

Procedures

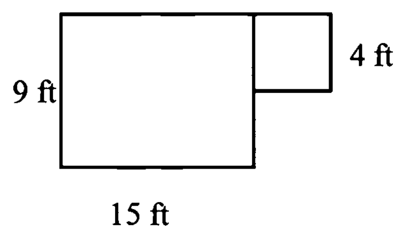
Four classes of deaf college students (n = 37) enrolled in NTID math classes and one comparison group of hearing college students (n = 12) were given a total of 30 math problems to solve that were presented under graphic and word conditions. For both conditions, the problems were similar (except the numbers to calculate were different) and sequenced to be increasingly more complex. The computation skills needed to solve these problems required multiplication, or a combination of addition, subtraction and multiplication. There were 15 equivalent problems presented within each condition similarly sequenced in three sets of five problems. The first set of five problems was two-dimensional requiring multiplication to calculate the area of a flat surface. The second set of five problems also required multiplication to calculate area while increasing the difficulty by requiring addition to or subtraction from the area. The third set of five problems further increased difficulty by adding a third dimension to the calculation of flat surface areas and also required the computational skills of multiplication, addition, and subtraction. An example from each of the three sets of math problems presented in the graphic and word problem conditions are provided below:

First set example
(total = 5 problems)



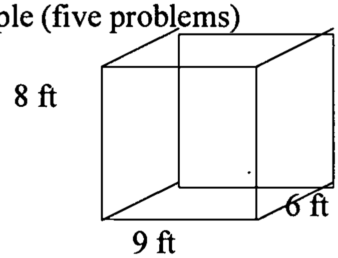

A= ___________

Second set example
(total = 5 problems)




A= ___________

Third set example (five problems)




Total Surface Area___________

Upon completing the 15 graphic math problems, the students were given 15 similar word problems that matched the difficulty and shapes of the graphic problems. For example:

First set example (total of 5 problems). The floor of a deck measures 16 ft by 12 ft. What is the area of the deck floor?

Second set example (total of 5 problems). A room measures 10 feet in length and 8 feet in width, with a closet that measures 2 feet by 4 feet. What is the total floor area of the room and closet?

Third set example (total of 5 problems). In a warehouse room, the men would like to paint the walls and ceiling. The dimensions of the room are 20 feet long by 16 feet wide by 8 feet high. What is the total surface area of the four walls and a ceiling for the men to paint?

## Results

The results showed that increased problem complexity similarly influenced the performance of both the deaf and hearing students. The data presented in Table 1 indicate that, regardless of hearing status, all students scores declined as problem complexity and difficulty increased from problem sets 1 through 3.

**Table 1.** Comparison of mean scores of deaf and hearing college students for solving similar math problems presented graphically and as word problems.

| | **Graphic Math Problems** | | | | **Word Math Problems** | | | |
|---|---|---|---|---|---|---|---|---|
| **Group** | **1** | **2** | **3** | **Total** | **1** | **2** | **3** | **Total** |
| **Deaf students** | | | | | | | | |
| Class 1 (n=8) | 4.9 | 4.1 | 2.3 | **11.3** | 3.9 | 2.9* | 1.7* | **8.4*** |
| Class 2 (n=10) | 4.8 | 3.0* | 2.4 | **10.2** | 4.3 | 2.6* | 1.6* | **8.5*** |
| Class 3 (n=8) | 4.9 | 3.1* | 2.6 | **10.6** | 4.6 | 2.4* | 1.6* | **8.6*** |
| Class 4 (n=11) | 5.0 | 3.9 | 2.3 | **11.2** | 4.5 | 1.5* | .18* | **6.2*** |
| **Hearing students comparison group** (n=12) | 5.0 | 4.1* | 3.7 | **12.8** | 4.9 | 4.4* | 3.4* | **12.8*** |
| **Significance (F test)** | **ns** | p<.05 | **ns** | **ns** | **ns** | **p<.01** | p<.01 | p<.01 |

**Significant group comparisons = ***

For the graphically presented problems (sets 1, 2, 3, & total) and the least difficult word problems (set 1), the performance pattern of the deaf students was generally comparable to the hearing students, and not statistically different. The exception involved the students in two classes (2 and 3) for the math problems presented in graphic set 2. This seems to be an anomaly, however, because the other two classes of deaf students performed comparably to the hearing students, and all of the deaf students performed equally well on the graphically presented math problems in sets 1 and 3, resulting in no significant differences for the total score. However, this was not the case when comparing performances of the deaf and hearing college students between the graphic and word conditions. The problem solving performance of the hearing students remained consistent for the graphic and word problems, while the deaf students' problem solving performance showed a sharp decrease with the word problems presented in sets 2 and 3 of the word condition. The problem solving performance of the deaf students in each of the four different classes when compared to the hearing comparison group was significantly different for word problem sets 2 and 3, as well as for the total on the word problems.

With respect to the variable of reading ability, Table 2 compares the mean scores of the participating deaf college students grouped by lower and higher reading level. Since this study used intact classes created by the natural enrollment patterns, students were not originally grouped by reading level. To examine three groups of distinctly different reading levels, students with reading scores in the ranges of 7.8 or lower, 8.0-8.8, and 9.3 or higher were grouped accordingly.

**Table 2.** Comparison of mean scores of deaf students' grouped by reading levels for solving similar math problems presented graphically and as word problems.

| | Graphic Math Problems | | | | Word Math Problems | | | |
|---|---|---|---|---|---|---|---|---|
| **Group** | **1** | **2** | **3** | **Total** | **1** | **2** | **3** | **Total** |
| **Lower level readers** m = 7.1 range = 6.6 - 7.8 (n = 10) | 5.0 | 3.5 | 2.7 | 11.2 | 4.0 | 1.9* | 1.3 | 7.2* |
| **Middle level readers** m = 8.5 range = 8.0 – 8.8 (n = 10) | 5.0 | 3.4 | 2.4 | 10.8 | 4.1 | 1.8* | .9 | 6.8* |
| **Higher level readers** m =10.1 range = 9.3–11.1 (n = 10) | 4.8 | 4.1 | 2.5 | 11.4 | 4.8 | 3.3* | 2.1 | 10.2 |
| **Significance (F test) Significant comparisons = *** | **ns** | **ns** | **ns** | **ns** | **ns** | $p < .05$ | **ns** | $p < .05$ |

As the data show in Table 2, the deaf students in the three grouped categories of reading levels performed comparably on the math problems in the graphic condition and for set 1 of the word problems. The problems in the graphic condition required no reading while the first set of the word problems was the least complex/difficult. However, as problem complexity and difficulty increased in sets 2 and 3 of the word condition, students with the higher reading levels demonstrated better problem solving performance. In fact, their pattern of performance looked similar to the comparison group of hearing students. What is surprising is that the problem solving performance of the deaf students in the middle reading level range (8.0 – 8.8)) was nearly identical to the students in the lower reading level range (6.6 – 7.8).

Discussion

Given their similarity in performance with the graphic problems and the least complex word problems, the data suggest that the deaf college students' computation and solving skills for these kind of problems are comparable to their hearing peers. Since the computational requirements were the same for both the graphic and word conditions, the deaf students' decline in performance with the word problem condition cannot be attributed to a lack of math computation and problem solving skills. Previous research (Pau, 1995) has shown that reading comprehension is a factor affecting younger deaf students' performance with math word problems. Thus, it was plausible to assume that reading ability could also explain this decline in performance with the more difficult word problems. The generally lower reading skills of deaf college students' could likely have hindered their ability to recognize the similarity of the math problems in the word condition to the almost identical problems that they successfully solved in the graphic condition. Not recognizing the similarity of the word problems to the graphic problems would have prevented them from utilizing low-road transfer of skills to solve the problems. The comparative analysis with respect to the measured reading grade levels of the participating deaf students presented in Table 2 shows that reading ability contributes to the deaf students performance in solving the more difficult math word problems.

Also, the qualitative comments of a number of deaf students in the middle and lower reading levels suggest that a learned avoidance response behavior could very well be another contributing factor to their continuing difficulty with word problems. For example, their comments included:

> When I see a word problem, I won't do it.
> I don't understand the word problem and I won't do it.
> When I see it (word problem), my mind freeze.
> I always avoid it, I can't do it.
> There are too many words, It confused me more.

Other qualitative statements made by the deaf students further illustrate their avoidance to word problems. Their emotions appear to be excessively strong and they are clearly willing to lose points rather than take the risk of attempting to solve the word problems.

> Why do we have to do the word problems? Are these problems exactly exist on the job?
> I know I don't need to do this because future job this won't happen. So therefore I won't waste my time with this.

This anecdotal information shows that the students do not understand the value to them of developing the analytical skills needed to problem solve, especially with math word problems.

Salomon & Perkins (1989) offer a number of suggestions to develop low-road and high-road transfer skills of students. Their suggestions include: 1) provide multiple opportunities for varied practice; 2) give opportunities to solve problems similar to ones students will eventually have to solve; 3) teach how to formulate a general rule, strategy, or schema that can be used with a variety of similar problems; and 4) give cues that will help students retrieve from memory earlier-learned information. The development of good problem solving skills and the ability to transfer one's problem solving skills to different problem situations do not occur naturally for most students. Teachers must provide multiple opportunities and repeated, varied problem solving experiences to enhance the development and fluency for problem solving and transfer of learning.

Based on previous research (Mousley & Kelly, 1998) and classroom experiences, the authors suggest the following instructional strategies to enhance the development of deaf students' problem solving skills.

> Teach all steps of the problem solving process. Do not assume that the students understand. Repetition and practice are critical to developing problem solving experience.
>
> Teach transfer of learning by providing diversity in problem solving experiences and explaining how to recognize similarities between problems presented differently. Don't assume that transfer is intuitive or automatic for the students.
>
> Do not avoid word problems. Deaf students need to be provided on-going solving experiences with word problems that require learning transfer throughout their school years to minimize anxiety and encourage them to take risks in trying to solve increasingly difficult problems.
>
> Provide repeated modeling to explain and demonstrate how to analyze the components of a word problem. It is erroneous to assume that English language skills and reading levels are the primary factors that hinder deaf students' ability to solve word problems and transfer their learning. The data presented here suggest that deaf students' performance with math word problems can be attributed partly to learned behaviors and partly to a lack of experiences in analyzing and reformulating word problems in appropriate ways that they then can apply their math skills to arrive at a solution.
>
> Show students that they have the computation and problem solving skills when working with math problems under the graphic condition. The key issue for teachers is to convince students that their computation skills are sufficient for any word problem and their problem solving skills are applicable to word problems.
>
> Provide connections between math word problems and examples from a variety of activities in the work world.

## References

Biehler, R.F., & Snowman, J. (1997) *Psychology applied to teaching* (8th edition). Boston, MA: Houghton Mifflin Company.

Ellis, H.C. (1978). *Fundamentals of human learning, memory, and cognition* (2nd edition). Dubuque, IA: William C. Brown.

Mousley, K., & Kelly, R.R. (1998). Problem-solving strategies for teaching mathematics to deaf students. *American Annals of the Deaf, 143*(4), 325-336.

Pau, C.S. (1995). The deaf child and solving problems of arithmetic: The importance of comprehensive reading. *American Annals of the Deaf, 140*, 287-294.

Salomon, G., & Perkins, D.N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist, 24* (2), 113-142.

*U.S. DEPARTMENT OF EDUCATION*
*Office of Educational Research and Improvement (OERI)*
*Educational Resources Information Center (ERIC)*

**REPRODUCTION RELEASE**
*(Specific Document)*

## I. DOCUMENT IDENTIFICATION:

Title: Deaf and hearing students' transfer and application of skill in math problem solving

Author(s): Ronald R. Kelly and Keith Mousley

Corporate Source:

Publication Date:

## II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, docu announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the follov is affixed to the document.

If permission is granted to reproduce the identified document, please **CHECK ONE** of the following options and sign the r

### Check Here, Please

__X__ Check here for Level 1 Release, permitting reproduction and dissemination in microfiche and other ERIC archival m electronic) and paper copy.

or

______ Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media fo archival collection subscribers only.

or

______ Check here for Level 2B release, permitting reproduction and dissemination in microfiche only.

### Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but n checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this documen above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its s contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and oth agencies to satisfy information needs of educators in response to discrete inquiries."

Signature: [signature]
Printed Name: Ronald R. Kelly
Address:

Position:
Organization: Rochester Institute of Technology
Telephone Number: (716) 475 6802
Date: April 7, 2000

## III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):