A study of perceptions of mathematics signs: implications for teaching

Paul Glaser
A Study of Perceptions of Mathematics Signs: 
Implications for Teaching

Master’s Project

Submitted to the Faculty 
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ROCHESTER INSTITUTE OF TECHNOLOGY

By 
Paul Lee Glaser

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Approved: ____________________________________________
(Primary Project Advisor)

____________________________________________________
(Second Project Advisor)

________________________________________
(Program Director)
Abstract

There is increasing importance being placed on the role mathematics signs play in teaching and learning in the classroom. Potential ramifications of invented signs on teaching and learning need to be investigated. Many teachers have different signs for certain mathematics terms and it is possible that a lack of standardization may influence learning. There is a particular need to investigate perceptions of technical signs in order to help prepare new teachers who pursue careers in mathematics education for the deaf. The present project was designed to assist new and experienced mathematics teachers and interpreters for the deaf as well as students interested in learning about mathematics signs. Perceptions about 25 math signs were examined through interviews with college professors, teachers, interpreters, and deaf students and an online survey was administered to 11 high school mathematics teachers. Only 8 out of 25 mathematics signs were found to be in widespread use among all mathematics teachers and interpreters in this study. Most teachers did not have signs for advanced mathematics terms and fingerspelled those terms to avoid inventing signs.
Acknowledgements

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CHAPTER 1

Introduction

“There is little research (but many opinions) on the best way to sign in science or math classes” (Lang, 2005). Caccamise and Lang (2000) also write that “Deaf people have traditionally had limited access to the dominant culture and there has not been a critical mass of Deaf scientists, technicians, or specialists within many fields to develop signs for all of the relevant terminology” (p. 175). There are also few mathematicians or teachers with both degrees in mathematics and experience with sign language available as a resource for identifying the best signs for mathematics terms. Without conceptually-accurate mathematics signs, deaf students may have difficulty understanding the concepts and this may influence their interest in becoming a deaf mathematician or mathematics teacher. This project will examine perceptions of professionals and students in order to learn more about mathematics signs. It is important to learn how to sign mathematics terms to enhance student learning. Systematic study of math signs may help teachers, interpreters and students.
CHAPTER 2
Review of the Literature

“The rapid expansion in postsecondary educational opportunities for the deaf in the United States over the past few years has led to the need for deaf Americans to learn and use technical vocabulary which few of them have used in the past. It could be argued that since these opportunities are now occurring for deaf people, that all that need to be done is ‘to leave well enough alone,’ and the technical sign-words needed will naturally evolve.” (Caccamise, Bradley, Battison, Blasdell, Warren & Hurwitz, 1977, p. 1). More systematic study, however, will assure higher accuracy of conceptual representation in technical signs. It is important to have technical signs for deaf students to understand the concepts of mathematics. There is a little research and resources focusing on mathematics signs.

Invented Signs

Invented signs may affect deaf students’ understanding of the concepts of mathematics. Because sign language has not developed in the area of mathematics and many mathematics concepts in signs do not exist. (Gregory, 1998, p.126). There have been suggestions for inexperienced teachers to exercise caution when inventing signs (see A National Action Plan for Mathematics Education Reform for the Deaf and Signs for Science and Mathematics: A Resource Book for Teachers and Students). Such invention may affect communication in mathematics classes. Both books suggest that teachers use fingerspelling if they do not know how to sign mathematics terms. Invention of signs for classroom use should be done only by experienced signers knowledgeable of the content, and through careful consultation with other experienced signers.
Gregory (1998) mentioned that the development of mathematics teaching through sign language is difficult because “sign language has not been developed in the area of mathematics in the past and signs for many mathematical concepts do not currently exist” (p. 126). It is an important issue as mathematics words are arbitrary and teachers have not yet found signs that have accurate conceptual representation for all words. Gregory called for a group of signers in Leeds, England to develop and standardize mathematics signs for instructional purposes.

*Situations for Interpreters*

For interpreters for the Deaf in mathematics classes, the 1989 report of the National Task Force on Educational Interpreting estimated that there were 2,200 educational interpreters working at the elementary and secondary levels (Stewart, p.165). There are more interpreters practicing in schools than in any other settings. There are several problems for interpreters in secondary education. First, interpreters may have little or no background in mathematics. Marschark et al’s (2004) article mentioned that there were not enough interpreters available to meet student’s needs and interpreting science, technology, engineering, and mathematics (STEM) still the need of investigation. Also, most colleges/universities in interpreting program do not offer courses to learn mathematics or other technical signs. “Medical and legal interpreting are acknowledged as requiring special skills, but the demands of university versus K-12 interpreting and STEM versus social science and liberal arts interpreting are still in need of investigation” (Marschark, Sapere, Convertino, Seewagen & Maltzen, 2004, p.1).

Some interpreters have sought to find solutions to these challenges. For instance, Stewart (2004) described two interpreters in a medical veterinary class with a deaf
student: "At one university, two interpreters were employed to interpret for a deaf student in a four-year veterinary program—a difficult program to interpret because of the heavy reliance on technical and medical terms and because of the logistics of interpreting in laboratories and around animals. The two interpreters and the deaf student developed strategies to solve the problems. Their strategy for handling new terminology was for one of the interpreters to write the unfamiliar words on a pad and pass it on to the student while the other interpreter continued to interpret and have the student come up with an invented sign they could use in class.” (Stewart, 2004, p.175).

At Rochester Institute of Technology (RIT), where there are hundreds of deaf students learning in mainstream classes, interpreters often study the textbooks and are assigned to the same courses in subsequent academic terms in order to increase familiarity and accuracy of signing. (Lang, 2005).

Communications Issues in Mathematics Classes

According to Caccamise et al (1977), a number of facts have suggested the importance of mathematics sign standardization to meet the communications needs of all deaf students. They write that many college deaf students prefer to use signs more than fingerspelling. Secondly, deaf students have difficulty understanding their interpreters and in keeping pace while a teacher is lecturing, especially when many words could have to be fingerspelled. Third, the deaf community supports the standardization of mathematics terms. Fourth, all teachers should be familiar with "the linguistic structure of existing signs have begun to invent sign equivalents for English technical vocabulary and some of these invested signs violate the structural patterns of ASL signs which have evolved
naturally, some are exactly like existing signs, and some are used for two or more distinct technical concepts.” (Caccamise, et al., 1977, p. 44).

Websites for Mathematics Signs

The website for the Clearinghouse on Mathematics, Engineering, Technology and Science (COMETS) is a comprehensive resource in the education of deaf students. The COMETS website was established at National Technical Institute for the Deaf (NTID). This project was funded by the National Science Foundation (NSF) and is a network of many different professionals who will use these resources for systemic reform. COMETS provides resources for professionals and parents responsible for the education of deaf students in STEM. “Despite rapidly advancing technologies and expanding opportunities for deaf people to enter the workforce in STEM careers, the quality of science and mathematics education for deaf students has not improved substantially over the past 20 years.” (Lang, 2005).

The COMETS Lexicon contains QuickTime movies of mathematics signs for a variety of audiences. Many people have contacted COMETS in search of signs for specific terms in mathematics. The researchers at COMETS have identified terms from science and math curricula and textbooks and these terms have been compared with nine published sign language dictionaries and other resources. (Lang, 2005). Signs found in these resources were included in the COMETS Lexicon for evaluation purposes.

In a study of science signs in another NSF project, the “Classroom of the Sea,” Lang, LaPorta, Hupper, Monte, Scheifele, Babb, and Brown (in progress) found that teachers having both sign language experience and science content degrees and/or certification are the best resources for determining signs with conceptual accuracy. They
found no significant difference between deaf and hearing teachers having these qualifications.

Another resource for a study of computational science signs sponsored by the National Science Foundation is the Deaf Educational Access For Computer Science (DEAF CS) “is a collection of activities and lessons that use modeling and simulation technologies to help students and their teachers explore math and science concepts” (National Science Foundation, 2002). All DEAF CS signs developed on the website came from interpreters, deaf professionals and a group of scientists. Website viewers can find Quicktime movies demonstrating the sign, its meaning and how that term is signed in a sentence. Some signs may be appropriate for use in mathematics classes for deaf students.

One of the resources for mathematics signs for teachers and students is Signs for Science and Mathematics: A Resource Book for Teachers and Students. This book is the most authoritative reference on mathematics sign language and with well-written and easily understood instructions for the use of each mathematics sign. In 1975, The Technical Signs Project (TSP) was established at the NTID, a college of RIT in Rochester, New York. This project collected and shared signs by skilled signers and resulted in the development and dissemination of 61 videotapes and 11 books. (Caccamise & Lang, 2000, p. 2). This book contains about 700 signs and was printed in part to support a National Science Foundation project for mathematics and science teachers and students. Most deaf students need to understand the effective sign language communication; this book updated TSP mathematics for all teachers and deaf students.
In addition, there are several suggestions for use of signs and Fingerspelling in academic settings.

Another resource for Technical signs in mathematics is: *Technical Signs for Mathematics* from Sydney, Australia by Pan Spicer and Ian Rogers. This book had a goal similar to that of the NTID Technical Signs Project—to collect, evaluate, produce, and share signs for use by people in the Deaf Education and Mathematics field. This project is for teachers for the deaf, interpreters and deaf students. However, this book may not be helpful to American teachers because these signs are Australasian Sign Language.

Other resources for mathematics signs for teachers, interpreters and students are available. These include Algebraic Signs for the Hearing Impaired from Johnson County Community College and Signs for Mathematics, and Project NEEDS Outreach website: [http://www.needsoutreach.org/Pages/sign-math2.html](http://www.needsoutreach.org/Pages/sign-math2.html).

**Recommendations**

There are also recommendations for teacher preparation programs and future research on mathematics signs from *Signs for Science and Mathematics: A Resource Book for Teachers and Students*:

1. State boards of Education should require all future teachers hold a mathematics or mathematics education degree as well as Deaf Education certification. And teachers should have training in Mathematics sign language.

2. Mathematics teachers for the Deaf should seek updates and improve their understanding and skills by attending mathematics seminars or workshops related to mathematics education and/or technical signs.
3. Don’t try to use strict English word-for-sign equivalents. You should be familiar with the meaning or referent of the sign, for instance, to *get* sick vs. to *get* a new car. People who use the same sign for these two meanings may cause confusion in communication.


“There has been very little research on the use of signing in the teaching of mathematics” (Gregory, 1998, p. 125). The present study attempts to systematically examine the perceptions of teachers, interpreters and students with a small number of mathematics signs in order to better understand the factors that are important to standardization and effective teaching.
CHAPTER 3
Design of the Study

The author created a glossary of a sample of mathematics signs using the COMETS website which includes QuickTime sign videos. The author's goal of this project is to collect, produce, and evaluate a small number of mathematics signs. The RIT Online Learning system was used to conduct the survey with mathematics teachers of the deaf. The website for the RIT Online Learning is http://clipboard.rit.edu/takeSurvey.cfm?id=2L72JF.

Interviews

Each respondent was interviewed individually for about fifteen minutes. First, the author provided a consent form and questionnaire to each participant (see Appendix A and B). Then, the basic instructions were provided before beginning the interview.

Throughout the procedure, all respondents were videotaped with a camcorder so that their responses could be reviewed carefully. All twenty-five 12 x 3.5 index cards with mathematics terms were shown. Each respondent looked at each index card and signed the term if they knew a sign.

The respondents were given positive feedback after each interview, no matter what their responses, to encourage them, but not to bias their own understanding of the mathematics signs.

Thirteen interviews were conducted, 5 with college professors of the deaf, 5 with interpreters, and 3 with deaf college students at RIT/NTID. Their perceptions of 25 mathematics terms were examined and summarized. These 25 mathematics terms are included in Appendix A along with the interview questionnaire. All interviewees in this
study use American Sign Language, English-based sign system, or a mix, as their primary mode of communication as well as lipreading, fingerspelling, gestures and body language.

Table 1. **Highest Educational Attainments of Respondents in the Study**

<table>
<thead>
<tr>
<th>n=13</th>
<th>Working on BA/BS</th>
<th>Have AA/BA/BS</th>
<th>Have MA/MS</th>
<th>Have Ph.D/Ed.D</th>
<th>Certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>College professors</td>
<td></td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Interpreters of the Deaf</td>
<td></td>
<td>4</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>College students</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 presents educational background information on the 13 interviewees. All college professors in the interviews have college degree(s) in mathematics and/or education/deaf education and are native signers. The author interviewed four deaf college professors and one hearing child of deaf adults (CODA). All college professors estimated their signing level (1 = novice, 2, 3, 4, 5, 6 = native ASL signer) as between 4 and 6, the mean rating is 5.2. They have been teaching deaf students in mathematics classes between 6 and 30 years.

The interpreters estimated their signing level as between 4 and 5; the mean rating is 4.7. They have used sign language between 9 and 25 years, and, they have interpreted in mathematics classes between 3 and 25 years.

Three deaf college students enrolled at RIT/NTID were also included in this study. All students took mathematics at the high school and college levels through interpreters. They are mathematics majors for undergraduate and graduate degrees at RIT. The three students estimated their signing level are between 5 and 6; the mean rating is 5.7. Also, they have used sign language between five and twenty-three years.
After all respondents filled out the background questionnaires, the last question the interviewer asked “if you don’t know a sign for a math term, what would you do?” Eight respondents answered “fingerspell,” five respondents said “Negotiate a sign with the student or teacher,” three out of thirteen respondents would like to invent the mathematics signs, and five participants mentioned that they would ask people around who know the field of mathematics.

After the interviews, the results were evaluated and a decision was made about which mathematics signs should be mounted in a survey in the RIT Learning Online system. There were 12 mathematics terms with high agreement. Thirteen terms had more than one sign. Deaf professionals appear to use initialization less often than hearing professionals, including the interpreters in this study. The three deaf college students, all from mainstream settings, also appear to use the initialization. The data for initialization can be found on Table 2.
Table 2.

*In-Person Interviews (n=13)*

<table>
<thead>
<tr>
<th>Terms:</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
<th>Code 4</th>
<th>Code 5</th>
<th>Code 6</th>
<th>Wrong:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Angle</td>
<td>1 (1,0,0)</td>
<td>9 (3,4,2)</td>
<td>1 (1,0,0)</td>
<td>2 (0,1,1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculator</td>
<td>5 (2,1,2)</td>
<td>7 (2,4,1)</td>
<td>1 (1,0,0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>5 (5,0,0)</td>
<td>7 (0,4,3)*</td>
<td></td>
<td></td>
<td>1 (0,1,0)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divide</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td>3 (2,0,1)</td>
<td>8 (2,4,2)*</td>
<td>2 (1,1,0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exponent</td>
<td>3 (2,1,0)</td>
<td>2 (1,0,1)*</td>
<td>3 (0,3,0)</td>
<td>4 (1,1,2)</td>
<td>1 (1,0,0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formula</td>
<td>13 (5,5,3)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graph</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logarithm</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>13 (5,5,3)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiply</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtuse Angle</td>
<td>1 (1,0,0)</td>
<td>9 (3,4,2)</td>
<td>1(0,1,0)</td>
<td>2 (0,0,2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pythagorean</td>
<td>1 (1,0,0)*</td>
<td>6 (2,2,2)</td>
<td>3(1,2,0)</td>
<td>1 (0,1,0)*</td>
<td>1 (1,0,0)</td>
<td>1 (0,0,1)</td>
<td></td>
</tr>
<tr>
<td>Theorem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadratic Formula</td>
<td>8 (3,3,2)</td>
<td>4(2,1,1)</td>
<td></td>
<td></td>
<td>1 (0,1,0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radius</td>
<td>4 (3,0,1)</td>
<td>6 (1,3,1)*</td>
<td>2 (2,0,0)</td>
<td>3 (0,2,1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Angle</td>
<td>5 (2,1,1)</td>
<td>2 (1,0,1)</td>
<td>2 (0,1,1)</td>
<td>2 (2,0,0)</td>
<td>3 (0,3,0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>6 (2,3,1)</td>
<td>2 (0,2,0)</td>
<td>1 (1,0,0)</td>
<td>4 (2,0,2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solve</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtract</td>
<td>11 (3,5,3)</td>
<td>1 (1,0,0)</td>
<td></td>
<td>1 (1,0,0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triangle</td>
<td>13 (5,5,3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venn Diagram</td>
<td>2 (2,0,0)</td>
<td>2 (0,0,2)</td>
<td>1 (0,1,0)</td>
<td>5 (1,3,1)</td>
<td>2 (2,0,0)</td>
<td>1 (0,1,0)</td>
<td></td>
</tr>
</tbody>
</table>

**BOLD:** signs used in survey of high school teachers.

(#professors, #interpreters, #students): * indicates initialization

Ten incorrect signs were provided during the interviews. Seven of these signs came from the interpreters, 2 came from the college students and 1 from a college professor. For instance, one interpreter signing RIGHT ANGLE used the sign “right” in
direction with an “angle” sign. Students would be confused by this and would receive the wrong concept from this sign.

For some advanced terms such as VENN DIAGRAM or PYTHAGROEAN THEOREM, there were more variations of signs than for basic terms such as ADD, PERCENT or MATHEMATICS. The author suspects that these results are due to the lack of experience in signing these terms and less opportunity to standardize the corresponding signs.

*Online Survey of High School Teachers*

The author invited 44 deaf high school mathematics teachers from the United States to evaluate those signs via email. Eleven teachers were willing to evaluate the signs. Five out of eleven teachers have an undergraduate and/or graduate degree as well as one teacher minored in mathematics. Four out of eleven teachers have the mathematics education certification. Another three teachers are in the process of obtaining the mathematics education certification.

Approximately 60% of the teachers have been teaching deaf students in mathematics between 2 and 5 years. Three teachers have been teaching deaf students in mathematics between 7 and 37 years. Four teachers are Deaf, one is hard-of-hearing and the other four are hearing. They estimated their signing level on a scale of 1 (novice) to 6 (native ASL signer): eight respondents are between 5 and 6 and the other three respondents are between 3 and 4.

In this study, about 50% of the survey respondents have Bachelors or Masters degrees and certification in mathematics and about 30% of them are in the process to obtain the certification in mathematics.
The author asked the teachers where they learned mathematics signs. They said:

- Both from interpreters and deaf math teachers
- Various schools and workshops
- Teacher assistants who are native to ASL and have been assistants in math classrooms
- Picking them up through learning and teaching
- Family generation

The teachers were also asked to make suggestions for educational researchers related to mathematics signs. Their suggestions included:

- A look at signs used in different regions.
- Published or an online web page about mathematics signs
- Send CD's to deaf schools and public schools with deaf education programs
CHAPTER 4
Analysis of the Data

Table 3 presents on-line survey data on the 11 respondents. All if the teachers responding to the RIT Online survey strongly agreed on eight of the mathematics signs. There were 12 mathematics terms with high agreement from the interviews, however, and thus the agreement was found to be higher within one setting (RIT). The eight signs with high agreement in both the interviews and the online survey include ADD, DIVIDE, EXERCISE, GRAPH, PERCENT, SOLVE, SQUARE and TRIANGLE. These terms may be considered to be “standardized.”

Also, as shown in Table 3, there were several signs (ACUTE ANGLE and SLOPE), which had about 50% agreement for each of two different signs. For the term PYTHAGOREAN THEOREM there were three different signs with approximately the same support among the respondents.

For such terms it was difficult to determine the best sign for the standardization. The preferences were also mixed for the deaf and hearing teachers.

When asked if they would be willing to use a sign in their teaching if 30 teachers were asked to evaluate it and 2/3 of them support its use, 10 of the 11 teachers responded they would.

Regarding PYTHAGOREAN THEOREM and QUADRATIC FORMULA, several teachers mentioned that they prefer to spell out the terms a few times before they use a sign. They want to emphasis fingerspelling first to be familiar with that term before signing the term.
<table>
<thead>
<tr>
<th>Terms:</th>
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CHAPTER 5

Conclusion and Implications

The primary purpose of this study was to examine how teachers evaluate mathematics signs for use with deaf students on the secondary education level. Some suggestions for teachers and interpreters may be developed from the results.

When a new mathematics term is introduced to deaf students, teachers and interpreters should fingerspell the term first to emphasize the spelling correctly before using the mathematics sign. This will make it easier for deaf students to learn the term.

The practice of initialization (using the first letters of some terms in the signs) for use with deaf children in elementary education may be beneficial. For instance, for the sign for TRIANGLE may be signed using the letter T on each hand instead of index fingers to trace the triangle shape in the air. It may be less confusing for young children to know which term that sign represents. Then in the secondary education, teachers and interpreters can use index fingers for triangle to sign to deaf young students.

For interpreters, the author would recommend colleges and universities offer a course called “Technical Signs.” This can include mathematics, science, medicine or engineering terms. Also, it is recommended that the Registry of Interpreters for the Deaf (RID) require an exam in signing technical terms before certification is granted to interpreters.

Interpreters who are very skilled with interpreting in mathematics classes should be invited to participate in a similar study to evaluate math signs. Linguists should also be invited to examine the handshapes, locations, and movements in mathematics signs.
This would help identify the best sign to use, following the rules of the American Sign Language.

At first, the author thought it would be good idea to use a sign if 30 teachers were asked to evaluate it and 2/3 of them support its use. But, after the data were analyzed, the author concluded that this idea is not appropriate, because it may include more teachers who are not skilled with sign language, or teachers who do not have mathematics education degree(s) or certification. It would be excellent idea for a group of native ASL math teachers and mathematicians to convene and standardize signs in mathematics. Workshops related to mathematics signs should be presented in deaf education conferences.

In conclusion, the author strongly recommends additional research to examine mathematics signs and to determine which sign should be standardized in dictionaries, CD-Roms or websites for future or current mathematics teachers. The strategies developed in this study will be helpful in standardizing signs for the use by mathematics teachers and interpreters.
References


Lang, H. (n. d.). *Clearinghouse on Mathematics, Engineering, Technology and Science*


Appendix A

Interview Questionnaire

For each of the math terms below, the interviewee will be asked:

1. If he/she has a sign for the term (the sign will be recorded on video for later analysis)
2. To rate a sign of the term (if one exists) using a Likert Scale

Part I. Background Information

For College professors (in person) and Teachers for the Deaf (online):

a. Are you Deaf, Hard of Hearing or Hearing?

b. What degree(s) are you holding now?

c. Are you certified in Mathematic Education? Deaf Education? Others?

d. Estimate your signing level (beginning, advanced, etc)?
   1=novice 2 3 4 5 6=native ASL signer

e. What is your position and responsibility in your school settings?

f. How many years have you used sign language? _______ years

g. How many years have you taught math to deaf students? _____ years

h. Where did you learn mathematics signs?

i. If you don’t know a sign for a math term, what would you do?
   a. 

25
For deaf college students:
b. Are you Deaf or Hard of Hearing? ______________________

c. What is your school setting? (Deaf Residential school, Deaf Day school, or mainstream)

________________________

d. Estimate your signing level (beginning, advanced, etc)?
   1=novice 2 3 4 5 6=native ASL signer

________________________

e. How many years have you used sign language? _____ years

j. Where did you learn mathematics signs?

________________________

f. Where did you learn mathematics signs?

________________________

For Interpreters for the Deaf:
a. What degree(s) are you holding now?

________________________

b. Are you certified interpreter? Yes or No

c. Estimate your signing level (beginning, advanced, etc)?
   1=novice 2 3 4 5 6=native ASL signer

________________________

d. How many years have you used sign language? _____ years

g. How many years have you interpreted in math classes? _____ years

h. If you don’t know a sign for a math term, what would you do?

________________________

i. ___________________________
Part II. Do you have a sign for the following term?

Acute Angle
Add
Calculator
Diameter
Divide
Equation
Exercise
Exponent
Formula
Graph
Logarithm
Mathematics
Multiply
Obtuse angle
Percent
Pythagorean Theorem
Quadratic Formula
Radius
Right Angle
Slope
Solve
Subtract
Square
Triangle
Venn diagram

Part III. Evaluation of existing signs for 11 high school teachers

Background Data

a. Are you Deaf, Hard of Hearing or Hearing?

b. What degree(s) are you holding now?

c. Are you certified in Mathemetic Education? Deaf Education? Others?

d. Estimate your signing level (beginning, advanced, etc)?
   1=novice 2 3 4 5 6=native ASL signer

e. What is your position and responsibility in your school settings?

f. How many years have you used sign language?

g. How many years have you taught math to deaf students?
h. Where did you learn mathematics signs?

i. If you don't know a sign for a math term, what would you do?

Please rate the following signs.

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<td>Add</td>
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Part IV. Comments
Appendix B

Consent for all participants/survey takers

CONSENT TO PARTICIPATE IN A MATHEMATICS EDUCATION RESEARCH STUDY

Form for Teacher Online Survey, Interpreters, College students, College professors

Title: A Study of Perceptions of Mathematics Signs: Implications for Teaching

DESCRIPTION

We would like your consent to participate in a short study examining mathematics signs. The study is being conducted by MSSE student Paul Glaser under the guidance of Dr. Harry Lang from the National Technical Institute for the Deaf.

You will be asked to observe a series of mathematics signs and evaluate your willingness to adopt and regularly use them in your teaching. There will be several general questions about your background. There is no risk to you. This study will help to improve the teaching of mathematics to deaf/hard-of-hearing students.

Confidentiality
Your identity will remain completely confidential. You will not be identified in any publication of research results.

Right to Withdraw
You do not have to take part in this study and, if you change your mind, you can withdraw from the study at any time.

If you need any additional information, please feel free to contact:

Harry Lang, Ed.D.
National Technical Institute for the Deaf
Department of Research
96 Lomb Memorial Drive
2433 Carey
Rochester, NY 14623-5604
Phone: (585) 475-6777
Email: hgl9008@rit.edu

Signature of investigator
Voluntary Consent:
All of the above has been explained to me and all of my questions have been answered. I understand that any future questions I have about the study will be answered by Dr. Lang at the telephone number or email address above. By signing this form, I agree to participate in the study and follow the protocol for all tasks.

"I voluntarily consent to participate in this study."

__________________________________________
Name of participant (Please print)