Teaching Mathematics to the Physically Impaired by Voice Operated Computing

by

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I. Introduction

In this paper we investigate voice operated computing as an effective method to learn and do mathematics for persons who cannot use their hands sufficiently well to manipulate symbols by hand or enter them from a keyboard. Although the methodology we will introduce can be applied to all areas of mathematics, the emphasis here will be on Statistics.

The voice program MathTalk© is employed throughout the paper. MathTalk© is a program written in the Dragon Dictate© script language that uses Dragon Dictate© as its speech engine and Scientific Notebook 3.5©, student edition, as its math word processor. Scientific Notebook 3.5© has two features which make it uniquely suited for this application.

1) It contains a compute subroutine which gives one the option of executing numerous Maple commands.

2) It includes the option of outputting the printed document in Braille, provided you have either the Nemeth Braille converter or the Duxbury Braille converter.

The paper is arranged as follows:

a) Initially, some description of the program MathTalk is given.

b) The motivation for the paper and the requirements for a successful voice operated math program is then outlined.

c) A brief discussion of the obstacles one encounters in attempting to teach a student to use voice operated computing to learn a basic course in mathematical statistics is given.

d) Finally, some examples of actual work performed by voice by the student in learning basic statistics are presented.

Math Mode Vocabulary

The math commands for MathTalk© are contained in the vocabulary Math Mode. This vocabulary contains commands for over 1 million math expressions. These

commands are designed to meet, as best as possible, the properties listed in Section 2. Although the commands include most common math symbols, they certainly do not include all possible symbols and expressions. However, by use of the mouse and menu commands, any mathematical symbol supported by Scientific Notebook 3.5° can be typed by voice commands.

Reason For The Paper

The stimulus for this paper comes from two sources:

1) **Pablo Aguilar and students like him all over the world**

Pablo Aguilar is a 32 year old senior Psychology/English major at Southern Methodist University (SMU) in Dallas, Texas. He is well-known on the SMU campus, and is an inspiration to both students and faculty alike. At the age of 19, Pablo contracted a rare disease which left him paralyzed from the neck down. He lives in a motorized wheelchair that he operates by moving his head. His primary educational and career goal is to complete his Master's Degree in Psychology and become a counselor for others. Pablo is very positive, outgoing, with a "can do" personality.

In the fall semester of 1999, he was faced with the standard statistics course required of all psychology majors at SMU. This presented a problem, for obvious reasons. Moreover, desiring to eventually obtain an MS in Psychology, Pablo needed to do more than just pass a statistics course—he needed to know some statistics and be able to use it. Having heard of Professor H.L. Gray's developments in using voice operated computers to do mathematics, Pablo contacted Dr. Gray for help. The resulting effort is the primary topic of this paper.

2) **The need for such a math processor expressed to the authors by personnel at the Texas School for the Blind.**

Dr. Gray's initial efforts to satisfactorily interface Scientific Notebook and Dragon Dictate was at the request of Ms. Susan Osterhaus at the Texas School for the Blind. The Braille printout option in Scientific Notebook makes this particularly desirable.

In this paper we will demonstrate the application of MathTalk to successfully teach, learn (as experienced by Pablo) , and do mathematics, particularly Statistics, by voice. In the process, we will discuss those features that are necessary for any voice program to be a successful teaching tool in mathematics. Moreover, we will observe some features of voice operated computing that may also enhance the teaching of mathematics and statistics for students who are not disabled.

II. Some Necessary Properties Of a Voice Operated Math Processor

The experienced gained with Pablo and other students with similar disabilities suggest that for any voice operated math processor to be a successful tool for learning and doing mathematics it must have the following properties.

1. A vocabulary large enough to type by voice most mathematical symbols.

2. A mathematics vocabulary of voice macros sufficiently broad that common mathematical symbols, from beginning Algebra to Advanced Calculus to Probability and Statistics, are easily employed .

3. Command names must be natural wherever possible. For example, say "x square" for x^2, **not** "x to the second power".

4. Command names must be selected to minimize recognition errors.

5. Errors must be easy to correct.

6. Printing saving and editing must be simple.

7. The program must be easy to learn and implement.

8. The program must include extensive tutorial material, including numerous examples.

III. Nature of the Study

Over the last 12 months the authors have worked together in a development/feedback/redevelopment mode to establish an effective voice operated mathematics processor. The subject matter covered was primarily the basic material covered in a standard introductory statistics course. This included: probability, random variables, distributions, estimation, confidence intervals and test of hypothesis.

The *modus operandi* was as follows. The general study program was laid out by Dr. Gray and primarily taught to Mr. Aguilar by Ms. Genter via the MathTalk program. There were two primary goals:

1) for Mr. Aguilar to learn statistics; and

2) to modify MathTalk to optimize its effectiveness in aiding students to learn and do mathematics.

It was therefore necessary for Ms. Genter to teach simultaneously "voice operated computing" and statistics. Mr. Aguilar also had a dual responsibility, that of learning voice operated computing and that of learning statistics. In addition, both Ms. Genter and Mr. Aguilar were required to produce feedback on which features of the MathTalk program were desirable and which were not and what additional properties were needed to optimize it as the desired teaching tool. Dr. Gray was then charged with providing such changes to the program. The final result was the program MathTalk 3.5 which we will demonstrate extensively in this paper.

IV. Issues in Teaching Statistics via Voice-Operated Computing

Most beginning statistics students face two hurdles as they work through an introductory course. The more common of the two is typical for introductory science and mathematics courses: the material and the vocabulary is brand new and requires a level of analytical thinking with which many students are unfamiliar. The second hurdle, the one so often voiced to instructors, tutors, advisors and the like, is that mastery of statistical concepts requires at least a minimum of mathematical skill and too many students harbor both a dislike and a fear of anything mathematical. As a result, introductory statistics students often begin the course assuming success to be an unlikely result. These fears are even more acute in the physically impaired.

One way in which instructors address this uncertainty about basic math skills is to assign homework or practice problems that, as an example, require computation of basic summary statistics or calculation of probabilities under various distributions. Problems such as these, especially given repetitively, serve to both strengthen a student's confidence in his/her ability to complete mathematical problems as well as to demonstrate the very many new concepts presented in a statistics course in an applied and (hopefully) meaningful manner.

The introduction of various software programs and graphing calculators is shifting the focus from pencil-and-paper or pocket-calculator solutions and graphing to problems that can delve more deeply into the analytical aspect of statistical concepts. But this change only affects the way in which the solutions are derived. In the end, a student in an introductory statistics class still must be able to read, process, and determine a method of solution for statistics problems. While computers may facilitate the manual part of the solution for the average student, without a mechanism for entering the mathematical symbols into the computer, a student without use of his/her hands is no better off than in the days of pencil-and-paper solutions.

Voice-operated computing for mathematical work bridges this gap for the physically impaired in several ways. First and foremost, it allows the student to participate fully in the learning process, which at its core requires practice in applied problems. To do so without voice-computing has required students to dictate symbols, formulas, equations, and potentially lengthy solutions to another person. When this person is not familiar with the mathematical or statistical nature of the material, explaining the steps to solve the problem is often impossible. On the other hand, if a transcriber can be found with some facilitation in statistics, there is always the potential for the dictator's work to be re-interpreted or "encouraged" by the "dictatee". While this second situation may be good for homework grades, it does little to assist the student in truly learning the concepts.

Another problem arises when the student is required to speak his/her responses to an instructor or instructor's aid. The act either requires the student to formulate and recollect steps without any recording that may be reviewed and revised along the way, or if the student is excused from providing details of the solution, it comprises his/her

incentive to truly assimilate statistical concepts. The use of voice-computing, however, is much, much more than simply a way to make the turning in of homework a less strenuous exercise. The student's ability to control the pace of problem-solving and to re-examine, correct, or completely retool the problem on which they are working or any previous problem returns the focus of the homework activity to the material being covered.

These issues are also involved in the taking of examinations by students with impairments. If the student is dictating, is the work being recorded accurately and without embellishment? If the student is speaking their answers, is he/she being subjected to an undue amount of pressure because they must present their work directly to another person, possibly the instructor, without the advantage of "erasing" an answer he/she later determines to be incorrect? Use of voice-computing to solve and present solutions in all situations alleviates these problems, if not eliminating them altogether. Voice computing, however, is not an "automatic" solution. Its implementation into an instructor's material and the student's routine requires planning, practice, and some additional time, at least initially. As with any new tool, there is a learning curve; in fact, there are two learning curves. The first involves the voice commands, and the second involves the application of these to the mathematical material. As previously mentioned, students learning introductory statistics with voice-computing software must not only face new subject matter, but must do so in what is most likely a brand-new environment. Just as one would not expect a student to take introductory statistics without a certain familiarity with, say, algebra, one cannot expect a student to successfully use voice-computing in statistics without first mastering the basic functions of the given voice software.

The authors found through their experience that there are essentially three skills that must be mastered before a student can comfortably use voice-computing for statistical work: dictation, introductory mathematical typing and computation, and something we will call "math-text integration", MTI. By "comfortable use", it is meant that the student is only doing statistics when he/she is doing statistics. That is, the only difficulty they face in completing an assignment is properly using the statistical concepts they have learned. They are not concerned with technicalities such as cursor placement, scrolling to previous answers, getting online assistance in remembering the required math commands, correcting typographical or recognition errors, voicing basic or common mathematical statements, etc.

The first skill is dictation, the simple act of speaking sentences, perhaps spontaneously, perhaps by reading from a text or paper. This practice addresses the fundamental activities required while using voice-computing software. It familiarizes the user with error correction, cursor movement, mouse functions and other functions experienced word-processor users take for granted. This training can begin with the Dragon Dictate tutorial. However this will not be adequate. Several weeks of training by a qualified instructor is at least desirable.

Just as importantly, with every paragraph recorded, the software is "learning" the users voice. This significantly reduces recognition errors both when learned words are used at later times and when new words are being introduced to the software. While MathTalk has a set of commands for scientific symbols that are unique to MathTalk, the actual word recognition is done by Dragon Dictate and as such, MathTalk users must be proficient with all Dragon Dictate functions to be proficient in MathTalk.

The importance of one's ability to dictate quickly and easily cannot be overemphasized. Learning statistical commands, because the student will also be learning the concepts behind those commands, is potentially frustrating enough without the added burden of constant technical problems. Unfortunately, the authors report this finding having "learned the hard way". That is, initially we attempted to incorporate voice-computing into the structure of the introductory Statistics class before Pablo had mastered the basics of voice computing. This proved to be costly both in terms of time and rate of success in Pablo's case. We believe that this reflects a fundamental principle, *learn to use the voice processor and then apply it to the subject!*

The second skill that should be mastered before beginning an actual statistics course is the ability to voice simple (or introductory) mathematical statements and to use the features of Scientific Notebook to carry out computations. Just as students are expected to have some experience with basic algebra and the use of a calculator before working statistical problems, students using MathTalk for statistical work need to be proficient at entering fundamental mathematical constructs such as equations, fractions, exponents, subscripts and miscellaneous symbols by voice. It is simply too much to ask of any person to "stop" learning statistics for a moment in order to be tutored briefly on a technical use of the program.

To develop the skills required to comfortably enter mathematical symbols and evaluate mathematical expressions, it is recommended that the instructor provide some hand-written exercises to practice computational techniques. Additionally a basic mathematics or algebra text from which the student can dictate and solve appropriate problems should be required. Exercises that relate to typical introductory applied statistics problems should be the focus. These might include: simple calculations; simplifying expressions; solving univariate equations; creating fractions (either singly or in the context of an expression or equation); and substituting values for variables using the "define equal" command in MathTalk. The commands [define equal], [evaluate], [evaluate numerically], and [simplify] are essential to the solution of typical statistical problems, and as such should be practiced extensively in simple examples. Only when proficiency at dictation, voice activated problem solving and correction (as necessary) is demonstrated should the student be asked to move on to statistical concepts.

The third skill determined to be a precursor to successful use of voice-computing in a statistics course is the skill we have called "math-text integration", MTI. This is really a combination of the previous two skills. Completing statistical problems, particularly

in the typically applied context of most introductory statistics courses, requires the use not only of mathematical symbols and computations but of words and explanations. To do this in MathTalk, one must constantly move from one mode to another, specifically from Math Mode to Dictate Mode. Practicing the "MTI" skill requires this back-and-forth movement throughout the exercises. Early in the process of learning MathTalk, for example, students can be asked to dictate their own problems into a file, rather than having them pre-typed, before computing the solutions. As the student's skill in voicing math commands improves, she/he can be asked to provide a written list of steps performed at the end of each computation. She/he can also be asked questions requiring, for example, that she/he describe how her/his answer would differ should certain aspects of the problem be changed. In short, any activity requiring the student to both dictate (use written words) and voice math interchangeably serves well as a first step to MTI. Once the act of switching from mode to mode is seamless, the student will be able to concentrate on learning the statistics.

One of the most difficult aspects of teaching statistics to a student who is unable to write is that he/she is unable to take notes. Having the notes written for him by the instructor, an aid, or other student is not a satisfactory alternative. The benefit of MTI is of course much more than the physical transcript it provides. It is fundamentally a tool which can help process information through the act of having to re-express what is heard on a sheet of paper or computer screen, to which can be added questions or thoughts that come about during a class meeting. To this end it is recommended that the student record all lectures and use MTI to transcribe the lecture at a later time.

Mr. Aguilar's first examination for the statistics course exemplified the problems with voice computing that we have noted, all of which could have been avoided with adequate planing and practice. In preparing for this first exam, Mr. Aguilar studied much as any student would, by relying on the textbook. But this is impractical when one must depend entirely on another to manipulate the pages. At the time of the first exam, the MTI skill had not been mastered so that adequate notes for study that were accessible by voice were not available. Moreover, Pablo's voice computing skills were still weak. As a result, his score did not reflect his knowledge or potential.

The second mid-term examination, on the other hand, proved to be a much smoother process. By the time it was given, Mr. Aguilar had become much more comfortable with MathTalk and its features, working with it not only every afternoon in class but also in the evenings on his personal computer at home. Just as students in the standard course were allowed to use a sheet of formulas and definitions while writing their examinations, Mr. Aguilar created a "sheet" of statistical formulas for his own use, with the exception that his also contained reminders about dictation and text manipulation commands he had previously found useful. On the second exam, Mr. Aguilar was able to demonstrate both his statistical knowledge and his improved proficiency in the use of MathTalk. Furthermore, he was able (at his request) to complete the examination without Ms. Genter present, a situation which put him noticeably at ease.

Another very simple technique Mr. Aguilar and Ms. Genter found beneficial was placing relevant definitions in a file entitled "statistics definitions". MathTalk includes numerous definition files. By placing the important definitions in this file, Mr. Aguilar could check any definition by saying "show statistics definitions".

From the instructor's perspective, the introduction of this technology to the course does not imply the student can operate as any other student in the class, nor does it relieve the conscientious instructor of some extra responsibility. Indeed, there were times that preparation for work with Mr. Aguilar required as much additional work as preparing for a class lecture. If the software is to be most beneficial, several stages must occur:

1. There must be time for instruction and practice in use of the MathTalk/Scientific Notebook program, including the preparation of basic mathematical exercises.

2. Time must be regularly scheduled for the student to consult with the instructor about the meaning and function of statistical commands in MathTalk, as well as for the student to retrieve material she was not able to record in the class lecture.

3. Some material must be prepared ahead of time for the student to implement in MathTalk.

4. Optimally, quiz material, examinations, and other non-text work should be copied into MathTalk so that the student may both read and answer questions on the screen. This allows the student to work without distraction in a format most similar to other students in the class. As MathTalk produces word-processor quality documents, it is quite easy to produce such material in MathTalk and then make paper copies for the class as a whole; as a result, this simple yet very beneficial step does not necessarily require a large amount of additional preparation time.

5. At times, an instructor may feel a new command or set of commands needs to be created in MathTalk so that the student may complete certain problems in a manner similar to methods discussed or practiced in class. In such instances, these commands must be developed, tested, and copied into the students program, or the student needs to be instructed in how to create or modify MathTalk commands.

From these remarks it should be clear that if universities and public schools are to offer adequate training in mathematics and science for the physically impaired a team effort is required. That is, it is unrealistic to expect professors and subject matter public school teachers to know, much less be proficient in, Dragon Dictate and MathTalk. This burden must necessarily fall on the special education faculty and staff. In order for the fields of mathematics and science to be an educational option for the physically impaired, voice computing through programs such as Dragon Dictate and

MathTalk must be taught as a basic skill to those individuals who do not have adequate use of their hands.

V. Examples

In this section we show several examples of problems solved by Mr. Aguilar. First, we introduce some basic skills and then perform some computations. We then proceed to some simple expressions and finally use the MTI skill to state and solve problems. In order to guarantee the reader understands the nature of the dialogue required, the first few examples are just the demonstration of the type of voice commands used to enter numbers, letters and special math symbols. The math symbols throughout this paper were all entered by voice. The voice commands in the following examples are enclosed in quotes and separated by commas. For example, if the user says "x square", instantly x^2 will appear on the screen. When it appears, the user says "plus". When the plus sign appears, they say "y cube" to get $x^2 + y^3$. Thus in the examples below we list the entire dialogue first with commands in quotations and commas between them to indicate slight pauses. Of course when the student says the symbols, they appear on the screen at the instant they are uttered.

Example 1: Saying numbers

- To Get: $5, 8, 0, 99$
  Say: **"5", "comma", "8", "comma", "zero", "comma", "99"**

- To Get: $\frac{\pi}{2}, 2\pi, \frac{1}{2}, \frac{2}{3}$
  Say: **"pi over 2", "comma", "2 pi", "comma", "1 half", "comma", "2 thirds"**

  To Get: 27.586
  Say: **"two seven point five eight six"**

- To Get: $-.0394$
  Say: **"minus point zero three nine four"**

Example 2: Saying simple math terms

- To Get: x, $3x$, $11B$, 4α, 21λ
  Say: **"x", "comma", "3 spaces", "3x", "comma", "3 spaces", "11 cap bravo", "comma", "3 spaces", "4 Greek alpha", "comma", "3 spaces", "21 lambda"**

Remark: In order to reduce recognition errors the International Alphabet is used for "sound alike" letters. For example "bravo" for "b" and "echo" for "e". For letters such as x, y, and z you can use the international alphabet but you do not have to.

To Get: x^2 l^3 z^6 x^{-4} $e^{-\frac{\pi}{2}}$

Say: **"x square", "lima cube", "z", "exponent 6", "x", "exponent minus 4", "echo" "exponent minus pi over 2"**

- To Get: a_1 λ_{12} σ_x W_{xy}

Say: **"alpha","sub one","lambda", "sub one two","sigma", "sub x", "cap w", "sub x y"**

- To Get: $\sqrt{x}$ $\sqrt[3]{R}$ $\sqrt[4]{\beta}$ $\sqrt[5]{\pi}$ $\sqrt[6]{3}$

Say: **"square root of x", "cube root of cap Romeo", "4th root of greek bravo", "5th root of pi", "6th root of 3"**

- To Get: $4 + 3i = 5(\cos 36°52' + i \sin 36°52')$

Say: **"4", "plus", "3 India", "equals", "5", "parentheses", "cosine", "36", "degrees", "52", "seconds", "plus", "India", "sine", "36", "degrees", "52", "seconds", "move out".**

- To Get: (x) (x,y) $(-1,1)$

Say: **"parentheses x","parentheses xy","parentheses minus one one".**

To Get: $f(x), f(1), f(-1), g(y), \lambda(\theta), \delta(\varepsilon), \Phi(z), \Gamma(\frac{1}{2})$

Say: **" f", "parentheses x", "comma", "f","parentheses 1", "comma", "f", "parentheses minus 1","comma", "g ", "parentheses y", "comma", "lambda", "parentheses theta", "comma", "greek delta", "parentheses epsilon", "comma", "cap fee", "parentheses z", "comma", and "cap gamma", "parentheses one half."**

Example 3: Saying equations

- To Get: $x + y = 3$

Say: **"x" "plus" "y", "equals" "3"**

- To Get: $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - X)^2$

Say: **"cap S squared", "equals", "fraction", "1", "over" "November minus 1", "move out", "sum with limits", "India equals", "limits 1 to November", "parentheses", "cap x", "sub i", "minus", "cap x bar", "move out", "squared"**

- To Get: $F(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{1}{2}t^2}\,dt$

Say: **"cap F", "parentheses x", "equals", "normal CDF"**

Example 4 : Evaluating mathematical expressions

- To Get: $z = \frac{(m-\mu)\sqrt{n}}{\sigma}$
  Say: **"z-statistic"**.

- To Get
  $m = 3.2$
  $\mu = 2$
  $n = 25$
  $\sigma = 3$
  $z = \frac{(m-\mu)\sqrt{n}}{\sigma} = 2.0$

Enter the values of m (here, $m = \bar{x}$), μ, n, and σ with the cursor at the end or in the equation by saying **"insert 1 line", "mike", "equals", "3 point 2", "define equal", "next line, "mu", "equals", "2", "define equal", "next line", "November", "equals", "twenty five", "define equal", "next line", "sigma", "equals", "3", "define equal", "move down 1" "evaluate numerically"**.

To Get: $P[a \le Z \le b] = \frac{1}{\sqrt{2\pi}} \int_a^b e^{-\frac{1}{2}t^2} dt$
Say: **"standard normal probability"**

- To Get:
  $a = -2$
  $b = 2$
  $P[a \le Z \le b] = \frac{1}{\sqrt{2\pi}} \int_a^b e^{-\frac{1}{2}t^2} dt = 0.95450$

With the cursor in or directly following the equation,
Say: **"insert 1 line", "alpha", "equals", "minus 2", "define equal", "next line", "bravo", "equals", "2", "define equal", "move down 1", "evaluate numerically"**

- To find the $P[Z \ge 2]$, proceed as follows to get:
  $a = 2$
  $P[Z \ge a] = \frac{1}{\sqrt{2\pi}} \int_a^\infty e^{-\frac{1}{2}t^2} dt = 0.02275$

Say: **"next line", "alpha", "equals", "2", "new definition"** (or **"define equal"**) **"probability z greater than or equal to alpha"**, **"evaluate numerically"**.

The student can calculate probabilities, p-values, and confidence intervals for the binomial, chi square, f, normal, standard normal, t, and uniform distributions in the same manner.

Example 5: An MTI example

In this example the text (i.e. statement of the problem) and the math were entered by Pablo, necessarily by voice, to illustrate MTI.

- To Get:
  (a) Use the quadratic formula to find the roots of $x^2 - 3x + 4 = 0$.

$$ax^2 + bx + c = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Therefore

$$x = \frac{3 \pm \sqrt{9 - 4 \times 4}}{2}$$
$$= \frac{3 \pm \sqrt{9 - 16}}{2}$$
$$= \frac{3 \pm \sqrt{7}i}{2}.$$

Starting on a **new line** say: **"dictate mode", "left parenthesis", "alpha", "right parenthesis", "space bar", "space bar", "Use", "the", "quadratic", "formula", "to", "find", "the", "roots", "of", "space bar", "space bar", "math mode", "x square", "minus", "three", "x", "plus", "four", "equals", "zero", "period", "next line", "review quadratic formula", "next line", "type", "therefore", "next line", "x", "equals", "fraction", "three", "plus or minus", "square root", "nine", "minus", "four", "times", "four", "move out", "over", "two", "move out", "next line", "five spaces", "equals", "fraction", "three", "plus or minus", "square root", "nine", "minus", "sixteen", "move out", "over", "two", "move out", "next line", "five spaces", "equals", "fraction", "three, "plus or minus", "square root", "five", "move out", "India", "over", "two", "move out", "period"**

Example 6: Some homework problems worked by Pablo with MathTalk

Given the following data: 1.23, 3.47, –2.08, –2.67, 1.88, –.09, .19

(a) Find the mean, standard deviation, and median.

(b) Find the .99 percentile point of a standard normal distribution

(c) Find the .99 percentile point of a t distribution with the appropriate degrees of freedom

(d) Assuming normality, find a 95 % confidence interval for the mean, μ.

Solution:

(a) With the cursor in or at the end of the data Pablo issued the following commands: **"sample mean"**, **"sample S D"**, **"sample median"**, to get successively

Mean(s): 0.27571
Standard deviation(s): 2. 1624
Median(s): 0.19

(b) Commands given by Pablo to work part (b):
"Standard Normal commands"
"z point zero 1"

Result: $z_{.01} = 2.326$

(c) Commands issued by Pablo to work part (c):
"t commands"
"degrees of freedom", "equals", "6", "define equal"
"t critical value"
"equals", "point zero 1"
"solve numerically"

Result:
$\nu = 6$
$\frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\,\Gamma(\frac{\nu}{2})}\int_t^\infty \left(1+\frac{u^2}{\nu}\right)^{-\frac{\nu+1}{2}} du = .01$, Solution is: $\{t = 3.1427\}$

(d) Commands issued to complete the problem:

"t confidence interval for the mean", "define equal"
"mike", "equals", "point 2-7-5-7-1"
"sierra", "equals", "2 point 1-6-2-4"
"tango", "equals", "3 point 1-4-2-7"
"November", "equals", "6"
"define equal"
"evaluate numerically"

Result:
$m = .27571$
$s = 2.1624$
$t = 3.1427$
$n = 6$
$CI = \left(m - t\frac{s}{\sqrt{n}}, m + t\frac{s}{\sqrt{n}}\right) = (-2.4987, 3.0501)$

VI. Concluding Remarks

In this paper we have tried to demonstrate the potential of voice computing to aid in teaching mathematics and science to persons who are unable to effectively use their hands. We believe voice operated computing to be a powerful tool in assisting such individuals to develop careers in technical areas. Moreover we also believe that there are many among physically impaired individuals who could contribute greatly to the fields of science, mathematics, and engineering if given the opportunity.

During this project it also became clear that voice operated computing could also be of great value to students in mathematically oriented courses whether they are physically impaired or not. That is, such things as critical values, p-values, confidence intervals, probabilities, etc. can be calculated by simply stating them along with the proper inputs. The same is true in mathematics in general. That is, for example, one could find the maximum of a complicated function by just defining the function and saying "find the maximum". Any number of examples of this type could be given. This would free the instructor to focus on the subject at hand rather than complicated numerical methods which only those very proficient in that subject have mastered.

For those interested in voice computing for mathematics and science who wish more information on the topic, contact Dr. H. L. Gray, C. F. Frensley Professor of Mathematics and Statistics, SMU Dept. of Statistics, Dallas Texas (e-mail: hgray@mail.smu.edu)or Metroplex Voice Computing, Arlington,Texas (e-mail: mathtalk@onramp.net).