Introductory Statistics:
A study to improve the students’ construction of meaning

Learning Problem Statement
and Proposed Study
for
ED 333A

Minette Alexandra Sy Chan, Yunn Chyi Chao, Gloria Isabel Miller
Stanford University
School of Education

July 11, 2001
I. ABSTRACT

In this paper, we describe a methodology for investigating whether a new delivery method for learning Introductory Statistics will be more effective in teaching students not only the computational manipulations of problems, but also how to apply the computational knowledge to the interpretation and solution of real world problems. Many students in Asia are able to quickly and successfully solve statistical problems when required to find numerical answers, but fail when the problem asks for a meaningful interpretation of the result. Or when faced with a problem in a work environment, many formally successful students fail to recall the methods used in statistics and/or cannot apply them successfully.

We begin with a brief description of two theories we employed, activity theory and the situative (socio-historic) learning perspective and briefly review their implications for current practices. We then argue that only by changing the instructional delivery methods to include authentic activities, group discourse, collaborative inquiry, and self-assessment will the students be able to develop the skills necessary to transfer and retain the statistical methods learned.

Both the situative learning perspective and activity theory take the view that considering the mind as something divorced from the individual’s surroundings is oversimplification. It simply fails to address the complexity of the relationship between mind and environment whereas a systems approach acknowledges their interdependencies (Greeno, 1997).

Because this approach to studying our problem could bring into question many other factors in discovering a solution, we will name our assumptions about some possible contributions from the system.

- Lack of appropriate teacher preparation is not a factor in this case because teachers in Asia are required to demonstrate proficiency in mathematics and in teaching skill prior to teaching descriptive statistics.

- Lack of appropriate equipment, such as calculators, graph paper etc. is not a factor because all of these items are available to all students attending the school.

- Lack of proper preparation of the student is not a factor because this study takes place in a school for preparation of engineering assistants. The students are required to take entrance examinations prior to enrollment.
II. THE PROPOSAL

A. BACKGROUND

The situative perspective asks us to rethink the concept of “knowing something.” From this perspective, it is no longer just a matter of storing ideas in your head to be applied to different situations. Rather “knowing is tied to context, distributed across the individual, situations, and other people. Learning is not just personal acquisition of knowledge, but instead as a participation in an activity system. In this case, the subject students are being trained to be engineering assistants (EA) in a factory environment. Their understanding and application of statistical methods will eventually impact the decisions made at the factory and consequently their community. It is essential for these future EA to effectively use statistical methods. Currently, new EA are unable to use the computational methods learned in school to contribute to problem solutions without guidance, assistance, and retraining by the factory. The community desires fully trained and effective EA.

The key principle is that, the associations between individual intellect and the environment are complex and interconnected and should be examined as an indivisible unit (Greeno, 1997). Although we name our assumptions, they are not eliminated from the equation. The alternative to traditional experimentation, and its philosophy of “simplification by isolation” (Salomon, 1995) is to observe how individuals learn in authentic, real-world contexts, like a classroom. This idea of examining the learning process “in situ” is shared by Engestrom (1990) who views human activity as an interdependent system involving the individual (or subject), tools, a problem space (or object), the community of people who are similarly concerned with the problem, the division of labor between community members, and the conventions (rules) regarding actions. In this view, the system as a whole is dynamic and continually changing and evolving.

It is these ideas that have informed our proposal. By improving the individual’s participation in systems activity, the learner will develop awareness of group practices and how the learner can productively engage in those practices.

B. LEARNING PROBLEM

Simply stated, the current practice of educating students in statistical computational methods does not promote the necessary skills for future application in a work setting. The future worker has trouble transferring the skills learned to a work environment and has difficulty recalling the methods of statistical analysis.

C. CURRENT PRACTICE

Investigation of current practice reveals three areas of concern: delivery, problem sets, and assessment. The current delivery method is based on didactic principles, lectures, and rote memorization. Students are taught the theory behind the computations, how to do the computations and read graphs. Students have little or no classroom interactions with each other. Group work is limited to solving computational problems.
The problems are derived from the texts and do not necessarily reflect real world problems. Problems require only short numerical answers, thus the student is rarely asked to relate the numerical answer to a description of the meaning of the results.

Students are required to take timed examinations with problems similar to those posed in class.

D. THE PROPOSED STUDY

HYPOTHESIS
By changing the current method of lesson delivery and assessment given in an introductory statistic course to include authentic activities, discourse, collaboration and inquiry, will help technical school students retain and transfer their knowledge to real-life applications.

METHODOLOGY
We propose to conduct a study at a technical college in collaboration with an experienced math teacher from the college. Working with the teacher, we will design a new curriculum based on the situative learning perspectives. In order to compare the effectiveness of the experimental curriculum to the existing traditional curriculum, students of about the same academic background will be randomly assigned to either the experimental or the control group. Ideally there will be not more than 20 students in each group for easy management. The same teacher will be leading both the control and experimental groups. We will observe the students in a variety of learning situations in and out of class activities. The observed activities will be videotaped and voice recorded. A pre-test and post-test will be given to determine baseline knowledge and knowledge acquired after instruction. Specifically, the pre- and post-test will focus on the application of statistical methods towards solutions of real-life problems. We will also conduct interviews with the teacher and experimental group students to gather information about their views on this new approach to the curriculum to inform design iterations.

THE CONTROL GROUP-TRADITIONAL CURRICULUM
Lessons will be conducted in the traditional lecture setting where the teacher does most of the talking. Class exercises are taken from the back of the textbook, mostly on the specifics of manipulating equations, performing calculations and graphing. Learning method employed by the majority of learners is rote memorization of the formulae, the methods and practice.

THE EXPERIMENTAL GROUP – NEW CURRICULUM
Overview
The entire curriculum will be centered on a project derived from a real factory problem. At the beginning of the course, these technical students will be grouped in teams of five. They will visit the factory to observe the manufacturing process and how sample data is collected at different stages of the assembly line. Each team will be assigned to a quality control engineer who will be their main contact person throughout the project and on subsequent visits. Lessons conducted in the classroom will be a mix of theory and smaller projects based on the data collected at the factory. For instance, the data collected from the initial visit to the factory will be used to supplement the topic of data summarization. Each team will have to decide the best way to organize and present the data. A report discussing their solutions will be presented in class.
The second half of the 10-week course will have the students working on their second major project. They are to provide a succinct report and suggestions to the respective quality control engineer (QC) to help solve quality output problems at that particular stage of the factory process. When working on this project, students may need to go back to the factory and consult the respective QC. Report will be submitted and discussed with the QC.

Based upon the research and data analysis done by the different groups of students, a general picture of the production process can be formed from which they should be able to identify the specific stages in the entire production process that are the primary reasons for defective products. Consequently, the students shall be able to see the relevance of their contribution to the improvement of the community, which in this case, is the factory workplace.

Assessments will be based on the level of learning achieved by the students during the inquiry process, their regular journal entries submitted and their project reports, in both written and oral forms. The journal entries should reflect on self-assessment and the results of the collaborative inquiry process by the individual learner. The project presentations will demonstrate the outcome of the data analysis they have performed. The reports shall include findings from the interviews with the QC, observation notes and calculations, possibly supplemented by videotaping and voice recording when deemed necessary.

Students will use spreadsheet software to further simulate a real working environment after they have demonstrated computational competency. The software will help them organize data and do simple statistical analysis similar to the current practices on the factory floor.

**THE ELEMENTS OF THE CURRICULUM**

*On designing the learning environment and curriculum*

The entire learning environment is built on authentic activities. Working on real-life projects, solving meaningful problems and making inquiries while working on their projects, collaborating with their peers, picking up social skills, will motivate them to want to learn more about statistics. At the same time, students will form a more coherent conception of introductory statistics.

**Authentic environment**

Lave and Wenger (1991) took into account the importance of identity on the learner’s part during learning activities. They theorize that genuine involvement in activities of the community can enhance the sense of identity learners have in their community, and thus increase their motivation to learn. As technical students envision themselves being part of the engineering and manufacturing communities upon completion of their studies, requiring them to actively participate earlier rather than later increases their sense of belonging. Through this activity, students begin to bridge the gap that separates the school culture from the culture of the home and community (Heath, 1983). At the same time, motivating them to want to learn more.

**Collaborative Learning**

The principles for the design of learning environment on which our hypothesis is founded is based on Vygotsky’s work. According to Vygotsky, social structures also mediate thought. In our setting,
students will collaborate with the experts (QC and the teacher), and with their teammates. Several research studies have indicated that students can learn much better in working with their peers rather than working on their own. Besides being able to tap the talents of each individual, the collaborations will enable students to also pick up some social skills while working with each other.

**Learning by collaborative inquiry**

Working on projects is the method we suggest to help students make meaning of what they’re learning. It is thought that learning becomes more active if the goal is clear (Cobb et al., 1991).

The projects are to encourage learning by collaborative inquiry. The value of collaborative inquiry provides direct cognitive and social support for the efforts of individual learners (Brown and Palincsar, 1989). This approach is based on the belief that robust knowledge and understandings are socially constructed through talk, activity and interaction among meaningful problems, tasks, and tools (Roseberry, A.S., Warren, B., & Conant, R.F., 1992). When working on the projects, the teacher guides and supports the students as they explore ways to approach and solve problems. For instance, since there is no one fixed answer to summarize data and interpret findings, students will have to grapple with finding the best way to organize and present data. Then they will find out if their interpretation is valid and useful to the factory. When a new questions pops up, they will need to find ways to solve it, they might even need to visit the factory for more information in order to solve these further questions! These questions grow from the students’ own inquiry and therefore more meaningful in constructing knowledge. In this way, students will learn how the statistics is actually applied and used in the real life.

Collaborative inquiry creates powerful contexts for constructing statistical meanings. In challenging one another’s thoughts and beliefs, students must be explicit about their meanings; they must negotiate conflicts of belief or evidence; and they must share and synthesize their knowledge in order to achieve a common goal (Barnes & Todd, 1977; Brown & Palincsar, 1989; Hatano, 1981; Inagaki & Hatano, 1983; Roseberry, A.S., Warren, B., & Conant, R.F., 1992). By encouraging full participation within the smaller groups in the experimental class, it is hypothesized that collaborative inquiry will naturally occur and different views settled in discourse.

**Practicing discourse**

In the situative view, an important part of learning the concepts in a domain is learning to participate in the discourse of a community in which those concepts are used (Greeno et al.1996). In this context, students will need to talk about statistical concepts, how and why certain statistical methods and theory are employed. During their project presentation as well as during their team and class discussions, they will demonstrate this synthesis of knowledge. They are required to explain and support their findings. They will learn how to formulate questions and evaluate their own and other people’s findings. The focus will be on how students explain and present their ideas and results rather than focusing entirely on whether their answers are correct.
**ASSESSMENT**

**PRE-TEST & POST-TEST**

A pretest at the beginning of the quarter shall be given to all students, whether they belong to the control group or the experimental group. This is simply a very basic test to determine the knowledge baseline of all of the students. The primary goal is to identify the starting point of their knowledge, comprehension and skills for later comparison to the acquired comprehension.

At the end of the academic quarter, students from both control and experimental groups shall be given a similar posttest to determine the level of understanding they have acquired on the material covered. This test shall be similar to the pretest and comprise of a real-life situation, e.g. statistical tables of stock market trends from a local newspaper, and ask students to analyze these data both quantitatively and qualitatively. This can be done in the form of asking for a histogram, statistical information (mean, range, standard deviation), and making forecasts (e.g. in the stock market case, choose which stock a student would buy and the length of time he/she would hold on to it). Results from the posttest can illustrate the depth of a student’s understanding of the topic and his competence in applying these theories (transfer) to this new situation. The results of the posttest together with all of the other gathered information will be used to determine the degree of success of the new curriculum.

**E. SUMMARY**

This paper addresses the learning problems of students studying introductory statistics under the common current practices employed throughout Asia. We propose to change the current method of lesson delivery and assessment by incorporating authentic activities, discourse, collaboration and inquiry process. It is our belief that this approach will help students retain and transfer their knowledge in real life situations. Based on the situative perspective, learning theories were explored and used to support our proposed curriculum. Among these principles are (1) creating authentic environments for learning, (2) participating collaborative inquiry, (3) discourse practice and (4) self-assessment. A methodology is also developed to study the effectiveness of the proposed curriculum, where pretests and posttests, together with the findings of the other data, will be used to measure the degree of success of the study.

**F. RELATED LITERATURE**

1. *IASE Statistical Education Research Group*, a special interest group within the *IASE* (International Association for Statistical Education), which it is also opened to all who share our common interest in carrying out research into the teaching and learning of statistics and probability. The *IASE* is at present the main international association devoted to improve and extend statistical education through the world at all educational levels. It encourages a variety of different activities, including research, as IASE recognizes the relevance of research in extending our knowledge, in advancing the academic recognition of a discipline, as well as in improving the practice of education.
2. A Capstone Course for Undergraduate Statistics Majors - John D. Spurrier, *Journal of Statistics Education* Volume 9, Number 1 (2001). This article discusses a capstone course for undergraduate statistics majors at the University of South Carolina. The course synthesizes lessons learned throughout the curriculum and develops students’ statistical skills to the level expected of professional statisticians. Student teams participate in a series of inexpensive laboratory experiments that emphasize ideas and techniques of applied and mathematical statistics, mathematics, and computing. They also study modules on important statistical skills. Students prepare written and oral reports. If a report is not of professional quality, the student receives feedback and repeats the report. All students leave the course with a better understanding of how the pieces of their education fit together and with a firm understanding of the communication skills required of a professional statistician.

### G. Bibliography


