Building the Numeracy Skills of Undergraduate and Elementary School Students

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Abstract

This paper describes a project with the goal of exposing both elementary school and undergraduate students to the concepts associated with the experimental method, from the formulation of a researchable question to the analysis and interpretation of the results. Under the guidance of their university mentors, fourth and fifth grade students formulated a research question, designed an experiment to answer that inquiry, recorded the appropriate measurements, calculated the necessary statistics, created visual displays of their results, and interpreted their findings at a student-centered Numeracy Conference.

1. Introduction

“Out there, in the streets that we travel, in the offices where we work, and in the newspapers we read and the television programs we watch await forces that would mislead and misinform us, exploiting the enormous public confusion over subjects like percentages, averages, fractions, compounding, and other basic mathematical ideas. This situation has no parallel in illiteracy. Literacy, after all, concerns a translation skill – learning to move easily between written and spoken speech. Numeracy concerns thought itself. You might exploit people’s innumeracy through an advertisement, for example, making a claim that seems to be valid but isn’t. But how would you exploit their illiteracy through an ad they can’t read?” (Dewdney 1993, p. 2)

The Age of Information has the potential to drown us in a sea of numbers. Johnny’s proficiency score is at the 94th percentile. Does this result indicate that a tutor be sought for Johnny? An experimental drug for your grandmother’s illness has a cure rate of more than 50 percent. Can we breathe a sigh of relief? Does she have a good chance for recovery? Does it matter that the clinical trials for the drug consisted of men only? A graph in a newspaper shows a decline in the rate of growth in income for professionals. Should the reader be concerned that the time periods portrayed throughout the graph are not equal? A television commercial tells us that children who eat breakfast earn better grades. Is the government’s sponsorship of breakfast programs the cure for educational ills? The quality of our personal, professional, and community lives depends on our ability to interpret and understand data presented to us in everyday situations; it depends upon our numeracy skills.

Although courses in mathematics build the foundation for numeracy, students need additional opportunities to interact with real data. This is similar to the process of becoming literate. A person, who learns to distinguish an adverb from an adjective, is building a foundation for literacy. However, that skill does not define a literate individual. One has to be given
the opportunity to understand nuances and interpret the meaning of language to be literate. In a similar manner, a person becomes numerate. The person must be immersed in situations where data are encountered and interpreted; students need to be provided with opportunities to hypothesize, collect data, and evaluate that data.

The purpose of this paper is to describe a project with the goal of exposing both elementary school and undergraduate students to the concepts associated with the experimental method, from the formulation of a researchable question to the analysis and interpretation of the results. It is thought that the undergraduates will benefit by mentoring the elementary school students. In so doing, they will experience the process of formulating a question and following the research process through to completion. Similarly, the elementary school students will benefit by experiencing the process, as well as by gaining technical knowledge using the Excel and PowerPoint programs in Microsoft Office. The project was completed twice in succeeding years. The paper will describe the combined results, including the improvements to the project resulting from the first year’s experience.

2. Participants

Four university students who had completed an introductory, sophomore level, statistics class participated in the study each year. Students were chosen based upon their desire to participate and their outstanding performance in the statistics course. One student participated both years. Two of the four students from the second project expressed interest in participating during a third year.

Thirteen elementary school students in grades four and five volunteered to participate in the numeracy activity during the first year. Fourteen elementary school students were included during the second year; four of those students participated both years. Three to five elementary school students constituted a group, which included a university student as a mentor.

3. Method

During the ten-week program, the university students met with the elementary school students once a week to assist them in conducting a research project. Each group formulated a researchable question, designed an experiment to answer that inquiry, recorded the appropriate measurements, calculated the necessary statistics, created visual displays of their results, and interpreted their findings. Each group also created a Microsoft PowerPoint presentation to share their findings at the Numeracy Conference that was held at the conclusion of the project.

Before starting the program with the elementary school students, the university students were asked to design a research project that could be completed with younger learners. Although the project could be modified or totally redone once they met with the elementary school students, the purpose of this assignment was to encourage the university students to contemplate the steps of the research process from beginning to end. Any problems with their proposed study were resolved during the first week of classes.

This requirement of having each university student draft an example experiment was important in building a foundation for their work with the elementary school students. For example, the ability to pose a researchable question was not an inherent skill possessed by the university students. One university student initially proposed the melting of candy-coated chocolate drops as a topic for study. Do the candy pieces melt faster in your hand or in your mouth? As she considered the stages of the experimental process, she faced problems with measurement. How would she measure her variable, “melting”? If she decided to note the time in which all of the dye was removed from the candy, there were many confounding variables to consider. Could one elementary school student have warmer or moister hands than another? It would be difficult to pinpoint the exact time in which all of the dye was removed from the candy without frequent observations that would compromise the exact condition being measured. Noting these challenges, the university student chose another topic that she was able to guide through the experimental process.

During the second year’s project, the university students were required to complete a short report designed to immediately document the instruction and learning evident in the weekly session with the elementary school students. Included in this account was a description of the progress made by the group in accomplishing the objective for the mentoring session. The university students also reported any problems experienced by the elementary school students. For example, did the students have difficulty understanding the importance of randomization? The university students documented a problem such as this and explained how the elementary school students were guided through their confusion. In addition, the university students recorded the elementary school students’ reactions to the activities. Were the elementary school students engaged in the activity? Did they offer suggestions and an eagerness to discuss the concepts being presented? These reports were submitted to the instructor immediately after the weekly session with the elementary school students.
During the quarter, each university student met weekly with the instructor. During these meetings, any difficulties encountered with the research study were discussed. For example, one student realized that the elementary school students in her group had failed to assimilate the concepts regarding data collection. She felt that the data collection procedures of the elementary school students lacked the standardization that she expected. During the discussion with the instructor, she decided to review the material with the elementary school students and ask them to repeat the data collection. These weekly meetings also provided an opportunity for the mentors to share the subsequent objectives for their elementary school students. Planned activities and possible problems were discussed.

Equally important were the reactions of the university students, which were shared during the weekly meetings. Although the instructor accompanied the university students to the elementary school each week, these one-on-one conversations were helpful in assessing the students’ perceptions regarding the project. It needs to be noted that these students were business majors, not education majors. Most of their experience with younger students was limited. One university student admitted during a meeting at the onset of the project that she was “kind of afraid” of dealing with younger students. It became clear that skill with the experimental approach was not the only issue to be addressed.

The university and elementary school students met at the elementary school one day per week for ten weeks. Each session lasted for approximately two hours. A typical meeting began with the students, separated into the four groups, sharing a snack. During this time, each mentor reviewed the progress made on the project, as well as discussed the group’s objective for that day. Elementary school students were encouraged to share their thoughts regarding such questions as: “What things or variables could influence our results?” and “What type of graph should we use to display our results?” After the snack, the groups began their tasks.

Each of the four groups developed a unique research project. This resulted in interesting questions being asked during the two-year span of the project. For example, one group investigated the shock absorbency of different packing materials: packing peanuts, shredded paper, and bubble wrap. An egg was packed in a plastic bag using one of these materials. The importance of standardization in the dropping of the egg was discussed. All students were to release, not throw, the egg from the same height. Each student completed four trials with each packing material in a random order – preset before data collection. The students recorded their results in a handwritten spreadsheet as they completed each trial, allowing the proportion of successful landings with unbroken eggs to be calculated for each packing material. Students found a slight advantage to shredded paper and packing peanuts. Although sophisticated probability concepts were not introduced to the elementary school students, discussions were conducted regarding the possibility of differing results should they repeat their project.

The popping rates of microwave popcorn were the focus of another group. Four brands of popcorn were tested to determine the brand yielding the largest number of popped kernels when popped under similar conditions. The concept of estimation was addressed by these students. At first, the group had decided to merely count the number of popped kernels. However, one elementary school student reasoned that their method of measuring would not be fair because some packages may contain more kernels than others. The concept of proportions was discussed. Another problem then surfaced; how would they determine the total number of kernels in each package without opening each bag to count each kernel? After much discussion, it was decided that they would open one bag and count the kernels. Using the weight of the bag and the total number of kernels in that package, they estimated the weight of a kernel, which allowed them to estimate the number of kernels in their tested packages.

The flying distances of three models of paper airplanes were tested by a group of students. The elementary school students were instructed on the folding of the three models with each student creating the three types of planes. The students discussed possible confounding variables and a means to control for their effects. They speculated that some students may be better at throwing paper airplanes. For that reason, they decided that they would each test all of the models. The influence of the throwing method was another confounding variable that was discussed. Creating an arc in the plane’s flight by launching the plane upward would influence its distance. It was decided that they would all try to launch their planes in a similar fashion. Finally, they realized that they might have more energy at the beginning than at the end of the trials. To minimize the effect of this confounding variable, the university mentor suggested that each student select pieces of paper to determine the order for testing the three types of planes. When it was time for the students to analyze the data, the students discussed various possibilities. They decided to display the average distance for each model on a Microsoft Excel graph.

The last meeting with the elementary school students consisted of each group practicing their presentations in preparation for the Numeracy Conference. Each of the younger students explained a Microsoft PowerPoint slide representing a part of the group’s research process (e.g., the determination of the question, the data collection step, etc.). The other groups provided the audience for the presenting students and discussed the presentations in terms of the numeracy concepts that they had learned during the project. For example, the university mentors asked the students to think of other possible
confounding variables relevant to the presented study or other possible ways of displaying the results.

Also completed at the last meeting was an exit interview. The elementary school students, as a group, were asked by their mentor to appraise the project. They were invited to suggest facets that needed to be changed with the project and aspects that they thought should stay the same. The comments of the group were summarized by the university mentor. In addition to these comments, the university students were asked to include their own evaluations.

As a conclusion to the project, a Numeracy Conference was held on the university campus. Using Microsoft PowerPoint presentations, which the elementary school students created with their mentors, the research findings were presented to family, teachers, and friends. The conference was conducted in the same fashion as a professional conference. Programs were created containing the research question and the names of the members for each group. Pictures taken during the project were also included in the program.

4. Results

Numeracy concepts represented in the projects

Table 1 identifies the statistical concepts associated with each of the studies previously described. The breadth of concepts, which were involved in these elementary projects, is noteworthy. All of the projects emphasized the importance of standardization procedures for collecting data. Random assignment was emphasized in the airplane and shock absorbency groups as a means of minimizing the effect of confounding variables. Descriptive statistics and graphs were used by all groups to interpret and display the data. One group employed estimation techniques while another group focused on variation in results. With the exception of descriptive statistics, both undergraduate and elementary school students developed an understanding of these concepts during the project.

| Standardization | Randomization | Estimation | Confounding Variables | Descriptive Statistics | Graphical Displays | Variation |
|-----------------|---------------|------------|-----------------------|------------------------|-------------------|-----------|
| Airplanes       | X             | X          |                       |                        | X                 | X         |
| Popcorn         | X             |            |                       |                        | X                 | X         |
| Shock Absorvency (eggs) | X            | X          |                       |                        | X                 | X         |

4.2 The university students’ feedback

The value of exposing both undergraduate and elementary school students to the experimental method was evident throughout the project. Although the university students had demonstrated a high level of achievement in a college statistics course, they experienced some difficulty in applying those same basic research skills. Most had difficulty creating a researchable question. The melting question, as described earlier, was one such example. Although the university students had completed several computer classes, some were still confused regarding the entry of their data into Microsoft Excel. The project using various packing materials was an example of this. The university student had guided the group in creating a great chart for collecting the data. However, the student could not visualize the format to use in transferring the data into the computer. As they participated in this hands-on experience, it was clear that the exposure to the experimental method was a unique experience for the university students.

In their weekly reports, several university students commented on the skills learned during the quarter. They were surprised by the gap between the classroom learning and the actual application of that learning. The importance of a pilot project was noted by one of the university students. This student’s group designed a project to determine if subjects could distinguish between regular soda and diet soda of the same brand. As an initial step, they tested a small group of students.
When each person was able to correctly distinguish between regular and diet soda, the group formulated a new research question. Another example of learning found in the reports of the mentors was the importance of planning the standardization techniques. As discussed earlier, one group repeated their data collection because of this void.

The university students reiterated their increased awareness of numeracy concepts in the exit interviews. They reflected on the problems encountered throughout the project and the skills learned to tackle the concerns. All students commented on the effort required to formulate a good question. Like the elementary school students, the need to evaluate a proposed study and determine confounding variables had been impressed upon them. Other observations included in the exit interview were more specific to particular projects. These included the necessity of prior planning for standardization procedures and the importance of a pilot project. All of the university students felt that the project was effective in reinforcing concepts learned in the college classroom.

The university students were enthusiastic about the project. During the first year of the project, all of the university students were seniors. One of those students stayed to continue graduate school and participated again for the second year. Several students from the second year’s project have volunteered to participate again. Much of this appeal was derived from the experience of working with the elementary school students. One of the mentors commented, “It was neat to see them [the elementary school students] think. They had so many energies and ideas all interacting together. It was interesting to see them work and figure things out.”

During the conception of this project, it was assumed that the elementary school students would gain more academic benefits than their university counterparts. While this may be partially true, particularly regarding technical skills, the assumption was not as valid as first thought. Due to a lack of opportunity to do hands-on research, university students had deficits in their understanding of the research process and the associated numeracy concepts. By doing a project geared toward elementary school students, the university students were able to supervise the projects while gaining an understanding of basic research concepts.

4.3 The elementary school students’ feedback

The weekly reports, written by the university students, documented that the project served as an initial experience with research methods for the elementary school students. The statistical concepts were entirely new to the elementary school students who experienced many of the same difficulties as their mentors. For example, in trying to create a researchable question, the elementary school students had no difficulty in suggesting possible topics. Ideas poured forth. One university commented that he was pleased by the “bubbling of ideas” offered by the elementary school students. It became the job of each university mentor to teach the young members to structure the inquiry so that the pertinent data could be collected.

During the exit interviews, the elementary school students demonstrated an awareness of numeracy concepts. When asked what they had learned during the project, many of the elementary school students responded, “We learned how to conduct research.” When asked for clarification, they were able to respond with the importance of randomization, the importance of standardization, the influence of confounding variables, and a familiarity with Microsoft Excel.

In addition to the educational aspects of the project, the elementary school students reported that they enjoyed the project. When the university students asked the group members what they would change regarding the project, all of the elementary school students responded positively. Several students commented that they wanted the project to last longer. Other students asked if it was going to be repeated the following year. The principal has reported that the elementary school students are currently inquiring about the possibility of a third year.

4.4 The parents’ feedback

During the numeracy conference, comments from the parents supported the idea that the elementary school students enjoyed the project and were excited about the research process. One parent remarked, “I never thought anyone could convince my son to stay after school for anything, but he looked forward to ‘Math Club’.” Another parent asked the author, “Were you really discussing confounding variables?” The student had mentioned the topic of confounding variables at home and the parent was impressed by her son’s comments.

5. Discussion of Incidental Learning

The experience of mentoring elementary school students was beneficial for the university students. One of the mentors affirmed this sentiment in her exit interview, “It was a great experience! It enabled me to apply what I had learned in the meetings. Also, I had to think ‘outside’ the box to create an interesting and valuable project, which would get the students
to learn at the same time. I hope the kids enjoyed my presence. I had fun with the project.” This student was the same individual who had earlier confided to the faculty member, “elementary school students kind of scare me.”

The university students were quickly made aware of the skills needed to deal with younger students. The obligation to have a clear concept of the skills to be taught became apparent to the university mentors. They learned that this foundation was necessary to teach others. In addition, they realized the necessity for a certain amount of structure to keep the elementary school students focused. As one university mentor observed, “I can’t believe how quickly the directions go in one ear and out the other.” This mentor learned to establish the students’ attention before beginning a discussion.

There were also incidental bits of learning for the instructor. Because the project was conducted twice, changes were implemented during the second year. The surprising number of gaps in the university students’ knowledge of the numeracy concepts led to more structure being incorporated into the project during the second year. One example was the weekly report completed by the university students. Due to the close monitoring of these reports, deficiencies in understanding were expeditiously corrected. In addition, it was no longer automatically assumed that the university students knew how to proceed. The instructor and the university students conferred weekly about the necessary skills to be taught and the procedures to be completed during the next meeting with the elementary school students. The university students were able to check their understanding and ask any questions needed to clarify their skills. The increased structure improved the project during the second year and would be followed in a continuation of the project.

6. Advantages and Disadvantages of the Project

The greatest advantage of the project was providing the university and elementary school students an opportunity to participate in the experimental process. As recognized by the university students, there is a big gap between the concepts learned from a book and the ability to apply those concepts when working with data. Because of their role as mentors to the elementary school students, the university students were able to experience the research process while studying an elementary-level topic. This permitted them to focus on the research process itself.

Another advantage of the project for the university students was the opportunity to mentor younger children. The need for clearly stated instructions and prior planning became obvious. The university students began to acquire the management skills necessary to deal with younger students.

If a disadvantage of the project had to be identified, it would be the time commitment. The weekly conferences with each of the university mentors, as well as the meetings at the elementary school, took time. Very often, the university students had to be taught how to apply the skills to real data. As in any other teaching situation, the project demanded that the instructor stay current and focused on the project.

7. Conclusion

The project was a success in exposing both elementary school and university students to the concepts of the experimental method as measured by the weekly meetings, the weekly reports, and the exit interviews completed by all students. Weekly meetings with the university students revealed gaps in their understanding of basic research concepts that were corrected before their participation with the elementary school students. In the weekly reports completed by the university students, the instruction necessary for the elementary school students was documented. The exit interviews of both groups supported a perceived increase in the awareness of numeracy concepts.

An additional outcome of the project was the enthusiasm generated for the research process. All of the comments from the elementary school and university students were positive. More pertinent than these favorable remarks was the observation that students wanted to repeat the project. The question, “Are we going to have ‘Math Club” again this year?” , illustrated the appeal of the project.

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