USING "TALKING ALOUD PAIR PROBLEM SOLVING" TO ENHANCE STUDENT PERFORMANCE IN PRODUCTIVITY SOFTWARE COURSE

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ABSTRACT

This paper looks at the impact of "Talking Aloud Pair Problem Solving" (TAPPS) on student performance in a productivity application course. The argument is that success working with productivity applications involves success solving problems. By enhancing students' problem solving skills, TAPPS enhances student performance. The empirical evidence presented indicates that those students who followed the TAPPS process did indeed perform better.

Keywords: Problem Solving, Student Performance, Productivity Software, and TAPPS

INTRODUCTION

Students often struggle with introductory computer courses. In introductory programming courses, students often seem to try to write code first and think about what it is supposed to do later. In teaching productivity software applications, it seems that students frequently apply rote sequences of mouse clicks and/or key stokes hoping to solve the current problem. What students frequently display are poor problem solving skills. Writing a program in C++ to accept two numeric input values, calculate their sum, and display the result is a problem to be solved. Taking data in a spreadsheet and creating a chart from that data is a problem to be solved. This paper is about explicitly addressing development of students' problem solving skills using "Talking Aloud Pair Problem Solving" or TAPPS. Initial experience implementing TAPPS in a sophomore level Productivity Software course suggests that using TAPPS improves student mastery of the course content. The paper is organized as follows.

The next section describes Thinking Aloud Pair Problem solving. That section briefly looks at the surface of the underlying psychology and learning theory literature. And it also references a number of studies indicative of TAPPS efficacy. The TAPPS section is followed by a methodology section. In the methodology section, the implementation of TAPPS will be discussed. The Methodology section will also discuss the measures collected and used in the Results section. The results section describes and explains the empirical results. The final section is a concluding Discussion section.

TAPPS

"Talking Aloud Pair Problem Solving" has a long history. It appears to have first been explored by Claparede (as described in Woodworth, 10) and was later used by Bloom and Broader (1) in their study of the problem-solving processes of college students. While the concept has been around a long time, the name, "Talking Aloud Pair Problem Solving," and the acronym, TAPPS, are credited to Whimbey and Lochhead (9). A year later, Lochhead and Whimbey (5) described TAPPS as a practical method easily accessible to instructors in any field.

The TAPPS process is deceptively simple. Students are divided into pairs. Within the pair, one student takes on the role of problem solver while the other student has the role of listener. The problem solver is to talk, to verbalize each step of his or her thought process, starting with a statement of the problem to be solved. As the problem solver works on the problem, they are to explain what they are doing and why. The listener role is the more difficult role. The listener must keep the problem solver talking. Short silences require the listener to prompt the problem solver for what they are thinking. The listener needs to understand in detail every step by the problem solver, including the diversions and errors. And the listener is not supposed to help solve the problem. The instructor's role is simply to enforce the rules – to insure that the problem solvers talk and fully justify their solution steps. The instructor must also prompt the listener to press for detail and remind the listener not to help solve the problem. Students switch roles from one problem to the next so that they all have an opportunity to "solve" and "listen."

What the TAPPS process does is require the problem solver to recognize their own problem solving steps. Often we humans just solve the problems we encounter without being aware of what we're doing. But work by Zimmer and Risemberg (11) indicates that metacognition is necessary for improvement of problem solving. In essence, students must recognize how they solve problems before they can improve their problem solving technique. Pistel (7) has looked explicitly at TAPPS and found that it effectively addresses this metacognitive issue.

In the last decade, there have been a number of studies of the efficacy of TAPPS. Lockhead and Whimbey (5) have numerous TAPPS success illustrations in their article. Johnson and Chung found that the TAPPS process enhanced aviation students' ability to troubleshoot problems and enhanced training efficiency. Jeon, Huffman, and Noh (2) found TAPPS to enhance high school student chemistry problem solving. Pate, Wardlow, and Johnson (6) found that TAPPS helped university students troubleshoot power plant problems. The list of successful studies could go on. But the literature indicates a few failures as well. Webb, Ender, and Lewis (8) were unable to find any improvement in 11-14 year old students planning and debugging of BASIC programs when TAPPS was used. Kim (4) has found evidence suggesting that TAPPS is culturally specific. Kim (4) confirms that TAPPS enhanced problem-solving ability for individuals with a Western cultural heritage. But for those with an Asian cultural heritage, Kim(4) found that TAPPS actually impaired problem-solving. Overall, there is considerable support for TAPPS efficacy but TAPPS does appear to also have limitations.

METHODOLOGY

TAPPS was introduced into sophomore level course providing instruction in Microsoft Office applications. The course and how TAPPS was implemented is covered below under Implementation. Issues of measurement are covered below under Measurement.

Implementation

The course covering Microsoft Office's productivity applications of Excel, Access, Word, and PowerPoint is taught in a lab environment. Basic knowledge of the Windows operating system, Excel, Word, and PowerPoint is a prerequisite for this course. A typical class session consists of the instructor demonstrating some feature of one of these software products followed by student hands-on experimentation with the same feature. Slightly more than half of this semester course is devoted to Excel. Although some knowledge of Excel is prerequisite, instruction begins with a quick review of the basics. Coverage of Excel continues until students are familiar with using What-If tools, the Solver, and Macros. The Excel segment ends with business modeling using financial functions. Access is used as an illustration of a database is the next largest component of the course. Emphasis is placed on database design, relating tables, and generating queries. Only a couple of weeks at the end of the semester are allocated to Word and PowerPoint.

TAPPS was introduced to the class on the first day. TAPPS connection to improved problem solving was emphasized as was the notion that successful use of the course's software products was really all about successfully solving problems. Students were divided into permanent Pairs for the remainder of the semester. The typical class period included two "Pair" problems for the students to work on after the instructor demonstration.

For the first couple of weeks, the instructor actively enforced the TAPPS rules by frequently reminding the class of the rules, listening in on individual pairs and "correcting" where necessary, and by asking why the classroom was quiet whenever the noise level dropped noticeably. After the initial 'TAPPS training" period, active enforcement of TAPPS rules fell off.

Measurement

When active enforcement of TAPPS rules fell off, students segmented themselves into three groups. About 40% of the students continued to actively practice the TAPPS process. Another 45% of the students simply worked together on the tasks rather than following the TAPPS process. The remaining 15% insisted upon working independently: often with their assigned Pair working independently by their side. While students occasionally switch from one approach to another, they settled into patterns. The instructor kept records for each class period. Based on over ten weeks of observational records, students were classified into TAPPS, Group, and Independent classifications.

A maintained hypothesis in this work is that successful problem solving is reflected in successful accomplishment of tasks with the software. The course had four hands-on "midterm" exams, two on Excel and one on Access and one on PowerPoint and Word. Student scores on these exams indicate how well they were able to accomplish tasks with the software and by inference how well they solved problems in this domain. Similarly, there was a comprehensive hands-on final examination. Scores on the final exam, like the midterms, reflect how well students were able to accomplish various tasks and also some degree of retention of material. Finally, there was to total score reflecting student accomplishment on all facets of the course (excluding homework). Thus there are three measures of student performance, Exams, Final, and Total. The question is whether TAPPS, through improved problem solving skills, has a positive impact on student performance.

Students had weekly, individual, homework assignments. These assignments were design for additional experience with the concepts and skills covered in the course. Not all students submitted all assignments and the degree of care taken in completion of the assignments also varied across students. Homework scores may reflect the student's innate ability, motivation, and familiarity and/or comfort working with computers. As such, homework scores should serve as a control variable to help explain individual differences in Exams, Final, and Total scores. Recall that the total score used in this paper does not include homework scores.

RESULTS

Complete data was available on 86 students. Students withdrawing from the course or failing to pass because they did not take the final or other exams were excluded from the analysis. Table 1 contains summary statistics for these data.

Table II shows average performance measures for each of the student groups as well as a count of the students in each category. In each case, those students in the TAPPS category out performed students who worked individually or students who worked together. While not a valid statistical test, the data in Table II is suggestive that students who followed the TAPPS process did indeed perform better. Significant differences of means by groups were tested for using oneway ANOVA. Differences in Exam means just missed being statistically significant at the traditional 5% level. Differences in mean scores for the Final and Total measures were statistically significant at a 1% significance level.

Regression analysis was used to further investigate whether the significant differences of means can be attributed to differences in Category or other individual differences. Three Dummy or indicator variables were defined for the three categories. Since these three indicator variables are mutually exclusive and exhaustive, the regression was run without a constant term. In essence, it was run with three separate constant terms, one for each category. It should be noted that a regression with just the three indicator variables is equivalent to the oneway ANOVA already reported.

Table III reports the three regression results. Each regression is based on the 86 observations. In each case, the regression model was statistically significant. As the individual t-statistics indicate, most of the coefficients were estimated with reasonably good precision. In the Final exam score regression, the estimates are the least precise but clearly meet the conventional significance test levels.

Table I: Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
HomeWork	86	225	34.9	98	250
Exams	86	348	40.6	149	398
Final	86	180	38.2	68	225
Total	86	755	98.2	369	866

Table II: Count and Average Performance by Category

Category	N	Exams	Final	Total
Individual	14	337	125	638
Group	38	346	171	722
TAPPS	34	358	193	792

Table III: Regression Results

	Exams		Final		Total	
Variable	**Coef.**	**t**	**Coef.**	**t**	**Coef.**	**t**
Individual	196.19	6.831	52.16	2.124	243.01	5.716
Group	207.98	8.426	82.14	2.781	295.27	5.478
TAPPS	239.93	7.474	98.61	2.897	357.28	5.147
Homework	0.63	5.068	0.61	5.708	1.35	6.073

Even accounting for the independent influence of Homework, the coefficients in each regression show a clear trend: the Group coefficient is always larger than the Individual coefficient and the TAPPS coefficient is always larger than the group coefficient. This indicates that those students using the TAPPS process performed better on their Exams, Final, and in their Total scores than students in either of the other two categories. But is this difference significant?

Using the regression's variance-covariance matrix, it is possible to construct a t-test to determine whether or not the TAPPS coefficient is significantly larger than the Individual and Group coefficients. Tests were constructed for each of the three regressions. In every regression, the TAPPS coefficient was significantly larger than the Individual coefficient. Thus those students following the TAPPS process clearly out performed those who worked individually. Testing whether the TAPPS coefficient was significantly larger than the Group coefficient was less clear. In the regression using Exam scores, it was not possible to reject the null hypothesis that the Group and TAPPS coefficients were the same at conventional levels of significance. However for the regressions with the Final exam score as the dependent variable as well as the regression with the Total score as dependent variable, null hypothesis was could be rejected at a 5% level for the Final and a 1% level for the Total score. Thus when using either the Final exam score or the Total score as the student performance measure, students who used the TAPPS process performed significantly better than students who just worked together (Group).

DISCUSSION

An untested premise of this paper is that successfully working with a computer, even using productivity applications found in Microsoft's Office, involves problem solving. Thus developing proficiency in such applications will involve some degree of proficiency in problem solving. Based on this premise, an instructional approach was adopted which combined a process developed to improve students' problem solving ability along with traditional software instruction.

This paper reported empirical results from this instructional approach. Student were classified into TAPPS, Group, and Individual categories depending upon the instructor's subjective assessment of whether the student was following the TAPPS process protocol, was simply working with another student, or was effectively working alone. While a subjective judgment, the instructor had recorded multiple observations of student behavior. These records were the basis upon which the classification judgment was made. Clearly, the results reported here are highly dependent upon the accuracy of the instructor's classification.

Another untested assumption is that student performance on midterm exams, the final exam, and the student's total score are valid measures of proficiency with the software products. Given that these measures are valid indicators of student performance, the results presented above indicate that students who followed the TAPPS process performed better than other students. The score differences observed were statistically significant.

Student performance depends on many factors from ability and motivation to other commitments and events in the student's personal life. Scores on homework assignments were introduced to the analysis to attempt to control for and account for these other influences. The regression results continued to show a pattern suggesting that those students who followed the TAPPS process performed better than the other two groups of students. For the Total score, the coefficient of the TAPPS indicator variable was sufficiently larger than the coefficient on the Group category to reject a null hypothesis that the coefficients were equal.

REFERENCES

1. Bloom, B.S., & Broder, L.J. (1950). *Problem-solving Processes of College Students: An Exploratory Investigation*. Chicago: The University of Chicago Press.
2. Jeon, K, Huffman, D, & Noh, T. (2005). The Effects of Thinking aloud Pair Problem Solving on High School Students' Chemistry Problem-Solving Performance and Verbal Interactions. *Journal of Chemical Education*, 82(10): 1558-1564.
3. Johnson, S.D. & Chung S.P. (1999). *Journal of Industrial Teacher Education,* 37(1): 87-101.
4. Kim, H.S. (2002). We Talk, Therefore we Think? A Cultural Analysis of Effects of Talking on Problem Solving. *Journal of Personality and Social Psychology,* 83(4): 828-842.
5. Lockhead, J. & Whimbey, A. (1987). Teaching Analytical Reasoning Through Thinking Aloud Pair Problem Solving. *New Directions for Teaching and Learning*, (30): 73-92.
6. Pate, M.L., Wardlow, G.W., & Johnson, D.M. (2004). Effects of Thinking Aloud Pair Problem

Solving on the Troubleshooting Performance of Undergraduate Agriculture Students in a Power Technology Course. *Journal of Agricultural Education*, 45(4): 208-218.

7. Pestel, B.C. (1993). Teaching Problem Solving Without Modeling Through "Thinking Aloud Pair Problem Solving." *Science Education*, 77(1): 83-94.
8. Webb, N.M., Ender, P, & Lewis, S. (1986). Problem-Solving Strategies and Group Processes in Small Groups Learning Computer Programming. *American Educational Research Journal*, 23(2): 243-261.
9. Whimbley, A. & Lochhead, J. (1986). *Problem Solving and Comprehension*. Hillsbrough, N.J. Lawrence Erlbaum Associates.
10. Woodworth, R.S. (1938). *Experimental Psychology*. New York: Holt & Co.
11. Zimmer, B.J., & Risemberg, R. (1997). Self-Regulatory Dimensions of Academic Learning and Motivation. In G. D. Phye (Ed.), Handbook of Academic Learning: Construction of Knowledge. San Diego, CA: Academic Press.