Association for Information Systems
AIS Electronic Library (AISeL)

AMCIS 1998 Proceedings

Americas Conference on Information Systems (AMCIS)

December 1998

Cognitive Logical Reasoning Skill and the Relationship to Spreadsheet Data Quality

S. Kruck
James Madison University

Cognitive Logical Reasoning Skill and the Relationship to Spreadsheet Data Quality

S. E. Kruck
James Madison University

Introduction

Electronic spreadsheets have made a major contribution to financial analysis and problem solving. Spreadsheets were the first software packages produced for serious business use, and their introduction marked a new era of end-user orientation of computers (Chan 1987). Spreadsheets are used extensively today in accounting and business applications. Although many decisions are based on the analysis of a spreadsheet model, it has been documented that there are often data quality problems, i.e. underlying formulas and resulting numbers are frequently wrong. A growing body of evidence indicates that these errors in spreadsheets are a pervasive problem.

In a previous study, Kruck and Maher (1998) demonstrated that a persons' logical reasoning scores, as determined by the Diagramming Relationships test, were significantly improved after spreadsheet training. The current study looks to see if there is a relationship between the *number of spreadsheet errors* and scores on the Diagramming Relationships test. We, as researchers, need to determine why spreadsheet models have data quality problems and develop techniques to increase the data quality in spreadsheets. Improving the cognitive skills related to spreadsheet design may be one such starting point.

Cognitive Skills Increase

Cognitive skills refer to individual differences in how we acquire, store, retrieve, and use knowledge. Cognitive skills affect the ability of the individual user's ability to plan and execute specific tasks. Cognitive skills are essential for everyday life and also help determine how well individuals are able to manipulate spreadsheet packages and create error free templates.

Different cognitive skills are necessary to complete different tasks. Card (1983) and Olson and Nilsen (1987) developed a listing of the required mental processes and memory capacities involved in specific tasks based on "reasoned arguments." Spreadsheet tasks require a high degree of problem solving and planning ability. These attributes are generally considered to be part of the logical reasoning skill.

Many studies have demonstrated that various cognitive skills increase during training. For example, Galotti et al (1986) found that training in syllogistic reasoning increased general reasoning ability for both good and poor reasoners. Syllogistic reasoning is the ability to take a given major premise and a minor premise, then determine if the conclusion is correct. Two studies, Kleigl et al (1989) and Batles and Kliegl (1992) trained subjects to increase their memory to retrieve lists in serial order. These two studies found that participants were able to approximately double their mnemonic skill. Four different experiments were conducted by Wenger and Carlson (1996) using arithmetic tasks, in conjunction with sequencing of steps. The researchers found that these tasks did increase the efficiency in using working memory.

More recently Kruck and Maher (1998) used spreadsheet training to determine if logical reasoning skills improved. An instrument developed by Educational Testing Services (ETS) was administered to both a treatment and control sample to measure cognitive logical reason skill. Logical reasoning can be measured by the Diagramming Relationships test developed by ETS. The specific factor measured is "the ability to reason from premise to conclusion, or to evaluate the correctness of a conclusion" (ETS 1976). The Diagramming Relationships test requires the participant to retrieve meanings from long-term memory and then perform serial operations on the retrieved materials. These same skills are also important for spreadsheet tasks (Card 1983; Olson and Nilsen 1987). The reading ability required to complete the test is minimized because of the pictorial representations of the relationships. This helps to ensure that logical reasoning will not be confounded with verbal reasoning.

The treatment group in Kruck and Maher (1998) was administered training over a six-week period in the proper method of developing accurate and effective spreadsheet models, while the control group did not receive this training. At the end of the six weeks, an equivalent instrument was given to each group to determine their current level of logical reasoning skill. Although the baseline reasoning scores of the two groups were not significantly different before the spreadsheet training process, they were significantly different after the six-week process was completed. The logical reasoning scores of the treatment group significantly improved after the training period, while the scores of the control group did not ($p < .004$ one-tail). However, what has not been empirically studied is the relationship between *spreadsheet errors* and logical reasoning skills. The next section demonstrates the importance of spreadsheet and the need for improvement in spreadsheet quality.

Spreadsheets

Importance

Various professional organizations and commissions have recommended the inclusion of computers in higher education. The American Accounting Association has recommended the use of computers in the educational curriculum process for the past 40 years (1959; 1964; 1970; 1986). Similarly, the Accounting Education Change Commission (AECC) has more recently reiterated the importance of incorporating computers into the educational process. Furthermore, the AECC recognizes the need for understanding design and implementation issues. The objectives of the AECC include having students understand how information is identified, measured, communicated, and used. More specifically, skills necessary for a successful accounting career include the ability to use data to "solve real-world problems" (AECC 1990). One way that data is being manipulated to solve these problems is through spreadsheets. The following two studies demonstrate that electronic spreadsheets have become one of the most frequently used software applications if not the top software application for the personal computer.

Heagy and Gallum (1994) questioned accountants in large and mid-sized firms regarding computer literacy desired of new employees. Two hundred twenty-nine accountants in public practice and 144 accountants from industry were included in the results. The accountants chose spreadsheets over five broad categories of computer knowledge. The other categories were database management systems, telecommunications, accounting systems, and systems development.

The most recent survey was directed at companies that recently entered the Fortune 500 list of corporations (Zhao 1997). The researcher believed that these successful corporations would be considered leaders in using information technology. Zhao wanted to obtain data about end-user skills that business professionals need now, and to determine what skills were expected to be necessary in the year 2000. The study asked about specific hardware skills such as the keyboard, mouse, printer, scanner, and modem. The study also asked about specific software packages, by name, in five software skill areas: operating systems, word processing, spreadsheets, databases, and desktop publishing. All of the 35 skills included in the survey decreased in importance for the year 2000 except for spreadsheet skills, UNIX operating system knowledge, and the ability to use a scanner. Spreadsheet skills were considered the most important application software to understand and apply both now and in the year 2000. These results indicate that spreadsheets are likely to remain among the top software skills needed for business professionals well into the foreseeable future.

Data Quality

Much evidence documents the existence of data quality problems in spreadsheets. This evidence has been gathered from students in academia as well as working professionals in business settings. Each of the studies in the table below demonstrates an unacceptably high error rates in spreadsheets for professionals as well as students and in real-world applications as well as experimental studies.

This brief literature review demonstrates that spreadsheet data quality is a problem and that cognitive skills can be increased with training. The missing link here is a relationship between the two. If it can be demonstrated that spreadsheet errors decrease with a increase in the cognitive logical reasoning skill as demonstrated by the Diagramming Relationship test, a training plan could be developed
to increase the logical reasoning skill in a fast and more efficient method, with a correlated decrease in the number of spreadsheet errors.

Author(s)	Year	Participants	% of Spreadsheets w/Errors	
Brown & Gould	1987	IBM employees	44%	
Davis & Ikin	1987	Live/real company spreadsheets		
		-major errors	21%	
		-inadequate and extremely error prone	53%	
Cragg & King	1993	Live/real company spreadsheets	25%	
Panko & Sprague Jr.	1997	Undergraduate students	37%	10908
		Inexperienced MBA students	35%	
		Experienced MBA students	24%	

Methodology

Participants will complete an experiment that will require them to create a spreadsheet model from a word problem and complete the Diagramming Relationships test. In addition, participants will complete a posttest questionnaire that will elicit demographic data, spreadsheet experience, and responses to several manipulation checks.

Conclusion

This study will allow a conclusion to be drawn between the data quality of spreadsheets and the cognitive logical reasoning skill as determined by the Diagramming Relationships test. If in fact this relationship does exist and those individuals that have better logical reasoning skills do create a better quality spreadsheet then a more effective and efficient training methods can be developed to increase the data quality in our spreadsheets.

References

References available upon request.