Research on Computing in Accounting Education: Opportunities and Impediments

A. Faye Borthick and Ronald L. Clark

ABSTRACT

The authors call for research on the effects of computing in accounting education while differences between computer use and non-use might still be detectable. Without research, accounting educators will not know the extent of learning effects associated with computer use or whether they are integrating computing into curricula in ways that maximize learning. This article surveys learning theories and concepts relevant to research on computing in accounting education and discusses five categories of attributes for measurement: performance, attitude, relevance to accounting practice, resource use, and time spent. Impediments to research are presented along with approaches for mitigating them.

COMPUTER use in accounting education began in the late 1960s, initially on mainframe computers and later on minicomputers. In the last few years, microcomputers, or personal computers (PCs), have become the machine of choice in accounting education. As each computing genre became available, proponents hoped its use would revolutionize accounting education by (1) improving student learning, or (2) reducing instruction time or cost. For documented cases of computer use in accounting education, progress toward achieving these goals has been mixed. Improvements in learning, if any, have been modest, and computer use in accounting education has often

\[\text{1 Computer use in accounting education has been recommended by reports of the American Accounting Association.}\]

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\[\text{Research support was provided by a University of Tennessee College of Business Administration Faculty Research Grant. The authors are indebted to Aline C. Girard and an anonymous reviewer for helpful comments.}\]
been time-consuming and costly. From the meager amount of research on computing in accounting education, the only definitive conclusion is that different methods of computer integration have different learning values for different topics [Clark and Borthick, 1986].

In spite of ambiguous results thus far, computer use in accounting education is growing. The urgency of computer integration is increasing as organizations increase their use of computing, especially for accounting and auditing functions. The growth of (1) continuous, on-line access to corporate financial information by internal and external users [Burton and Davidson, 1983], (2) the capability of structuring information by need rather than by what is available [Borthick, 1986], and (3) electronic trans-organizational data flows [Richardson, 1983] is increasing the need for information technologies to be included in the educational mainstream.

As computing permeates organizations, the success of accounting graduates at all levels will increasingly depend on their ability to use computing to accomplish organizational objectives. The pervasiveness of computing in accounting practice means that entry-level accountants must either possess computing skills or learn them on the job. Graduates with minimal computing skills are disadvantaged relative to those with the skills because they must learn their accounting jobs and computer use simultaneously.

The dual goals of (1) enhancing accounting education to improve learning, and (2) preparing students for work in computing-intensive environments point to increased computer use in accounting education. Indeed, integrating computing into accounting curricula makes intuitive sense. Given dual goals for computer integration, it is appropriate to have different approaches to implementation.6

THE NEED FOR RESEARCH

Given the momentum of computer integration efforts, it behooves accounting educators to investigate the effects of computer use in accounting education. Differential effects could arise (1) in comparisons of alternative integration strategies, or different ways and methods of using computing, and (2) in comparisons of computer use with no computer use. The question is not whether computing will eventually pervade accounting education, but whether it will occur in ways that maximize its contribution to student learning. Without research, educators will


2 For discussions of the state of computer integration into accounting education and references to original work, see Armitage and Boritz [1986] and Helmi [1986].

3 See Thomas [1983a] and Hart et al. [1984] for surveys of computer use in accounting education.

4 See Doherty and Pope [1986] for a discussion and history of computers as tools to augment their users' abilities.

5 For surveys and discussion of computer-related skills practitioners and academicians desire in accountants, see American Accounting Association [1973; 1986]; Baldwin and Kneer [1986]; Ijiri and Kriebel [1985]; Sloan [1983]; and Summers [1985].

6 For discussions of different approaches to computer integration, see Asman et al. [1985]; Clark et al. [1985]; and Helmi [1986]. As these authors observe, it is important to choose implementation tools and strategies that match learning objectives.
not know the extent of learning effects or whether they are integrating computing into curricula in ways that maximize learning.

LEARNING THEORIES APPLICABLE TO COMPUTER USE

There are several reasons why computer use ought to improve accounting education, the most obvious one being the transfer of the computational burden to the machine so students can concentrate on accounting rather than on tedious calculation. Several authors [Ijiri, 1983; Thomas, 1983b; Wu, 1984] claim that microcomputer use helps students think analytically and algorithmically, good preparation for accounting careers in which analyzing data is more important than performing mechanical procedures. The claim that computer use promotes analytic and algorithmic thinking stems from the premise that one has to think that way to create computer instructions, e.g., with a programming language or a spreadsheet program, to solve problems involving mathematical relationships among variables. The claim does not necessarily apply in situations in which one merely uses computer programs or spreadsheet templates created by others.

Transferring the computational burden and thinking analytically and algorithmically are general prescriptions which will require research to test their usefulness in improving student learning. Some specific learning theories and concepts relevant to accounting education are (1) productive thinking, (2) creative thinking, (3) attention directing, (4) learning strategies, (5) non-cognitive aspects, and (6) beliefs. Table 1 summarizes these theories and concepts and cites the major authors.

Productive Thinking

*Productive thinking* [Wertheimer, 1945, 1959] is insightful learning based on understanding rather than on rote memorization of facts and rules. In Wertheimer's experiments, learning based on insight was more generalizable and longer lasting than learning based on memorization. The learner first becomes familiar with general principles and then thinks about particular problems to formulate their solutions. Starting with general principles permits the learner to see how specific applications relate to the general case. From this point of view, one learns best by discovering the essential nature of the problem before focusing on specific details or situations [Duncker, 1945].

In the Gestalt tradition, Duncker [1945] and Wertheimer [1945, 1959] believed that problem solving was a function of the subconscious and hence was neither observable nor subject to manipulation. As a result, the authors had no suggestions for teaching beyond the exhortation to proceed in a manner sure to lead to discovery of the underlying nature of problems.

The need to teach many complex computational procedures in accounting hinders instructors' abilities to help students grasp underlying principles. With computer use for what would otherwise be time-consuming computations, it might be possible for instructors to spend more time helping students grasp organizing principles.
TABLE 1
Learning Theories and Concepts Relevant To Computer Use

<table>
<thead>
<tr>
<th>Theory</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productive thinking</strong></td>
<td>Wertheimer [1945, 1959]</td>
</tr>
<tr>
<td>Learning based on understanding</td>
<td>Duncker [1945]</td>
</tr>
<tr>
<td><strong>Creative thinking</strong></td>
<td>Dewey [1933]</td>
</tr>
<tr>
<td>Analyzing problems and generating, evaluating, and implementing ideas</td>
<td>Osborn [1963]</td>
</tr>
<tr>
<td></td>
<td>Parnes, Noller, and Biondi [1977]</td>
</tr>
<tr>
<td></td>
<td>Evans [1986]</td>
</tr>
<tr>
<td><strong>Attention directing</strong></td>
<td>Broadbent [1953]</td>
</tr>
<tr>
<td>Controlling response by directing attention</td>
<td>Guthrie [1959]</td>
</tr>
<tr>
<td><strong>Learning strategies</strong></td>
<td>Bourne, Dominowski, and Loftus [1979]</td>
</tr>
<tr>
<td>Modeling successful strategies</td>
<td>Nickerson, Perkins, and Smith [1985]</td>
</tr>
<tr>
<td>and teaching them</td>
<td>Rubinstein [1975, 1980]</td>
</tr>
<tr>
<td></td>
<td>Schoenfeld [1980, 1985]</td>
</tr>
<tr>
<td></td>
<td>Flavell [1976]</td>
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<tr>
<td></td>
<td>Rissland [1985]</td>
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<tr>
<td></td>
<td>Brown and Burton [1978]</td>
</tr>
<tr>
<td></td>
<td>Sleeman and Brown [1982]</td>
</tr>
<tr>
<td><strong>Non-cognitive aspects</strong></td>
<td>Cronbach [1975]</td>
</tr>
<tr>
<td>Recognizing affective aspects</td>
<td>Silver [1985]</td>
</tr>
<tr>
<td><strong>Beliefs</strong></td>
<td>Nisbett and Ross [1980]</td>
</tr>
<tr>
<td>Countering dysfunctional influence of misconceptions</td>
<td>Kahneman, Slovic, and Tversky [1982]</td>
</tr>
</tbody>
</table>

That is, with computer use, students could learn underlying principles and then apply them in specific situations, while developing problem-solving insights. Such an approach ought to be more beneficial than piecemeal presentation of a series of accounting procedures. The contribution of computing to promoting productive thinking is that it creates an environment in which productive thinking can occur because there is more time for it, namely, the time previously consumed in computation. Furthermore, with computer use, it is more feasible to investigate complicated relationships among variables.

In a test of productive thinking, Borthick and Clark [1986] found no performance difference between students preparing integrative and non-integrative assignments in a managerial/cost accounting course, but the integrative assignment students reported they experienced greater learning.

**Creative Thinking**

*Creative thinking,* a generalization of productive thinking, has been defined [Evans, 1986, p. 253] as:

the total thinking process involved in the production of an idea, concept,
creation, or discovery that is new, original, useful, or satisfying to the user or someone else at some point in time.

Evans' definition is consistent with Parnes, Noller, and Biondi's [1977, p. 14] definition of creativity:

the association of thoughts, facts, ideas, etc., into a new and relevant configuration, one that has meaning beyond the sum of the parts—that provides a synergistic effect.

According to Evans [1986, p. 253], creative thinking:

1. Results in new ideas and discoveries for solving meaningful problems;
2. Blends knowledge, imagination, and evaluation;
3. Occurs through the association of knowledge and experience in new ways; and
4. Results in outcomes such as products, processes, models, algorithms, or implementation strategies.

In order to learn how to think creatively, it is helpful to have a structured methodology for approaching problems. Dewey [1933] proposed one of the earliest normative problem-solving processes, consisting of defining the problem, identifying alternatives, and selecting the best alternative. VanGundy [1981] proposed a four-step process comprising:

1. Redefining and analyzing the problem;
2. Generating ideas;
3. Evaluating and selecting ideas; and
4. Implementing ideas.

The first three steps in VanGundy's process are similar to Dewey's approach, with the addition of implementation as an explicit step. Others (e.g., Ackoff [1956]; Churchman, Ackoff, and Arnoff [1957]; Morris [1967]; Saaty and Alexander [1981]) proposed approaches similar to VanGundy's.

Evans [1986, pp. 256-261] proposed a creative thinking paradigm based on the process defined by Parnes et al. [1977] and Osborn [1963]. The problem-solving process consists of:

1. Mess-finding: be sensitive to problems;
2. Fact-finding: observe carefully and discover facts;
3. Problem-finding: define problems;
4. Idea-finding: see new relations, use effective techniques for discovering new ideas, and refine strange ideas into useful ones;
5. Solution-finding: evaluate the probable consequences of actions; and
6. Acceptance-finding: plan for the implementation of ideas and allow for the influence of interpersonal relationships on problem solving.

Techniques that have been used to teach creative thinking include cases, projects, and field studies. The link between instruction and performance outcomes has, however, been difficult to determine.

Attention Directing

A learning theory that has a specific prescription for teaching is the theory of attention directing, which says that
attention is important in determining response [Broadbent, 1953]; that is, response is a function of what subjects notice as they respond. According to Guthrie [1959, p. 186], "what is being noticed becomes the signal for what is being done." Thus, controlling (or directing) attention is a way of influencing behavior, and educators could improve learning with strategic use of attention directing.

Attention directing could be a means of improving accounting education by highlighting important stimuli for students. In a test of attention directing, Borthick and Clark [1987] found that using a computer-implemented language analyzer to direct students' attention to syntactical and stylistic writing flaws improved overall writing quality. Computer-implemented attention directing could be used as a way of helping students focus on important stimuli.

**Learning Strategies**

Research in problem solving [Bourne, Dominowski, and Loftus, 1979] has identified two aspects of problem solving that complement earlier work on productive thinking. The aspects are (1) the procedures used to seek solutions once learners believed they understood a problem, and (2) how learners compared generated solutions to solution criteria and decided when solutions were good enough to stop working. Recently, educational researchers [Nickerson, Perkins, and Smith, 1985; Rubinstein, 1975, 1980; Schoenfeld, 1980, 1985] have shown increasing interest in problem-solving strategies and generally useful thinking skills. Nickerson [1986, p. 314] attributed the growth of the thinking-skills movement to the belief:

that nearly exclusive emphasis by an educational system on the acquisition of domain-specific knowledge produces people with an underdeveloped ability to think and to apply that knowledge effectively outside the classroom.

If one substitutes "accounting procedures" for "domain-specific knowledge," then the statement is consistent with educators' recent calls [Ijiri, 1983; Thomas, 1983b; Wu, 1984] for more analytical and algorithmic thinking in accounting education.

Controlling solution procedures and deciding when one is done solving a problem are examples of the metacognitive aspects of problem solving. According to Flavell [1976, p. 232],

"Metacognition" refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition . . . if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in a multiple choice type task before deciding which is the best one . . . .

Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective.

In short, metacognition is one's awareness of what one is doing to accomplish goals and how one is doing it.
Researchers have attempted to (1) describe solution strategies used by experts, and (2) teach the strategies to students. In many cases, solution strategies involve heuristics, or collections of procedures and related descriptive knowledge with prescriptions for how and when to apply them. Problem-solving strategies are also central to the field of artificial intelligence (AI), and its tools, such as knowledge representation, process description, and planning/control mechanisms, ought to be useful in problem solving in accounting. As Rissland [1985, pp. 174–175] explained,

AI concepts make it easier to describe what we know and intuit about learning and, if we want, to experiment and test out our ideas by implementing them as programs. This expressive power makes it possible to demystify and describe our knowledge: how it is structured, stored, acquired, and refined. . . . Applying this approach to . . . problem solving is especially relevant . . . because by better understanding and describing such knowledge, we will be better able to transfer it to our students and thereby help them improve.

In addition to testing problem-solving strategies, computers could be used to create environments (1) which gather data about problem-solving processes as they are occurring, and (2) in which students could have the opportunity to solve challenging problems [Silver, 1985, p. 263] on their own or with an intelligent tutor helping them when they encountered difficulty (see, e.g., Brown and Burton [1978]; Sleeman and Brown [1982]). In addition to intelligent tutors, expert systems [Hayes-Roth, Waterman, and Lenat, 1983; Waterman, 1986] could be used to help students solve complex problems.7

Non-Cognitive Aspects of Learning

Non-cognitive, or affective, aspects of learning comprise factors such as the learner’s motivation, interests, self-esteem, confidence, perceived level of control, sense of satisfaction, attitude toward learning, perseverance, and willingness to take risks. Some of these aspects have been investigated through the perspective of individual differences couched in the concept of aptitude-treatment interaction (ATI) [Cronbach, 1975]. Although these non-cognitive aspects seem to influence intellectual performance in problem solving, the research support is weak [Silver, 1985; Battista, 1978].

One aspect of attitude that may be a factor in students’ learning is their degree of computer anxiety, or fear or aversion to computer use [Minch and Ray, 1986]. Although resistance to computer use has been documented in business settings [Nickerson, 1981], the problem of computer anxiety in management may not be as extensive or severe as once believed [Rockart and Treacy, 1982; Howard and Smith, 1986]. Computer anxiety caused by lack of familiarity with computers should be surmountable with student use of computing in accounting education.

7. Booker and Kick [1986] developed an expert system for helping students learn the requirements of APB Opinion No. 21 on selection of interest rates in note exchanges.
Beliefs

Closely related to affective considerations is the concept of one's belief system. For example, D'Andrade [1981] demonstrated that cultural belief systems can influence memory, perception, and cognition. For problem solving in accounting, some relevant beliefs are the misconceptions associated with naive probabilistic reasoning, or the propensity to make erroneous probabilistic estimates of the likelihood of events. Summaries of psychological research on people's intuitive probability judgments are contained in Nisbett and Ross [1980] and Kahneman, Slovic, and Tversky [1982]. The research question in accounting education is how understanding of faulty reasoning can be used to improve problem-solving abilities through instruction.

Performance

The single most important dimension is student performance, that is, whether students perform better with or without the particular computer use. In independent tests of PLATO modules for introductory accounting, McKeown [1976] and Groomer [1981] found equivalent or better performance for students using interactive PLATO modules for working problems than for those working problems in the conventional way. McKeown used PLATO for original instruction, and Groomer, for tutorial assistance. Neither author proposed a theoretical basis for why an automated tutor ought to yield better results than human ones.

A weakness in Groomer [1981] was its lack of control for differences in the amount of time treatment and non-treatment students spent on course activities. Groomer [1981, p. 939] reported greater average times for students using the PLATO tutor than for students using human tutors. This differential might have been responsible for results attributed to the treatment.

In a study of achievement associated with use of pre-written computer programs to provide assistance with homework assignments in intermediate accounting, Friedman [1981] found that students using the programs performed better than students not using them. He did not, however, control for differences in time spent nor did he estimate its magnitude. He offered no theory to explain performance differences.

Fetters, McKenzie, and Callaghan [1986], in a study of menu-driven programs for lease and price-level accounting procedures, found initial positive
impact on achievement levels associated with computer use. The impact disappeared over time for good students but remained for weaker students. They attempted to design homework and computer cases to equalize the time treatment and non-treatment students would spend on course activities. They did not, however, report whether they achieved this objective. Thus, differential time spent may have influenced the results, especially if the weaker treatment students spent more time on average than non-treatment students. The authors did not suggest a theory justifying the computer use.

Dickens and Harper [1986], on the other hand, found no performance difference between two groups of students, each of which used one but not both of two menu-driven programs, one for earnings per share and one for interperiod tax allocation. In this experiment, giving both groups access to the treatment for pedagogical reasons effectively nullified the treatment effect; indeed, the results are consistent with this interpretation. Another weakness in the treatment itself was the restricted access to computer use, limiting most students “to a one hour exposure” [Dickens and Harper, 1986, p. 142]. In addition, there was no control for differential time spent, nor did the authors propose a theoretical basis for their computer use.

In a test of the theory of productive thinking in a managerial/cost accounting course, Borthick and Clark [1986] found no performance difference between students using integrative versus non-integrative spreadsheet assignments. A flaw in the research design was the occurrence of both control sections together in the first quarter of the experiment and both treatment sections together in the second quarter. Thus, history threatened internal validity in that over the experimental quarters (Fall 1983–Winter 1984), student awareness of the need for computing in accounting was growing rapidly. Nor was there any control for differential time spent on course activities.

In a test of the attention-directing ability of a language analyzer, Borthick and Clark [1987] found small but significant improvement in overall performance on written assignments in accounting systems by students using a microcomputer program for language analysis. Language analysis is the examination of writing for the purpose of identifying potentially improvable syntactic structures; it does not address matters of meaning or literary license. The simplistic capabilities of current language analyzers suggest that Summers’ prediction of “a program that looks for key words, concepts, and relationships—that grades the paper” [1983, p. 162] is unlikely in the next few years. The results were controlled for differential time spent on writing assignments.

As the preceding summary indicates, research results varied with respect to performance differences. In no case did computer-using students perform worse than students in conventional instruction although only two studies controlled for the effect of differential time spent by treatment and control students. These studies embraced several different types of computer use, namely, computer-assisted instruction [McKeown, 1976; Groom-
TABLE 2
Performance Results and Weaknesses

<table>
<thead>
<tr>
<th>Application/Author</th>
<th>Result: Use Compared to Non-Use</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLATO Modules for Introductory</strong></td>
<td>Equivalent or better</td>
<td>No theory</td>
</tr>
<tr>
<td>McKeown [1976]</td>
<td>Better</td>
<td>No theory</td>
</tr>
<tr>
<td>Groomer [1981]</td>
<td></td>
<td>Differential time</td>
</tr>
<tr>
<td><strong>Time-Sharing for Financial</strong></td>
<td>Better</td>
<td>No theory</td>
</tr>
<tr>
<td>Friedman [1981]</td>
<td></td>
<td>Differential time</td>
</tr>
<tr>
<td><strong>Menu-Driven Programs for Financial</strong></td>
<td>Initially better; remained better for weaker students</td>
<td>No theory</td>
</tr>
<tr>
<td>Fetters, McKenzie, and Callaghan [1986]</td>
<td></td>
<td>Differential time</td>
</tr>
<tr>
<td>Dickens and Harper [1986]</td>
<td>No difference</td>
<td>Confounded treatment</td>
</tr>
<tr>
<td><strong>Integrative Versus Non-Integrative</strong></td>
<td>No difference</td>
<td>History</td>
</tr>
<tr>
<td>Spreadsheets for Managerial</td>
<td></td>
<td>Differential time</td>
</tr>
<tr>
<td>Borthick and Clark [1986]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Language Analysis for Systems</strong></td>
<td>Better</td>
<td>Robustness of language analyzers</td>
</tr>
<tr>
<td>Borthick and Clark [1987]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

er, 1981], operation of time-sharing or menu-driven programs for accounting procedures [Friedman, 1981; Fetters, McKenzie, and Callaghan, 1986; Dickens and Harper, 1986], student development of spreadsheets [Borthick and Clark, 1986], and language analysis [Borthick and Clark, 1987]. These examples certainly do not exhaust the possibilities for types of computer use. In particular, they do not include an example of an expert system. Table 2 summarizes these research results.

A potential hazard in measuring performance differences is that learning with computer use may lead students to learn different things than they would without it. The authors cited above discussed how they ensured fair testing for all students; the general tactic was to compose representative tests for conventional instruction. Testing students with conventional exam questions, however, may not permit them to demonstrate learning associated with computer use, but testing with questions designed specifically to measure computer-induced learning may not measure conventional performance. As more innovative uses of computing appear, it may not be possible to rely on conventional kinds of test questions.

**Student Attitude**

Student attitude toward computer integration is important as a proxy for the perceived learning value of com-
puter use in accounting. Attitude reflects one's receptiveness toward and expectations for learning particular subject matter. Educators cannot assume that attitude toward computer use is constant. For example, Borthick and Clark [1986] found initial enthusiasm for computer use but less enthusiasm as students acquired computer experience.

Relevance to Accounting Practice

Computer use in an accounting curriculum helps students learn how to learn to use the computing tools they will encounter in practice. The identity of the crucial learning objective is to gain familiarity with the generic kinds of tools accountants use, such as spreadsheets, database managers, information and research services, tax preparation services, accounting systems, word processors, and electronic mail and conferencing systems. The experiential component of education in information technologies should be strengthened to improve future accountants' ability to make intelligent use of technology [Moore, 1983, p. 114]. Accountants need the managerial skills for deciding how technology ought to be applied, but acquiring these skills requires knowledge of technological capabilities and implementation constraints.

Determining the relevance of particular computing-related learning activities to accounting practice has traditionally been accomplished through surveys of (1) computer use in practice (e.g., Journal of Accountancy [1983]; Connors [1983]; Greenberg [1984]); and (2) practitioner assessments of desirable computing-related abilities of the accountants they hire (e.g., Baldwin and Kneer [1986]). More such surveys will be needed, although survey users must be aware that publication of survey results typically lags computer use.

Resources Used

The resources required for development and delivery of computer-augmented education affect the speed, pervasiveness, and comprehensiveness of computer integration. The more resources are required, the slower, the less pervasive, and the less comprehensive computer integration will be. Careful documentation of resource requirements will permit educators to plan and implement orderly and sustainable computer use.

Different kinds of computer use require different amounts of instructor preparation of computing-related materials. McKeown's [1976] PLATO modules consumed approximately 15,000 hours of development time for two semesters' topics. At the other extreme, little instructor development is needed when students prepare their own spreadsheet models to solve homework problems from conventional textbooks. To the extent that commercial software can be used or adapted for teaching, development time can be reduced. For example, Borthick and Clark [1987] used a commercial language analysis program.

Time Required

In environments such as accounting in which there is more to be learned than it is possible to learn, the time required for learning is a limiting fac-
tor. If it had the potential to reduce learning time for a given comprehension level, computer use would be desirable for efficiency considerations alone. The possibility for time reductions was raised by McKeown [1976, p. 128] who found that “students can be brought to at least as good a performance level with less class time and significantly less total student time spent on the course using PLATO as compared to conventional teaching.” Groomer [1981], on the other hand, reported that computer users spent more time than non-users.

Some accounting educators fear, however, that computer use may induce students to spend time on computing to the detriment of time spent on accounting. Fetters, McKenzie, and Callaghan [1986], however, found no basis for the claim that computer use hindered students’ ability to learn accounting in their study of lease and price-level accounting.

Regardless of time demands for computer use, accounting educators need to help students develop realistic expectations for the time required to achieve learning objectives. Realistic expectations are especially needed for computing-related activities since they can be time intensive. If they underestimate the time required for computing-related activities, students may become needlessly frustrated with learning which involves computing.

RESEARCH IMPEDIMENTS: WHAT TO CONTROL OR AVOID

Research on computing in accounting education is an example of educational research, subject to the hazards explained by Campbell and Stanley [1963]. Educational research is typically characterized by incomplete control of the design, less than optimal conditions for measurement, and inconclusive results. Depending on their nature, these characteristics threaten the internal and external validity of the research. Earlier discussion in this paper pointed out threats to the validity of existing research on computing in accounting education. In educational research, crucial experiments with clear-cut results are rare; more common are series of replicated, cross-validated experiments which constitute cumulative progress.

Research on computing in accounting education is consistent with the educational research tradition, and this section explains the particular threats to validity and approaches for mitigating them. Many of the factors identified here appear in Campbell and Stanley’s list of threats to internal and external validity [1963, pp. 5–6]. These factors, summarized in Table 3, are explained below.

Theoretical Base

A crucial aspect of conducting research on computing in accounting education is selecting or creating a theoretical underpinning for motivating research questions. Without theory, empirical research exists in a vacuum, unconnected to other research and lacking an explanation of its meaning. Some theories which could be applied to research on computing in accounting education were discussed earlier.

Hawthorne Effect

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TABLE 3  
Threats to Validity and Mitigating Controls

<table>
<thead>
<tr>
<th>Threat</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hawthorne effect</td>
<td>Adjust for number of hours worked</td>
</tr>
<tr>
<td>2. Self-selection</td>
<td>Assign students randomly to sections</td>
</tr>
<tr>
<td></td>
<td>Restrict entry and exit from classes</td>
</tr>
<tr>
<td></td>
<td>Adjust for number of hours worked</td>
</tr>
<tr>
<td>3. Experimental mortality</td>
<td>Keep experiment secret</td>
</tr>
<tr>
<td>4. Keyboard skill variation</td>
<td>Assign students randomly to sections</td>
</tr>
<tr>
<td></td>
<td>Restrict entry and exit from classes</td>
</tr>
<tr>
<td>5. Measurement error</td>
<td>Plan evaluation procedures</td>
</tr>
<tr>
<td></td>
<td>Use multiple graders</td>
</tr>
<tr>
<td></td>
<td>Use multiple attitude questions</td>
</tr>
<tr>
<td>6. Testing interaction</td>
<td>Omit/include pre-test selectively</td>
</tr>
<tr>
<td>7. Interference-selection interaction</td>
<td>Adjust for entering computer proficiency</td>
</tr>
<tr>
<td></td>
<td>Adjust for prior computer experience</td>
</tr>
<tr>
<td></td>
<td>Coordinate and sequence computer use</td>
</tr>
<tr>
<td>8. History: increasing computing competence</td>
<td>Experiment while differences still detectable</td>
</tr>
<tr>
<td>9. Unequal cell sizes</td>
<td>Adjust for unbalanced designs</td>
</tr>
</tbody>
</table>

computing in accounting education mean researchers must be aware of possible student reactions due solely to the use of computing. Reacting to the experiment itself is known as the Hawthorne effect [Mayo, 1933]. Reactive effects are especially likely in experiments comparing computer use with no computer use. Indeed, Groomer [1981] and Friedman [1981] cited it as a possible confounding factor in their studies comparing computer use with computer non-use. The Hawthorne effect may be manifest in computer-using students spending more time on assignments than non-users.

An indication that students might exhibit reactive effects to computer use occurred in one experiment in which students were more enthused about computing before use than afterward [Borthick and Clark, 1986]. Reactive effects might be especially likely if extra attention from instructors accompanies computer use or students work extra hours to complete computer-related assignments. A control for some reactive effects is to adjust results for the number of hours instructors and students spend on experimental tasks.

Self-Selection

The newness and fanfare about computing also mean that highly motivated students may volunteer to undertake computer projects and work-averse students may avoid them. For example, two control group students in Borthick and Clark [1987] claimed to have used the language analyzer, thus contaminating the control group. In Bettors, McKenzie, and Callaghan [1986], 11 non-using students studied
with computer-using students. In neither case did removing these students from the analysis change the results appreciably. Self-selection means that outcomes may be more attributable to the subjects themselves than to experimental treatments, especially in comparisons of performance with and without computer use. In addition, results for one type of student may not be generalizable to all students.

Controls for self-selection are random assignment of students to experimental sections and restricted access to computer facilities. When registration procedures do not permit random assignment, the next best practice is to prohibit student entry and exit to courses based on desire to undertake or avoid computer use. In practice, this means keeping experimental arrangements secret until after establishing course enrollments, especially for multi-term experiments once the incidence of computer use has become known. In unrestricted computer labs and where students provide their own computers, access restrictions are unlikely to be binding, especially if students are authorized for other computer-related activities. To control for self-selection to extend computer-use time, researchers can adjust results for the number of hours worked.

Experimental Mortality

A factor related to self-selection is experimental mortality, or differential withdrawal of students from treatments once they have begun computer-related activities. One control for mortality is to keep experimental arrangements secret until after establishing course enrollments. Mortality is less likely in required courses taken in prescribed sequences. Researchers typically report mortality and compare it to that of prior non-experimental courses.

Keyboard Skill Variation

Some students display an aversion to typing, or using keyboards, and hence are reluctant to use computers even though some computing activities related to competence in accounting subjects. A control for variation in keyboard skill is random assignment of students to experimental sections as explained above.

Measurement Error

Measurement errors may occur when measurements are (1) too coarse to detect small differences, or (2) not comparable across computer using and non-using treatments. When performance is integral to computer use, there may be no comparable non-computer performance measure for comparison.

Controlling measurement error requires carefully planned performance evaluation procedures. For subjective aspects such as performance on essays or reports, there should be multiple graders with a determination of intergrader reliability. For subjective aspects such as attitude, there should be multiple survey questions for the same factor with multivariate analysis to compose the factors.

Testing Interaction

Related to measurement error is the effect of testing interaction with experimental variables. For example, pre-test
questionnaires for attitudes toward computing may sensitize students to experimental variables and affect subsequent response to post-test questionnaires. A control for testing interaction is to use designs including a pre-test for some students and omitting it for others, e.g., the Solomon four-group design [Campbell and Stanley, 1963, pp. 24–25].

Instructor Variability

The newness of computing implies significant variability in instruction due to differential instructor competence with computing. To date, research in computing in accounting education has typically been conducted by instructors well versed in the chosen computing methods and eager to direct student use of them. Experimenting instructors' predilection for computing may be a source of bias since students readily become aware of instructor preferences.

Even though it reduces instructor variability, having the same instructor across all experimental sections reduces generalizability to other instructors. Having enough experimental sections to cross treatments and instructors controls for instructor variability, and improves the generalizability of the results.

Interference-Selection Interaction

As computer use increases, so does the likelihood of (1) treatments involving computer use interfering with each other (multiple treatment interference), and (2) prior computer experience of students confounding results (interaction of selection bias and the experimental variable). As computer use grows, but until it reaches a steady state in secondary school and collegiate curricula, there will be a significant variability in students' computing backgrounds. Variability may be quite pronounced in class sections containing students with and without recent computing experience.

A control for multiple treatment interference is to adjust results for (1) entering computer proficiency, measured, for example, by a diagnostic test, and (2) the amount and kind of prior computing experience. This control does not, however, address the hazard of simultaneous treatment effects. In this case, steps such as coordinating computer use with colleagues and organizing the curriculum to sequence computer use are required.

History: Increasing Computing Competence

The previous paragraphs noted the wide variation in students' computing backgrounds. A related phenomenon, now becoming a matter of history, is the increasing level of computing competence in accounting students, consistent with the general level of computer assimilation in society. As computer use and competence increase, it may be more difficult to detect performance differences in experiments involving computer use and to deny computer use to some students in order to conduct research. For example, Dickens and Harper acknowledged the need "to ensure that all participating students were provided with exposure to the microcomputer" [1986, p. 141]. Thus, there was no control group of
students who did not use either program, nor was there a group using both programs. Experiments like this one illustrate the need to conduct research now (before computer use becomes even more pervasive), when differences due to computer use versus non-use might be more apparent.

Data Analysis: Unbalanced Designs

Even if random assignment of students to experimental sections were possible, experimental mortality has the potential to unbalance designs. Limited access to computing facilities may restrict the size of treatment groups, e.g., Groomer [1981], or curtail the number of hours for computer use, e.g., Dickens and Harper [1986]. In addition, student enrollment across academic terms may vary by a factor of two or more. A control for unbalanced designs is to use analysis methods which adjust for unequal cell sizes.

CALL FOR RESEARCH

The authors’ thesis is that research on the effects of computing in accounting education should be conducted now, while it might still be possible to detect differences between use and non-use. Without research, educators will never know the extent of learning effects or whether they are integrating computing into curricula in ways that maximize learning. This research is, of course, subject to the hazards of educational research in general and to the vagaries of computing environments in particular.

REFERENCES


