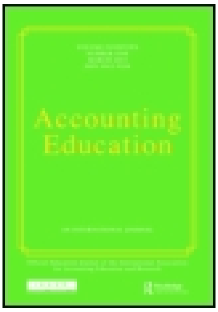

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Impact of Formulas, Language and Instruction on Student Performance on Cost-Volume-Profit Problems

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ABSTRACT *This study investigated how three factors impacted performance on cost-volume-profit homework problems: language, formula use, and instruction. Students enrolled in Introduction to Financial Accounting (the first principles of accounting course) and Managerial Accounting (the second principles of accounting course) from eight different US colleges completed homework problems presented in everyday language or accounting language, with or without a formula 'cheat sheet' on the screen, and with or without prior instruction. Scores on formula-facilitated questions (those solvable by use of traditional cost-volume-profit formulas) were contrasted with scores on application questions, novel word problems requiring students to apply their knowledge about how cost behavior and sales impact profits. Students performed better on assignments phrased in everyday language. Students with formulas provided during homework completed more formula-facilitated questions correctly but some evidence indicated that they did worse on application questions; more work is needed in this area. Instruction effects were very small. Participants without instruction performed just as well as instructed students when problems were presented in everyday language* or *if formulas were provided.*

KEY WORDS: Cognitive load theory, approaches to learning, procedural knowledge, formulas, technical language, performance aids

Introduction

Our teaching and professional experiences suggest that many students have difficulty answering cost-volume-profit (CVP) problems correctly, even when working at the most basic level, the one-product linear assumption. We have noticed that our managerial colleagues are also puzzled because, on the surface, basic CVP topics do not appear difficult. We have been surprised by how many of our colleagues explain the poor performance

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as students not knowing how to use the CVP formulas. That is not our experience and this study began as a way to rule this out as an explanation for student difficulty.

As we considered more potential explanations for failing to learn the CVP principles, we developed an interest in how formulas, rather than being a source of difficulty, may instead make the topic deceptively easy. That is, formulas may give students the impression that CVP is primarily an exercise in formula use and there is little concentration or mental effort needed to master the topic. Further, we wondered if the array of new terms that accompany CVP analysis might impede or interfere with learning the relationships between cost behaviors and profits. We are not aware of any line of research into these pedagogical issues and so this work is an exploratory study of variables that impact CVP learning outcomes.

Part of acquiring accounting expertise includes mastering how cost behavior impacts profits and applying that knowledge to new problems. As a routine, instructors and textbooks in managerial accounting use technical accounting terms and present CVP formulas in their instruction of these concepts and linkages. The practice of starting novices with technical terms ('accounting language') and accounting formulas, however, may not be optimal for learning and may actually hurt deeper understanding. The initial effort to learn technical terms may divert mental resources needed for comprehending the concepts. Even worse, providing formulas early in the learning sequence may inadvertently encourage students to use the formulas as performance aids, 'plugging-and-chugging' their way through the material, suppressing motivation for understanding. If either of these potential learning threats impacts students, technical jargon and/or formula use may need to be downplayed or delayed in order to encourage student comprehension.

Participants in this study worked typical back-of-the-chapter CVP homework problems and then were asked to apply the CVP concepts used in the homework to new problems. In order to find out if accounting language and formulas aided or hurt performance, we assigned participants to one of four possible conditions by crossing 'formulas' or 'no formulas' with 'accounting language' or 'everyday language'. We also used students that had no prior instruction in CVP topics (least prepared) and those preparing for their CVP course exam (most prepared). Overall, the study reveals that using everyday language and instruction help performance, although the effect size of instruction is so small as to be worrisome. Having formulas handy during homework completion helps with formula-facilitated questions but not on questions that require applying CVP knowledge.

Hypothesis Development

Impact of Formulas on Learning

Formulas may help learning. Acquiring the rules and recognizing basic facts is the work of the novice and the first stage in acquiring expertise (Dreyfus and Dreyfus, 2005). In accounting, strong procedural knowledge (knowing the steps needed to perform tasks) rather than declarative knowledge (just knowing more concepts) is critical in gaining expertise (Herz and Schultz, 1999). Accounting equations may help students by providing a process roadmap and documenting the rules they need to learn. That is, formulas serve as a memory aid (mnemonic) of the process and relationship among concepts (rules), and increase the odds that procedures are done correctly (Clark, Nguyen and Sweller, 2006). For math-related tasks, procedural skill and conceptual understanding generally build together (Siegler, 2003; Star, 2005) and interleaving concepts with computational procedures or formulas affords the best overall understanding (Rittle-Johnson and Koedinger, 2009). In science, students encouraged to use math exhibited greater qualitative understanding, indicating that in some cases mathematics can propel understanding (Schwartz, Martin and Pfaffman, 2005). For instance, learning how variable costs differ from fixed costs (declarative knowledge of the concepts) should assist in understanding the process for finding the break-even point. Since CVP formulas document rules and procedures, they should assist in developing competence on CVP topics. Rather than being helpful across the board, formulas may improve performance only in certain circumstances. In algebra, for instance, formulas helped with complex problems (Koedinger and Roll, 2012; Koedinger, Alibali and Nathan, 2008) but not with simpler ones (Koedinger and Nathan, 2004).

Formulas may hurt learning. Students typically adopt either a 'surface approach' to learning, where the student's goal is to remember, or a 'deep approach', where students exert effort to understand and connect the learning to prior knowledge (Biggs, 1987; Entwistle and Ramsden, 1982). One study with upper-level accounting majors found that 47% had a propensity to memorize, that is remember the formula and how to use it without questioning or attempting to 'digest' what is being taught (Sharma, 1997). Another work suggested that courses in commerce were more associated with a 'reproducing' approach to learning (Lizzio, Wilson and Simons, 2002). Survey data of accounting students found that they generally agreed that they 'concentrate on memorizing a good deal' (Sharma, 1997).

When performance aids, such as formulas, are readily available, they can be counterproductive to deep learning (learning for understanding) because performance is possible without learning (Clark, Nguyen and Sweller, 2006). That is, learning is compromised because formulas can effectively be used without reflection. The importance of deep learning over surface-level learning (rote learning) has been recognized in accounting (Beattie, Collins and Bill, 1997; English, Luckett and Mladenovici, 2004; Joshi and Babacan, 2009). When assignments are dominated by questions answerable by remembering or referring to formulas, typical in accounting courses, the learning context is ripe for surface approaches to learning (Joshi and Babacan, 2009; Lizzio, Wilson and Simons, 2002; Sharma, 1997). Clearly, if students merely memorize the formula for break-even, they may compute break-even competently, but that procedural knowledge may only be useful in the future when problem facts map directly to the formula. Without assessments insisting on higher-level outcomes, accounting students can falsely believe that knowing how to use the formula is enough.

The decision aid literature refers to chronic 'de-skilling' because easily available tools make it possible to perform without expertise (Arnold and Sutton, 1998). To build a knowledge structure required for expertise, students need to acquire the concepts and then the linkages between the concepts (Boldt, 2001). Having a formula handy permits students to perform mindlessly because rule-guided imitation is enough (Dreyfus and Dreyfus, 2005). Could formulas permit accounting students to fall prey to the tendency to use what is easy and available, and therefore never learn the concepts or the linkages between them, derailing the path to expertise? Could formulas give students a false sense of security, an illusion of competence (Koriat and Bjork, 2005), and cause them to stop working short of full comprehension?

This study examines whether providing formulas as a routine early in the learning sequence, or assessing with a predominance of formula-facilitated questions, may lead to 'plug-and-chug' use as a performance aid, without the need for, and the development of, deep comprehension. In other words, formulas may promote surface approaches to learning and therefore impair the building of accounting expertise. Given that formulas may help performance by providing a process map, but hurt the ability to apply concepts by permitting performance through rote memorizing of undigested formulas, we therefore hypothesize that, while formulas should help with formula-facilitated problems, they are not expected to impact application questions where formulas cannot assist.

> H1a: Students given formulas when completing the assignment will perform better on formula-facilitated questions than students not given formulas to use when completing the assignment.

> H1b: Formula condition will not impact performance on application questions probing knowledge of how cost behavior and sales levels impact profit.

Technical Terms May Slow Learning

The learning process taxes limited working memory (Anderson, Reder and Lebiere, 1996). Cognitive load theory argues that difficult concepts may overtax learners' mental resources, especially for novices who have not yet acquired substantial prior learning (Ayres, 2006; Mostyn, 2012; Sweller, Van Merrienboer and Paas, 1998). Once learning has occurred, working memory limitations are relieved because students can combine ideas together into schemas and process complex ideas as one item (Ayres, 2006; Mostyn, 2012). Until that learning 'consolidation' occurs (schema development), the concentration required to figure out what is needed for the problem, especially if it contains technical terms, can interfere with learning (Mostyn, 2012; Paas, Renkl and Sweller, 2003). Imagine, for instance, a student reading a business story and trying to tease out which amounts given in the scenario are fixed in order to accumulate the fixed costs needed for the break-even formula. The 'hunt' takes all their concentration at first, because each amount must be analyzed for its cost behavior in the context of the client's business, e.g., are the rent, postage, and utilities fixed costs for this particular business? After practice, finding the fixed costs in the fact set is effortless, and they can more readily notice more aspects of the situation. That is, until the technical terms become automatic, students may not have the short-term mental resources to do the 'hunt' for fixed costs and simultaneously attend to how the incremental contribution margin can fall to the bottom line because fixed costs do not shift with activity. For a more extensive explanation of accounting tasks creating mental load that interferes with learning and schema development in an accounting context, see Mostyn (2012).

Most math tasks, such as those involved in CVP problems, are presumed to be difficult from a working memory resource point of view, because completing them involves holding partial information in memory (formulas, math rules, relations) while processing new information (task fact pattern) to arrive at a solution (Raghubar, Barnes and Hecht, 2010). In addition to being a math-based subject, CVP has high element interactivity, making it particularly demanding on working memory (Clark, Nguyen and Sweller, 2006). That is, students must not only know the concepts of variable costs, fixed costs, sales volume, revenue and profits, but also know how each might respond to changes in another, the linkages among the concepts (Paas, Renkl and Sweller, 2003). Introducing technical terms too early in the learning process may divert mental resources from learning the interactivity of variables necessary for full comprehension of CVP topics. In other words, using technical terms at the outset while studying CVP topics may actually slow down learning. This study will present a homework assignment in 'everyday' language to some participants to see if students perform better when they completed homework without technical terms. Therefore, we hypothesize that:

> H2: Students completing the assignment presented in everyday language will perform better that those using accounting language.

Including Students Receiving No Instruction

We asked students enrolled in the introductory financial accounting course and the financial portion of the principles of accounting course to complete the homework assignment even though they had no experience or instruction in CVP topics (hereafter referred to as 'uninstructed' students). To be fair, these students had no instruction and had not survived the 'culling' of the first course in accounting, a course with a notoriously high failure rate (Wooten, 1998). So, they would be expected to perform worse than managerial students because they have not been tested by the first course (culled) or instructed in managerial concepts.

While the possible insight gained from giving a homework assignment to students who had never studied the material may not be readily apparent, there are actually several potential benefits. First, it measures baseline performance for students with no prior instruction. Though these uninstructed students are not expected to perform well, neither can it be assumed that their average score will be effectively zero, because it is not known to what extent reasoning or conjecture based on contextual clues can facilitate arriving at correct answers. Referring managerial accounting student performance to this baseline therefore gives a more accurate gauge of the impact of the instruction in the managerial accounting course. Second, including uninstructed students permits us to compare the language effect on students who have been introduced to the accounting language and those not yet exposed to CVP jargon. Finally, for formula effects, comparison to students with no instruction in CVP will indicate if novices can reach correct answers by simply using formulas as a performance aid, superficially matching up formulas with problem data with no understanding of the underlying concepts required. Nonetheless, concerning the effect of course experience, we propose the self-evident hypothesis:

> H3: Managerial accounting students will perform better than uninstructed students.

Method

Participants

The study was a quasi-experiment non-equivalent control group design without pre-test (Campbell and Stanley, 1963), conducted with students ($N = 594$) enrolled at eight different institutions each in a different state in the United States (California, Colorado, Florida, Georgia, Michigan, Ohio, Texas and West Virginia) and with eight different instructors. Faculty participants were recruited from attendees of conference sessions and focus group events aimed at improving instruction in accounting courses. The institutions included two-year community colleges ($N = 116$) and four-year institutions ($N = 478$).[1] Students ranged in age from 18 to 56 years, with a mean age of 22.3 years, and were 46.6% male. Accounting majors comprised 23.7% of students, 61.1% had a business-related major other than accounting, and the rest were non-business majors or were undeclared. Table 1 shows participation by course enrollment, institution type, and treatment condition.

Procedure

Students completed an online homework assignment on CVP topics for homework credit or extra credit points. The assignment consisted of four business situations, one for each CVP topic in this study (contribution margin, break-even, target profit, and margin of safety). Following the business facts, there was a total of nine 'formula-facilitated'

Table 1. Participants by type of institution and treatment condition.

	Managerial accounting		Uninstructed students[a]	
	No formulas	Formulas	No formulas	Formulas
Two-year schools				
Accounting language	22	21	8	10
Everyday language	21	22	6	6
Four-year schools				
Accounting language	38	40	80	79
Everyday language	40	37	81	83
All participants				
Accounting language	60	61	88	89
Everyday language	61	59	87	89

[a]Financial accounting students had no instruction on CVP topics.

questions (fact pattern directly mapped to variables needed in traditional CVP formulas) and four 'application' questions, requiring understanding of cost behaviors and sales on profits (cannot be completed straightforwardly using a CVP formula). Students were asked to show their work and most did provide explanations and computations.

As students logged into the online homework page, the system randomly assigned them to one of the four homework conditions: with formulas/accounting language, without formulas/accounting language, with formulas/everyday language and without formulas/everyday language (see Table 1). In each condition, students read the business situations and responded to questions using the problem data. Students were instructed to work alone and not use their book.[2] Use of a calculator was permitted. At the end of the assignment, the students were asked to rate their perception of the level of difficulty and clarity of the problems.

Students enrolled in the managerial accounting course, which contains the CVP unit, were given the assignment after the CVP unit was completed and immediately before taking their CVP exam. This attempted to measure the impact of the factors when student performance should be near its peak. Uninstructed students, those enrolled in a financial accounting course, completed the assignment after covering the accounting cycle, so they would be familiar with basic accounting terms such as revenue and net income but not CVP-specific terms like contribution margin. Uninstructed students were asked to give the assignment a 'good faith effort'. Since these students did not have a CVP unit in their course, they received extra credit (rather than homework credit). Students were told that credit would be awarded for completion of all problems in the assignment and not based on the number of correct answers.[3]

Materials

We created a homework assignment containing 13 questions on contribution margin, break-even analysis, target profit analysis, and margin of safety (see questions in Exhibit A). Nine questions were 'formula-facilitated' questions, solvable using traditional CVP formulas, and four questions could not be solved by any CVP formula (Exhibit B), 'application questions.' These four application questions required understanding of the interactivity of costs and sales with profit and thus probed for understanding of these linkages in a new fact pattern.[4] Twelve questions were fill-in-the-blank questions and one was a multiple choice question (break-even application question). All were graded as correct or incorrect, with no partial credit. The instructions indicated that 'yes' or 'no'

Exhibit A. Cost-volume-profit homework question types and language conditions.

Accounting language problems	Everyday language problems
Contribution margin: Taco Joe's, owned and operated by Joe Cool, Jr, is a favorite of the local college crowd. Joe's tacos are priced at $1.50 and the variable cost per taco is $1.20. **Formula-facilitated questions**: What is Taco Joe's contribution margin? Contribution margin ratio? Total contribution margin for selling 200 additional units? **Application question (incremental analysis)**: One day Joe gets an idea for a snappy new advertising campaign to improve sales. Right now, Taco Joe's sales total $54,000 per month. With the new advertising, Joe figures he can increase revenue by 20%. The extra advertising would cost $3000 per month. Should he do it? You must explain your reasons to get credit.	**Contribution margin**: Taco Joe's, owned and operated by Joe Cool, Jr, is a favorite of the local college crowd. Joe's tacos are priced at $2.00 and it costs $1.20 in ingredients (premium taco meat, sour cream, etc.) to make each one. **Formula-facilitated questions**: For each taco sold, how much profit does Taco Joe's make? What percentage of each taco sold actually goes to profit? If Taco Joe's sold 100 more tacos, how much additional profit would be made? **Application question (incremental analysis)**: One day Joe gets an idea for a snappy new advertising campaign to improve sales. Right now, Taco Joe's sells $36,000 in tacos per month. With the new advertising, Joe figures he can increase sales by 20%. The extra advertising would cost $3500 per month. Should he do it? You must explain your reasons to get credit.
Break-even: Top-Loading Tyler's Video Emporium sells classic 1980s movies in the vintage VHS tape format. Tyler's movies are priced at $20 and his variable cost per unit is $16. He pays $1600 per month for rent on his store location. For simplicity, let's assume there are no other revenues or expenses **Formula-facilitated questions**: What is Tyler's break-even point: (1) in product units? (2) in sales revenue? **Application question**: Tyler receives a notice that the rent on his store is going up. How will this affect Tyler's break-even point (increase/decrease/no change/I'm not sure)?	**Break-even**: Top-Loading Tyler's Video Emporium sells classic 1980s movies in the vintage VHS tape format. Tyler purchases his tapes wholesale from a supplier for $10 each and sells them to his customers for $15. He pays $1400 per month for rent on his store location. For simplicity, let's assume he has no other products or expenses. **Formula-facilitated questions**: How many tapes does Tyler need to sell in a month to cover all his expenses and break even? What total sales in dollars must Tyler make to break even? **Application question**: Tyler receives a notice that the rent on his store is going up. How will this affect the number of tapes he must sell to break even?
Target profit: April Lou Harvey is the founder of April Showers' Flowers, a multimillion-dollar floral empire. April got her start as a humble flower girl selling roses to diners at fancy romantic restaurants for $3.00 each. A well-known florist supplied her with roses at a unit cost of $1.50 and also charged her a weekly fee of $150 for the right to be their distributor. **Formula-facilitated question**: April's goal was to save money each week for her dream of opening a florist shop of her own someday. How many roses did April need to sell in a week for a target profit of $300? **Application question**: April always worked hard, and in one particularly good week she sold exactly twice as many roses as she needed for her targeted profit. How much profit did she make that week?	**Target profit**: April Lou Harvey is the founder of April Showers' Flowers, a multimillion-dollar floral empire. April got her start as a humble flower girl selling roses to diners at fancy romantic restaurants. She bought roses from a well-known florist for $1.00 each and sold them to her customers for $4.00. She also had to pay the florist a weekly fee of $240 for the right to be their distributor. **Formula-facilitated question**: April's goal was to make a profit of at least $300 every week to save up for her dream of opening a florist shop of her own someday. How many roses did April need to sell in a week to reach her goal? **Application question**: April always worked hard, and in one particularly good week she sold exactly twice as many roses as she needed to reach her profit goal. How much profit did she make that week?

(*Continued*)

Exhibit A. Continued

Accounting language problems	Everyday language problems
Margin of safety: The Branlove Cereal Company sells fancy gluten-free organic cereal for \$4.00 per box. Branlove's forecasted sales are \$400,000 for this month and its sales at break-even are \$180,000. **Formula-facilitated questions**: What is Branlove's margin of safety: (1) in dollars? (2) as a percentage of sales? (3) in product units? **Application question**: How much could cereal sales drop before Branlove takes a net loss?	**Margin of safety**: The Branlove Cereal Company sells fancy gluten-free organic cereal for \$4.00 per box. Branlove expects to sell \$300,000 in cereal this month, and needs to make sales of at least \$180,000 to cover all its expenses and break even. **Formula-facilitated questions**: (a) How much does Branlove expect sales to exceed what they need to break even? (b) What percentage of the expected sales is the amount in (a)? (c) How many boxes of cereal sold does the amount in (a) represent? **Application question**: How much could cereal sales drop before Branlove no longer makes a profit and starts losing money?

was not a complete answer and grading was based on the supporting computations and reasons.

To investigate the effect of language on student performance, we created a second version of the above assignment in which all CVP-specific terminology was replaced with everyday language that preserved the meaning of the problem statements without using CVP jargon. Each CVP-specific term was replaced with its definition, for example 'What is Tyler's break-even point in product units?' in the accounting language version became 'How many tapes does Tyler need to sell in a month to cover all his expenses and break even?' in the everyday language version. See Exhibit A for problems in both language conditions.

To investigate the effect of formulas on student performance, students randomly assigned to the formula condition were given a numbered list of CVP formulas as a reference while working on the problems, similar to those commonly found in managerial accounting textbooks. An everyday language version of the formula reference page accompanied the everyday language version of the assignment (see Exhibit B for formulas in both language conditions). To maximize compliance in formula use, the instructions directed students to use the provided reference page (termed a 'cheat sheet') and indicate the number of the formula that was used in solving each computational problem. Formula numbers were not asked for on the application questions.

Measures

We computed a total score and two other separate scores, one for formula-facilitated questions and another for application questions. The total score is the percentage correct out of 13 questions (e.g. nine correct out of 13 would be a total score of 69%). The formula-facilitated score was computed as the percentage correct out of the nine formula-facilitated questions (e.g. six out of nine correct would be a formula-facilitated score of 67%). The application score was computed as the percentage correct out of the four application questions (e.g. three out of four correct would be an application score of 75%).

We computed the average rating on the survey questions at the end of the online assignment from the seven-point Likert-type responses. We asked students to rate 'How easy or

Exhibit B. Formula 'cheat sheet'.[a]

Formulas in accounting language:

Total Contribution Margin = Unit Contribution Margin × Number of Units Sold

Margin of Safety Units = Actual or Budgeted Sales − Break-Even Sales

$$\text{Break-Even Units} = \frac{\text{Total Fixed Costs}}{\text{Unit Contribution Margin}}$$

$$\text{Target Profit Units} = \frac{\text{Total Fixed Costs} + \text{Target Profit}}{\text{Unit Contribution Margin}}$$

Formulas in everyday language:

Total Profit from a Sale = Profit per Product Unit × Number of Units Sold

Units Sold above Break Even = Actual or Expected Units − Units Needed to Break Even

$$\text{Units to Sell to Break Even} = \frac{\text{Total Non-Product Costs}^{b}}{\text{Profit per Product Unit}}$$

$$\text{Units to Sell to Reach a Profit Goal} = \frac{\text{Total Non-Product Costs}^{b} + \text{Profit Goal Amount}}{\text{Profit per Product Unit}}$$

[a]These formulas are the 'per unit' computations for the four topics. The cheat sheet provided also contained separate formulas to compute these in dollars and percent.

[b]Non-Product Costs are expenses like rent and insurance that are not affected by the number of product units made or sold.

difficult did you find the problems on this assignment?' and 'How clear were the problem statements to you?' The scales were symmetrical with a neutral midpoint (i.e. 'neither easy nor difficult' or 'neither comfortable nor uncomfortable').

Results

A Shapiro-Wilk test of normality showed that the scores were normally distributed within each condition (Shapiro and Wilk, 1965). Students who began but did not complete the assignment were omitted from the study. This resulted in 28 students being omitted, leaving a total of $N = 594$ students whose results were analyzed.[5] Cronbach's α of 0.85 for the questions is above the acceptable level of 0.7, indicating that the questions have a reliable level of internal consistency. The total scores and the separate scores for formula-facilitated and application questions in each of the eight conditions are reported in Table 2.

Effect of Formulas, Language and Instruction on Total Scores

In an ANOVA of total score (all questions) with the three fixed factors (formulas, language and instruction), all three factors, the interaction of language and instruction, and the interaction of language and formulas were statistically significant (Table 3). Students did better with formulas, in everyday language, and with instruction, supporting H2 and H3. Examining the practical effect sizes, instruction increased the average score by 5.4%, everyday language increased the average score by 8.0%, and formulas increased the average score by 8.4%.

Since it is hypothesized that the formula factor will impact formula-facilitated and application question performance differently (and also to determine if the other factors impact the two question types differently), the component scores were also analyzed separately. In an ANOVA with formula-facilitated scores and the three fixed factors (formulas, language and instruction), all three main effects and all two-way interactions were significant (Table 4, Panel A). Examining the practical effect sizes, instruction increased average scores by 6.2%, everyday language increased the average scores by 8.4% and providing formulas increased the average scores by 12.9%. This supports H1a, that formulas would help on formula-facilitated questions.

There are three two-way interactions in the ANOVA on formula-facilitated scores. The first, formulas × language, occurs because everyday language improved scores when formulas were absent (70.9% versus 53.3%) but not when they were provided (74.7% versus 75.4%). The second, formulas × instruction, stems from formulas assisting uninstructed students (74.3% versus 57.7%) more than they assisted managerial students (76.1% versus 68.5%). Finally, the third, language × instruction, results because everyday language raised scores for uninstructed students (73.0% versus 59.3%) but not for managerial students (72.6% versus 72.0%). Figure 1 illustrates how formula scores changes based on formula, language and instruction conditions.

Since providing formulas had a significant impact on performance, we ran a post hoc ANOVA with students who were given formulas (Table 4, Panel B). Interestingly, when formulas were provided, neither language, instruction nor their interaction was significant. Similarly, in an ANOVA with students working in everyday language (Table 4, Panel C), neither formulas, instruction nor their interaction was significant.

By collating identical incorrect student responses to formula-enabled questions, we looked for patterns or common errors in any of the conditions. The most frequently occurring error on each question comprised only 6.8% of answers for managerial students and 9.9% of answers for uninstructed students.

Effect of Formulas, Language and Instruction on Application Questions

The application questions (Exhibit A) differ from the formula-facilitated questions because they require that students apply their knowledge in ways that do not fit into a formula pattern. That is, unlike formula-facilitated questions, where students can hunt for expected ingredients to complete a computation, the application questions varied in

Table 2. Percentage of homework problems completed correctly by type (standard deviations in parentheses).

	Managerial students		Uninstructed students	
	No formulas	Formulas	No formulas	Formulas
Panel A: Total scores				
Accounting language	59.4 (26.8)	67.7 (21.6)	42.8 (24.6)[a]	61.5 (20.6)
Everyday language	63.8 (25.1)	65.1 (21.3)	63.6 (24.1)	66.6 (21.6)
Panel B: Formula-facilitated scores				
Accounting language	65.4[b] (31.6)	78.5[b] (24.8)	45.1[b] (28.4)	73.3[b] (23.4)
Everyday language	71.6 (29.2)	73.6 (24.6)	70.5 (28.3)	75.4 (24.5)
Panel C: Application scores				
Accounting language	45.8 (26.5)	43.4 (25.4)	37.8 (24.6)	34.8 (23.7)
Everyday language	46.3 (22.7)	45.8 (24.2)	48.0 (32.9)	46.9 (24.1)

[a]Total score mean for uninstructed students without formulas using accounting language differed significantly from the other conditions, $p < 0.001$.
[b]Difference between no formulas and formulas condition was significant, $p < 0.001$.

Table 3. Analysis of variance on total scores.

	Sum of squares	DF	Mean square	*F*	*p*
Model	622.178	7	88.883	9.767	.000
Intercept	36,381.007	1	36,381.007	3997.956	.000
Instruction	69.588	1	69.588	7.647	.006
Language	116.192	1	116.192	12.768	.000
Formula	148.131	1	148.131	16.278	.000
Instruction × Language	88.107	1	88.107	9.682	.002
Instruction × Formulas	22.060	1	22.060	2.424	.120
Language × Formulas	77.681	1	77.681	8.536	.004
Instruction × Language × Formulas	10.789	1	10.789	1.186	.277
Error	5332.542	586	9.100		

terms of their demands on the student's declarative and procedural knowledge. Cronbach's α of 0.43 for the application score confirms that the application questions varied too much from each other to be considered 'one measure' of anything (a value above 0.7 typically indicates internal consistency). So, the overall score for the conceptual questions will not be used for analysis. Instead, we will analyze each question individually.[6]

Two of the four application questions had scores in a limited range. Most students correctly answered the multiple-choice question about how the break-even point changes

Table 4. Analysis of variance on formula-facilitated scores.

	Sum of squares	DF	Mean square	*F*	*p*
Panel A: Formula-facilitated score					
Model	63,737.205	7	9105.315	12.646	0.000
Intercept	2,740,529.944	1	2,740,529.944	3806.327	0.000
Formulas	20,880.328	1	20,880.328	29.001	0.000
Language	7468.507	1	7468.507	10.373	0.001
Instruction	5519.287	1	5519.287	7.666	0.006
Formulas × Language	10,582.412	1	10,582.412	14.698	0.000
Formulas × Instruction	2877.061	1	2877.061	3.996	0.046
Language × Instruction	6144.272	1	6144.272	8.534	0.004
Formulas × Language × Instruction	1335.154	1	1335.154	1.854	0.174
Error	421916.067	586	719.993		
Panel B: Formula-facilitated score, students who had formula cheat sheet					
Model	1135.940	3	378.647	0.644	0.587
Intercept	1,621,420.629	1	1,621,420.629	2758.201	0.000
Language	213.485	1	213.485	0.363	0.547
Instruction	135.432	1	135.432	0.230	0.632
Language × Instruction	876.421	1	876.421	1.491	0.223
Error	172,829.186	294	587.854		
Panel C: Formula-facilitated score, students who had everyday language					
Model	1196.340	3	398.780	0.560	0.642
Intercept	1,511,476.178	1	1,511,476.178	2121.068	0.000
Formulas	863.312	1	863.312	1.211	0.272
Instruction	8.355	1	8.355	0.012	0.914
Formulas × Instruction	145.641	1	145.641	0.204	0.652
Error	208,079.616	292	712.601		

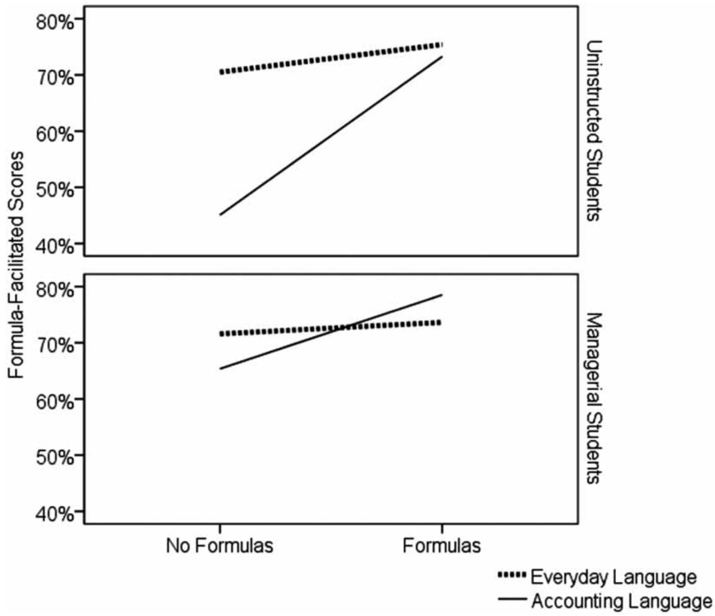

Figure 1. Interactions of formula-facilitated scores by condition

when costs rise (89.2% of the managerial students and 87.0% of the uninstructed students) and very few got the incremental analysis question correct (11.2% of the managerial students and 7.4% of the uninstructed students). Therefore, we will confine our statistical analysis to the two questions in which we observed a range of scores (the margin of safety and target profit questions).

The results of ANOVAs on scores for the margin of safety and target profit questions with the three fixed factors as independent variables are shown in Table 5. The formula condition is the only significant variable in both ANOVAs, which does not support H1b, that formulas should not impact performance on application questions. As can be seen in Figure 2, the students with formulas did better on the margin of safety question but worse on the more demanding target profit analysis.

The margin of safety question mirrored the formula-facilitated question, phrased as the meaning of margin of safety without using the technical term. The question essentially probed to see if students recognized the concept of margin of safety. As a post hoc test, we compared the margin of safety computation score to the margin of safety application score. The correlation of these two scores, while statistically significant ($p < 0.001$) was small (Pearson's correlation = 0.22 for formula condition and Pearson's correlation = 0.14 for no-formula condition). While margin of safety (in dollars) was computed correctly by 82.2% of students with formulas and 69.9% of those without formulas, only 49.3% of those with formulas and 40.2% of those without formulas could identify margin of safety in the application question. This clearly shows many students did not realize the formula-facilitated and application questions asked for the same thing. In an ANOVA with change in score on margin of safety (formula-facilitated score minus application score) analyzed by formula condition, there was no significant difference between the two groups in score drop from computation to definition probe application question ($F = 0.43$, $p = 0.514$).

Table 5. Analysis of variance on application questions.

	Sum of squares	DF	Mean square	*F*	*p*
Margin of safety					
Model	2.753	7	0.393	1.599	0.133
Intercept	118.155	1	118.155	480.394	0.000
Formulas	1.243	1	1.243	5.053	0.025
Language	0.708	1	0.708	2.880	0.090
Instruction	0.063	1	0.063	0.257	0.613
Formulas × Language	0.014	1	0.014	0.056	0.812
Formulas × Instruction	0.192	1	0.192	0.781	0.377
Language × Instruction	0.346	1	0.346	1.406	0.236
Formulas × Language × Instruction	0.164	1	0.164	0.668	0.414
Error	144.129	586	0.246		
Target profit					
Model	4.158	7	0.594	2.808	0.007
Intercept	57.143	1	57.143	270.107	0.000
Formulas	3.050	1	3.050	14.419	0.000
Language	0.007	1	0.007	0.033	0.855
Instruction	0.000	1	0.000	0.002	0.963
Formulas × Language	0.007	1	0.007	0.031	0.859
Formulas × Instruction	0.168	1	0.168	0.792	0.374
Language × Instruction	0.738	1	0.738	3.489	0.062
Formulas × Language × Instruction	0.029	1	0.029	0.139	0.709
Error	123.971	586	0.212		

On the target profit question, students given formulas averaged 14.7% lower (24.2% versus 38.9%). Unlike the incorrect responses for formula-enabled questions, two significant patterns were present among student errors on this question. This question asks for the profit when exactly twice as many units needed for a target profit were sold. The leading error was to assume this gives twice the target profit (20.7% of answers), neglecting that

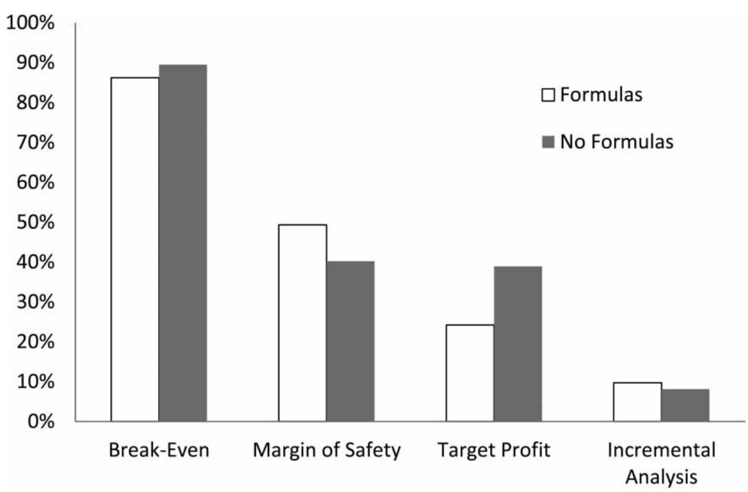

Figure 2. Scores on application questions by formula condition

fixed costs only need to be covered once. In an ANOVA with 'twice target profit error' (yes/no) as the dependent variable and the three fixed factors (formulas, language and instruction) as independent variables, instruction was the only significant factor ($F = 5.08$, $p = 0.025$) with uninstructed students making the error more frequently. The second most common error was to compute profit as the total contribution margin from twice the target units (9.8% of answers), which neglects fixed costs altogether. In an ANOVA with 'twice contribution margin error' (yes/no) as the dependent variable and the three fixed factors (formulas, language and instruction) as independent variables, language was the only significant factor ($F = 23.14$, $p < 0.001$), with students working in accounting language making the error more frequently. Though providing formulas depressed performance on this question, both common errors are errors in conceptual reasoning and do not appear to have resulted directly from attempting to apply a formula where it does not belong.

Unfortunately, with two of the four questions being too easy or too difficult to discriminate and the margin of safety question being a definition probe (hence formula availability was of help), the inventory of application questions useful to study any formula effect was too small. A result that hinges only on two questions should be approached with caution, and more investigation in this area is warranted.

Post-Hoc Testing by Institution Type

There were eight different participating institutions, some two-year schools ($N = 116$, 19.5%) and some four-year schools ($N = 478$, 80.5%) (Table 1). The number of participants was unbalanced between schools and between instructors so ANOVA results would not be reliable (Kirk, 1995). Students enrolled in two-year schools scored higher on formula-facilitated questions (76.1% versus 66.8%, $F = 3.80$, $p < 0.001$) and application questions (48.3% versus 42.1%, $F = 2.65$, $p = 0.011$).[7]

Student Perceptions

At the end of the assignment, $N = 586$ students (98.7% of participants) answered the questions about their perception of problem difficulty and clarity. Table 6 summarizes the survey results. Students overall did not feel the assignment was particularly easy or difficult (means were close to the scale midpoint). We ran ANOVAs of the difficulty and clarity ratings with the three fixed factors: (1) formulas (provided versus withheld), (2) language (accounting language versus everyday language), and (3) instruction (managerial versus uninstructed). For perception of difficulty, we found significant main effects for formula, language, the interaction of formulas and language, and the interaction of formulas, language and

Table 6. Mean student ratings of homework assignment (standard deviations in parentheses).

	Managerial students		Uninstructed students	
	No formulas	Formulas	No formulas	Formulas
Student rating of assignment difficulty (1 = extremely easy, 7 = extremely difficult)				
Accounting language	4.37 (1.06)	4.07 (0.93)	4.91 (1.06)	4.03 (1.03)
Everyday language	4.03 (1.11)	3.69 (0.90)	3.83 (1.34)	3.83 (1.05)
Student rating of assignment clarity (1 = very unclear, 7 = very clear)				
Accounting language	5.22 (1.50)	5.13 (1.55)	4.25 (1.41)	5.25 (1.29)
Everyday language	5.20 (1.52)	5.22 (1.43)	4.92 (1.55)	5.17 (1.35)

Table 7. Analysis of variance on survey results.

	Sum of squares	DF	Mean square	*F*	*p*
Panel A: Perception of difficulty ratings					
Model	85.137	7	12.162	10.476	0.000
Intercept	9595.549	1	9595.549	8265.081	0.000
Formulas	20.386	1	20.386	17.599	0.000
Language	35.355	1	35.355	30.453	0.000
Instruction	1.749	1	1.749	1.506	0.220
Formulas × Language	6.339	1	6.339	5.460	0.020
Formulas × Instruction	0.482	1	0.482	0.415	0.520
Language × Instruction	3.003	1	3.003	2.587	0.108
Formulas × Language × Instruction	7.495	1	7.495	6.456	0.011
Error	679.170	586	1.161		
Panel B: Perception of clarity ratings					
Model	66.241	7	9.463	4.556	0.000
Intercept	14,407.713	1	14,407.713	6936.523	0.000
Formulas	12.384	1	12.384	5.962	0.015
Language	3.669	1	3.669	1.766	0.184
Instruction	12.281	1	12.281	5.912	0.015
Formulas × Language	3.516	1	3.516	1.693	0.194
Formulas × Instruction	15.458	1	15.458	7.442	0.007
Language × Instruction	2.396	1	2.396	1.154	0.283
Formulas × Language × Instruction	6.598	1	6.598	3.176	0.075
Error	1200.552	578	2.077		

instruction (Table 7). This confirms that students with formulas, those working with everyday language, and those with a combination of these advantages, found the assignment easier. For perception of clarity, students with formulas, prior instruction, or the combination of both, found the problems clearer. Interestingly, there was no statistical difference in overall perception of difficulty between managerial and uninstructed students and no difference in perceived clarity in everyday versus accounting language.

Discussion

Student perceptions validate the literature review on level of difficulty. That is, removing formulas made the assignment seem more difficult and using everyday language made the assignment seem easier. As expected, students without formulas and with accounting language reported the highest level of difficulty and those with formulas and everyday language reported the lowest level of difficulty.

Starting with the most unexpected finding, the hypothesis that instructed students should unequivocally outperform uninstructed students, originally proposed as self-evident, was supported but with an insignificant effect size. Since managerial students have already passed the first accounting course, they should be academically stronger than their uninstructed counterparts. Students with the benefit of the book, the lecture and homework assignments only scored, on average, 5.4% better than students who were not enrolled in a course teaching CVP. Of the three factors examined, instruction had the least impact on student performance. We cannot excuse these results by insisting that it was the lower ability schools contributing to this result, because the open-enrollment two-year schools outperformed the four-year schools with stricter admission policies. If we give uninstructed students a cheat sheet or remove technical jargon, the advantage of instruction disappears altogether. There appears to be a huge opportunity for improving CVP instructional practice. For instance, more emphasis (in both instruction and portion of the course grade) on application of concepts and less on production of computations mapped to formulas may improve student outcomes.

We found that eliminating technical terms improves performance. This may indicate that students can better focus on the connections between cost behaviors and profits when they do not have jargon to decipher at the same time. This finding is consistent with expectations from cognitive load theory that technical terms early in the learning process, before they have become automatic, requires additional working memory resources and may slow or interfere with learning (Clark, Nguyen and Sweller, 2006). Everyday language may also make the task clearer. Due to the extremely limited number of usable application questions, we were unable to discern if those working in everyday language showed better comprehension. Future work that investigates the potential benefit of delaying the introduction of technical terms[8] with a fuller array of application questions would help discover if the reduction in mental demands improves early performance.

The finding on the impact of formulas for application scores (versus formula-facilitated scores) may signal a potentially troubling result but the evidence on the worrisome aspect is too scant to reach a clear conclusion. As expected, students with formulas outperformed those without them on formula-facilitated questions, on average by 12.9%. The analysis of interest, however, was on how those with formulas performed on application questions. Because two questions had little variation in scores (one was answered correctly by nearly all and one was answered correctly by only a small percentage), only two application questions could be examined, margin of safety and target profit. Of those two, one was answerable by reference to the formula (margin of safety) and so those with formula sheets could do better without comprehension. Interestingly, the drop in scores between computing margin of safety correctly and recognizing it in a problem fact pattern was 32.9% for those with formulas and 29.7% for those without formulas. The differences were not significant between groups but it is discouraging that about half of those correctly computing margin of safety could not recognize it after just computing it in the prior question. The target profit question was the most intriguing. While this question did show that those with formulas did worse, a result hinging on one question should be approached with great caution. Future work with a wider array of application questions may be able to reveal more conclusively whether there is a formula effect or not.

This exploratory study into CVP performance contributes to the literature in a number of ways. First, current instructional practices do not advance performance more than a trivial amount, confirming our initial reason for this inquiry: students do not easily understand the main cost-volume-profit ideas. Furthermore, the overall scores for application questions show that, on average, students cannot apply CVP knowledge to novel word problems. The big question is: Why is this so difficult? One potential reason is that to go beyond the early beginner phase, a phase mostly attainable even without instruction if you omit technical terms or provide formulas, CVP topics may require what Van Gog *et al*. (2005) and Ericsson, Roring and Nandagopal (2007) termed ‘deliberate practice’, that is, concentrated effort on the type of exercises that improve expertise. Van Gog and Ericsson show that all repetition is not equal; some tasks do more to develop expertise than others. Simply put, a steady diet of formula-matched problems, often the typical fare in managerial accounting, may not get students very far. Students may need practice with problems for which shallow formula application is not effective. This paper raises more questions than it answers. We hope our colleagues are as intrigued as we are and will help us learn the ‘why’ behind these results in future studies.

Second, this paper indicates that students are good at plug-and-chugging their way through formulas, even without specific instructions on how to do so. Our colleagues that believed that students cannot use formulas now have some evidence that they can look elsewhere for an explanation of why the CVP scores are low. If the terminology in the formula is a barrier, perhaps that can be easily addressed given the results that a reduction in technical terms seems to help.

Third, formulas make it easy to accumulate course points and so students may be tempted to settle for surface approaches to learning and not exert the mental effort to 'digest' the connections and concepts (Biggs, 1987). Instructors can control this to an extent with assessments. If our assessments, the 'hidden curriculum' (Crooks, 1988), emphasize formula use because exam questions are predominantly answerable with formula recall, we are setting up our students to stop short of our bigger course goals. Such exams tell students (wrongly) that they are 'successful' when they can use formulas skillfully (by awarding some large proportion of the points for doing so), and so students may be content to stop there. The literature suggests that our accounting students have this pragmatic tendency (Lizzio, Wilson and Simons, 2002; Sharma, 1997). Instructors may wish to ensure that their assessments contain a balance of formula-facilitated and application level questions to prevent students from 'succeeding' when their ability is basically confined to using the decision aid (Arnold and Sutton, 1998; Joshi and Babacan, 2009).

Finally, this work sends a cautionary note, albeit on scant evidence, to those that may permit 'cheat sheets' during assessments and to those that emphasize formula knowledge through the construction of exams predominantly answerable with formula recall. While further work is needed to determine if formula use reduces students' ability to apply concepts to new problems, this work certainly hinted at the possibility.

Limitations and Future Work

Starting with the issues we believe are most plausible, we acknowledge a number of limitations. First, this study focused on cost-volume-profit topics. It is not clear whether there is something particularly unusual about these topics that make it hard to achieve a meaningful performance increment over uninstructed students. Replicating this study on other accounting topics would help reveal whether the effects found are topic-specific.

Possible explanations for the lower application scores are that the application questions were simply more difficult than repeating a formula-based process, or that the formulas were presented before the concepts during lectures, which cognitive science indicates may interfere with conceptual learning (Rittle-Johnson and Koedinger, 2009). Future work that investigates the impact of the ordering of conceptual versus procedural instruction or ways to make application more successful in general would advance understanding of this threat to learning outcomes.

The results showed a negative formula effect on one application question. We call for further work to investigate the relationship between formula use and the ability to succeed in application questions.

Though the effect of instruction was observed to be unexpectedly low, it is not known to what extent managerial students actually availed themselves of the course resources, including lectures, textbook and homework. It would be useful to investigate this further in future work, where time-on-task could be controlled.

This study used a convenience sample of eight instructors at a wide array of institutions. There may have been something about those instructors or institutions that is not typical of instructors in other accounting programs.

Participants were given credit for a good faith effort and not for correct responses. Although this assignment was given prior to the CVP exam, when the learning might have been more consolidated and refined, the overall performance was at the minimum passing level for coursework. Although there is evidence in the data that students were making a diligent effort, a study where score had more impact on the student's grade may lead to different results.

Students were randomly assigned to the formula and language conditions but not to the instruction condition. There may have been differences between the uninstructed students and the managerial students that led to these results. We find this to be one of the least likely explanations because managerial students must first succeed in the preceding introductory financial course, leading to a prediction in the opposite direction of the observed results.

Conclusion

This study investigated the effect of three factors on student performance on CVP problems: formulas, language and instruction. Surprisingly, students receiving 'business-as-usual' instruction performed only 5.4% better than uninstructed students. In addition, the low overall scores tell us what we already sensed: students have trouble solving CVP problems correctly. This study alerts curriculum designers and instructors that we need innovations and strategies to prompt better CVP learning outcomes.

Our study found that the use of everyday language in instruction warrants further investigation. Students working homework problems presented in everyday language performed better. And, when uninstructed students were given everyday language, they did as well as instructed students. Future work may be able to discern if withholding the technical terms early in the learning process, until comprehension of the concepts has begun, may improve students' ability to apply CVP concepts.

The results also indicate that further investigation is needed to study the potentially negative impact of formula availability or assessments dominated by formula-facilitated questions. Having formulas displayed on the screen (analogous to having the book opened during homework completion) improved formula-facilitated scores. Although students given formulas answered more formula-facilitated questions correctly, they performed worse on the application question, which required them to use their knowledge flexibly. This study hints, admittedly on the limited evidence of only one question, that CVP instruction that emphasizes formula use may lead to inflexible problem solvers who have limited conceptual understanding (Blote, Van Der Burg and Klein, 2001), and raises the possibility that providing formulas as a course routine, at least for CVP topics, may suppress motivation for understanding, encourage surface level 'plug-and-chug' approaches, or lull students into a false sense of knowing. This is worthy of follow-up work to verify the result.

Straightforward manipulation of formula use and language equalized performance between instructed and uninstructed students, suggesting such manipulations may have a role in future research on designing improved instructional strategies. We stress our work is not intended nor is it appropriate in any way to view these results as an indictment of the faculty participants' competence, diligence or dedication. We do not yet know whether prevailing instructional practice in managerial accounting overemphasizes straightforward formula use rather than how to understand and apply concepts. Our intent is to begin a conversation about that possibility and the effects of shifting that emphasis.

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Notes

[1]The schools range in degree of competitiveness from an acceptance rate of 37% and combined SAT of 1300 at the 75th percentile of admitted students (21% of study participants) to open enrollment two-year schools (20% of study participants).

[2]Students were not proctored. In related work using the same materials, the second author proctored 28 students in both formula and no-formula conditions and median and mean completion time were 35 minutes (range of 18–42 minutes with an outlier of 56 minutes). This was slightly longer than the average completion times for the participants in the study (median of 21 minutes and mean of 31 minutes). Given these completion times, it appears that most students likely followed instructions and did not consult outside resources.

[3]Scores were over 80% on three of 13 questions (23.1% of the questions) for both managerial and uninstructed students. The highest scoring questions were at the beginning (1st), in the middle (8th) and towards the end (10th) of the sequence, indicating that the students remained diligent to the end of the assignment.

[4]After preparing the question sets, we asked seven instructors to review them and then rate the assignment for clarity and level of difficulty. Minor changes were made in wording based on this feedback. Clarity was rated 6.14 and difficulty was rated as 3.86, both on a seven-point Likert scale.

[5]As students logged into the homework site, they were randomly assigned so that each condition had the same number of participants. If a student exited the assignment without finishing, they were deleted from the assigned condition, enabling the next student to take their spot. No data were retained on the 28 students that did not complete the assignment, other than counting them.

[6]The Cronbach's α value does not increase with the deletion of any single question.

[7]The pattern of higher scores for two-year schools persisted when analyzing only managerial accounting students (77.4% versus 69.5% on formula-facilitated questions and 50.0% versus 42.7% on application questions) and only uninstructed accounting students (72.6% versus 65.5% on formula-facilitated questions and 43.3% versus 41.7% on application questions).

[8]We acknowledge that technical terms permit precision and parsimony in more advanced work. Furthermore, national certifying exams use and require understanding of the lexicon of the profession. We do not suggest eliminating technical terms but perhaps a delay of their use with novice students.

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