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Cognitive Load Theory: What It Is, Why It's Important for Accounting Instruction and Research

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ABSTRACT: The purpose of this paper is to increase the awareness of accounting instructors, particularly those teaching introductory courses, of an important and relatively new development in cognitive psychology. This development, called cognitive load theory (CLT), both identifies the cognitive constraints of novice learners when learning complex tasks and also provides specific methods for improving learning efficiency. Despite extensive CLT research and its widespread application in the instructional design applications for many other fields, very little discussion has appeared in accounting education literature. This suggests not just an oversight, but also a great opportunity. This paper will present: (1) an overview of CLT and its use, (2) a brief history of recent learning theory and its effect on accounting education and the development of CLT, (3) a discussion of the key elements of CLT and its prescriptive research results for the classroom, and (4) suggestions for how CLT might benefit accounting research.

Keywords: introductory accounting education; cognitive load theory.

INTRODUCTION

It is not surprising that introductory accounting is required in virtually all college business programs and even in some non-business programs. As generations of accounting instructors have reminded students in introductory courses, "Accounting is the language of business." Introductory accounting creates a widespread dissemination of essential accounting content, whether it is taught as a basic, principles, financial, user-focused, or hybrid course. Introductory accounting instruction also must manage a wide variety of beginning student backgrounds and abilities. It follows, therefore, that the introductory-level instructional design is critical and should incorporate as many useful empirical tools as possible that consider the needs of a variety of user populations. The inclusion of cognitive load theory (CLT), a relatively recent development in the evolution of instructional psychology, as part of introductory accounting instructional design offers a great opportunity to meet this objective.

In a nutshell, cognitive load theory is a hypothesized representation of how a human brain processes data, such that learning occurs. The theory identifies specific functional elements of the processes that involve data process sequencing, types of memory used, and universal limiting

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parameters. An important advantage of the theory has been the capacity to empirically replicate studies that describe the human cognitive process—which, it turns out, has some remarkable similarities to the evolutionary development of computer architecture—such that general principles can be developed that apply in a wide variety of instructional applications. As a result, academic literature for various disciplines is frequently reporting improved learning outcomes in classroom environments that apply CLT. For example, by applying CLT to redesign an introductory C programming class used by mechanical engineering students, the instructor reported a statistically significant improvement in overall student evaluations of teaching effectiveness and course satisfaction, with no change in mean grade assigned, despite an increase in the level of exam difficulty and number of assignments (Impelluso 2009). Other examples: a university calculus instructor applied a key CLT element in a process to help students and reported significantly improved course and final exam grades (Miller 2010), and a Bavarian vocational school tested the use of CLT for short periods in bookkeeping courses and reported improved performance in conceptual and procedural knowledge (Stark 2004). The idea of including "cognitive load," a key element of the theory, as a dependent variable while researching various instructional ideas is also occurring.

Numerous empirical studies have advanced CLT and suggested applications that have resulted in widespread journal publication. These have reported CLT applications in disciplines ranging from multimedia and language instruction (Diao and Sweller 2007; Plass et al. 2003) to teaching geography (Bunch and Lloyd 2006) and statistics (Lovett and Greenhouse 2000), designing graphical user interfaces (Martin-Michiellot and Mendelsohn 2001), optimizing intelligent tutoring systems (Courtemanche et al. 2008), designing tests for students with disabilities (Elliott et al. 2009), team decision efficiency in naval warfare (Johnson et al. 2002), and digital imaging training for physicians (Devolder et al. 2009), among many others. In an examination of major instructional design journals, book reviews, papers, and other documents in the field from 1980–2008, the phrase "cognitive load theory" was the second most frequently used phrase and "worked examples" (a key element of CLT) was the third most frequently used phrase. During this same period the single most frequently cited instructional design journal article concerned cognitive load theory, and four of the top five most frequently cited articles related to the use of cognitive load theory (and six of the top ten) (Ozcinar 2009). During a more recent period from 2003 to 2008, in an examination of the top five educational psychology journals, two of the top ten and four of the top twenty most productive researchers in the field used CLT as their topic of research (Jones et al. 2010).

In this paper, following a short description of CLT, we will briefly discuss the development of cognitive psychology and the history of CLT. We then identify the essential elements of CLT and show how specific procedures can be applied to benefit students—particularly novice students—within an accounting context. The paper will then conclude with suggestions that might be useful for future accounting education research.

An Overview of CLT

Cognitive load theory, a development of what is called "cognitivist" theory in psychology, primarily focuses on increasing the learning efficiency of complex tasks. ("Efficiency" means the learner effort expended in order to remember and comprehend a given amount of content; however, this in turn implies a consideration of educational resources expended as well.) Cognitive load theory addresses efficiency by researching an explicit, hypothesized representation of mental structure, called working memory and long-term memory; the structure's functionality; and how it processes input data. CLT research has developed specific procedures to improve complex-task learning efficiency by identifying the constraints within this system, how data input (called "load") challenge these constraints, and methods of optimizing amount and type of load.

This orientation distinguishes CLT from other learning theories in at least two ways. First, many other learning and instructional design theories do not attempt to evaluate research results within the context of a hypothesized mental structure and its method of operation. Instead, for those theories that are tested, it is sufficient that specific content delivery procedures are evaluated and conclusions drawn, with suggestions for possible future research. Second, it is important to keep in mind that CLT concentrates on efficiency—optimizing a mental operation, not simply describing what needs to be done in order to learn, what helps people learn, or desirable learning outcomes. For example, a school of thought suggests that proper environment and social interaction will improve learning achievement for many students. This does happen (Lehtinen et al. 1995; Slavin 1995). However, the theory does not address the issue of efficiency of the process or attempt to explain empirically why the effect occurs. Similarly, pedagogical applications of constructivism (content is interpreted in the context of experience) such as "active learning," in which the learner controls the learning process according to what is personally meaningful, may in fact result in desirable learning outcomes in certain circumstances, but the degree of efficiency is not addressed. Somewhat differently, another theory, the widely known Bloom's taxonomy (and other taxonomies) of learning, describes levels of competencies (originally: knowledge, comprehension, application, analysis, synthesis, and evaluation) to achieve, but does not address the details of a best process to achieve desired competency objectives. These and other theories also generally do not distinguish between novice learner and experienced learner efficiency when studying a given subject, a useful idea for instructors to consider when thinking about content design and delivery for a beginning class with a variety of student backgrounds.

CLT, however, did not develop autonomously, apart from the rest of cognitive psychology. Although it is distinctive and a definitive advancement in many ways, it does incorporate key elements of prior landmark ideas in the field. CLT is certainly a beneficiary of the last century of creative thought, successes and failures, and trial and error. Some understanding of the recent evolution of cognitive psychology (including its effects on accounting education) will help explain both the development of CLT and its potential contribution in the area of introductory accounting.

OVERVIEW: RECENT EVOLUTION OF CONTEMPORARY LEARNING THEORY

Contemporary Foundations

From the early twentieth century, Edward Thorndike, Lev Vygotsky, and John Dewey generally would be considered as the prominent learning theorists, whose ideas contributed to the development of major schools of thought and pedagogical applications. Thorndike proposed that learning primarily occurred as the result of stimulus and response; whenever the response produced favorable sensations or feelings, learning occurred and the response was reinforced. This thinking was directly based on Pavlov's earlier stimulus/response conditioning experimentation. Thorndike's thinking directly led into one major instructional path that later came to be described as "behaviorist theory," developed by B. F. Skinner, that would have a major educational impact on American education in the 1950s and 1960s. In contrast, Vygotsky and Dewey proposed theories that social interaction and personal experience were significant elements in the learning process. This eventually led to an entirely different teaching approach that, as things later turned out, followed the behaviorists. This school of thought came to be known as "constructivism."

Behaviorism

Behaviorism, widely implemented for nearly twenty years but for the most part abandoned today, did in fact contribute some key instructional procedures that have been repeatedly tested and effectively become academic doctrine. Unfortunately, behaviorist pedagogy did not allow for any of the many other significant mediating (intervening) influences on learning beyond carefully orchestrated stimulus and response, which doomed the idea to eventual failure. Nevertheless, as a result of behaviorism, this pedagogical legacy remains with us today: objective accountability, testing with feedback, sequencing, identifiable steps, and recognition of stimulus-response motivation. Behaviorism also provides cautionary experience when developing tutoring and online learning delivery systems.

Constructivism

Constructivist learning ideas have been expressed in a variety of forms and names over recorded history. Constructivism essentially states that humans construct their knowledge and their understanding of reality primarily in the context of personal experiences and social interactions, which unavoidably mediate the outcomes of any learning process; this also means that we use our experiences to transform information into ways that we can easily remember it. What later became known as constructivist learning theory was most notably articulated and formalized by Jean Piaget in the 1960s and 1970s in his theories of learning and human development. The constructivist theory of knowledge and learning resulted in a wide variety of teaching applications, with any particular derivative methodology depending on one's interpretation of the constructivist theory or some of its variants. Many of these practices probably have in common a reaction to the prior influence and difficulties with the earlier behaviorist-based teaching methods.

A variety of new pedagogical methods under the general rubric of "constructivism" became fashionably widespread beginning in the 1970s, and into the 1980s and 1990s, with some continuing to this day. These methods are variously described by names such as "active learning," "learner-controlled learning," "discovery learning," "cooperative learning," and "learning styles." Constructivism applied to problem solving is often referred to as "problem-based learning," in which the instructor does not attempt to directly teach students what they need to learn, but rather works to improve critical thinking skills and self-directed learning, often by requiring deductive reasoning in the context of copious data. (Knowing your own best learning process is usually called "metacognition.") All of these methods emphasize an instructor's role, primarily as that of a coach and facilitator who decides the course topics, and engages and advises students interactively. Each student is given the primary responsibility for his or her own explanations, interpretations, and critical thinking development, often requiring interaction with other students. For example, an accounting case study is an application of a constructivist approach. Another more extreme example could result from what I recently experienced while teaching a basic online class, with a student asking, "Why is it necessary to have all these GAAP rules?" There was a variety of responses to this question, and a seriously constructivist instructor would have simply facilitated discussion, perhaps raised questions about principles versus rules, and validated much of every student's own efforts and conclusions as constructive, without providing "correct" answers. A different and more moderate constructivist approach might be to assign this type of question as an individual or study-group research project, requiring interpretation and explanation, but with no single right answer required.

Pedagogical methods knowingly or unknowingly based on constructivist theory continue to this day. Some methods are useful additions to curriculum delivery; examples of this in accounting are the emphasis on improving content relevance (and therefore personal motivation) that is now frequently appearing in many introductory accounting textbooks, the widespread acceptance of the case study method, and the interest in group project assignments. However, as the various constructivist-derived methods became established in practice, important shortcomings began to appear. Most noteworthy was the inability to demonstrate a learning efficiency benefit of constructivist methods in controlled studies; in fact, randomized, controlled experiments by CLT researchers within the growing school known as "cognitivists" began to repeatedly demonstrate that the above-described constructivist methods would usually inhibit learning efficiency (Kirschner et al. 2006; Sweller et al. 2007; Mayer 2004) for those students new to a given subject (a "domain"). Moreover, not only did those using constructivist methods lack a reliable body of research to support their practices, but continued cognitive-based research began to produce specific, empirically validated procedures that demonstrably increased learning efficiency, especially for beginning students new to a domain.

As noted, accounting education did not escape the widespread influence of constructivism and its resulting pedagogy; also promoting the application was the Accounting Education Change Commission (AECC), created in 1989, which integrated constructivist philosophy in its position statements, advocating "learning to learn," as well as encouraging case study and small group activities. In accounting, the utility of research results validating constructivist methods has to be characterized as mixed, at best. As with the educational psychology research, there are no accounting research studies that demonstrate these methods make learning more efficient than any other approach, such as lecture, textbook, or tutoring. Even effectiveness studies (i.e., does one method produce a better outcome than another method) applying constructivist methods, which have primarily concentrated on cooperative learning and case study, and to a lesser degree learning styles, have shown overall results sufficiently problematic that any uniform application or doctrine seems unjustified (Gabbin and Wood 2008; Watson et al. 2007, 2003; Hwang et al. 2008; Clinton and Kohlmeyer 2005; Ravenscroft et al. 1997). Several points stand out as reasons for this conclusion. First is the consistency of experimental outcomes themselves for any particular methodology: some studies do demonstrate improved effectiveness, and other similar studies (sometimes under different conditions) do not. Second, the possible variables and their slippery nature inherent in many studies can make generalizations for even statistically significant outcomes difficult, as well as contribute to variations between studies. For example, suppose that we are reviewing the results of a cooperative learning study comparing the outcome of group study to traditional lecture. The results show that group work results in improved individual assessment performance compared to lecture. Another similar study shows no significant difference or opposite results. It is quite possible that motivated groups of good students could outperform a mediocre (or poor) instructor; conversely, a very good teacher could produce better individual results than groups that are poorly prepared or not fully cooperative. Third, the potential variation in student characteristics can vary outcomes and should qualify conclusions. Virtually all research has been conducted with university-level students, many of them at the intermediate accounting level and above. Introductory accounting students include a wider variation in background, ability, and interests. Virtually no research has been done in introductory accounting at the community college level, where variations are greatest and which accounts for roughly 37 percent of all undergraduate enrollment (Snyder 2009).

Cognitivism

Cognitivist ideas form the foundation of cognitive load theory. As in many areas of educational psychology, the roots of cognitivism stretch into previous centuries. However, its recent advancements began to develop even as the behaviorist applications were growing in widespread use. Cognitive psychology examines learning by describing the structure of the brain, identifying functional elements of the structure, and analyzing how a built-in process within the structure processes sensory input data. In effect, the name refers to the study of the mechanisms of the mental activities involved in learning (which even behaviorism did not do, although both theories share some common elements such as stimulus/response and input data constraints).

The essential cognitivist constructs are short-term (working) memory, long-term memory, and schema. Working memory acquires sensory input and temporarily stores, analyzes, deconstructs, and synthesizes the input. However, working memory can hold only small discrete amounts of information (approximately 4 +/– 1 "chunks") for very brief periods of time (about 30 seconds) without rehearsal (Cowan 2001; Miller 1956). There can be some subjectivity here, but generally a chunk is a related group of information elements. For example, the identification of "accounts receivable" in an introductory setting would be one element in the chunk of "current assets." It is also one element in the chunk of "receivables." At a more detailed level, it is a chunk that contains the related sub-elements of account receivable features and issues of accounts receivable valuation. In turn, accounts receivable valuation is another chunk. Long-term memory holds mental constructs (facts, relationships, processes, etc.) called schema for very long periods, and the developed schema can be numerous, large, and complex (Chi et al. 1982). Schema formation is created incrementally in chunked elements in working memory, and with repetition a schema is transferred to long-term memory either as a new schema or as an addition to and/or modification of an existing related schema. Learning is a change in long-term memory and represents development of some level of expertise; that is, long-term memory schema development creates the difference between novices and experts.

Although schema of ever-increasing complexity can be developed in long-term memory, working memory has the ability to access and treat even large and complex schema as a single element that can be "downloaded" only as needed, and so does not impose a load on working memory as does new complex information. For example, it would be far easier for you as an accountant to consider the implications of using company book value as an investment method than a novice investor with no accounting background—you can draw on a complex domain-specific schema that includes the cost principle, asset valuation methods, the meaning of depreciation, depreciation methods, contra accounts and names, financial statement reporting, impairment, and so on. As you think about this, these complex and related schema elements can be referenced very easily into your working memory as you consider possible new information. Further, you had no awareness of this knowledge until it was just now required by working memory to be brought back into working (conscious) memory for some kind of processing.

Within the framework of cognitivist ideas, cognitive load theory was first developed and published in the mid-1980s as a result of problem-solving experiments by John Sweller (and others) at The University of New South Wales. These experiments were replicated and expanded with results summarized in later papers (Sweller and Chandler 1991). Ongoing research and applications of the theory continue into the present day. The essential hypothesis of the theory, validated as predictive by experimental results, is that the amount and complexity of information required to be held in working memory for any learning objective significantly affects the efficiency of learning. Holding this information requires effort, and this effort is referred to as "cognitive load." As explained above, working memory capacity is severely limited (although with clear variations among individuals), so if learning efficiency is be improved by manipulating instructional design, it becomes important to determine both how load is created as the result of design and how this load can be optimized. As time went on, further experiments began to reveal results that encouraged the idea that, in fact, it would be possible to design input in ways that would optimize cognitive load and improve learning efficiency.

HOW CLT WORKS

Types of Load Created

Specifically, CLT classifies three types of cognitive load in a hypothesized mental process. The combination of these loads are additive within the limit of working memory.

Intrinsic load is the cognitive effort required as a result of the inherent complexity of the material to be learned. The material requires working memory to simultaneously hold multiple pieces of information at varying levels of complexity. This is a "necessary" and valuable load, because the comprehension and synthesis of the information must ultimately become part of developed schema. However, a very important point to bear in mind is that the level of intrinsic load is relative to the level of schema already developed in a given individual. In other words, although material might be quite complex, the cognitive load imposed on a student will be greater or lesser depending on the extent of the schema already developed by that student from prior studies. The third variable affecting intrinsic load is a learner's natural working memory ability and how it is utilized. The functioning, of course, varies among individuals and can be affected by social, emotional, and physical considerations.

One example of a relatively complex intrinsic load would be the preparation of a statement of cash flows by someone new to the topic. This learning objective would require comprehension of the following inherent and necessary interactive elements: (1) definition of operating, investing, and financing; (2) ability to identify operating, investing, and financing transactions; (3) understanding the difference between accrual and cash basis accounting; (4) understanding the relationship between an income statement and a balance sheet; and (5) the procedures for converting changes in accrual basis account balances into their cash flow equivalents. Furthermore, each of these elements has necessary numerous sub-elements. If, for example, a student does not have a well-developed schema identifying the difference between accrual and cash basis accounting, perhaps from insufficient emphasis in prior content, the cognitive load increases significantly. For some students, natural working memory ability can help mitigate this, but overall learning will still be less efficient because of the added element interactivity that now has to be sorted out. At the basic level, the possibilities for increased intrinsic load are numerous, primarily driven by type of content and the greater variety of student backgrounds and abilities than at more advanced levels.

Extraneous load is the unnecessary load imposed on working memory as a result of the instructional delivery method. This load lowers efficiency and impedes schema development. It makes learning unnecessarily effortful. A central theme of CLT is the reduction of extraneous load; we will see in a moment that there are a variety of very useful methods that can do this and that improve learning efficiency. Repeated experiments have demonstrated that a reduction in extraneous load can improve learning efficiency because additional working memory becomes available for processing intrinsic load and for developing schema, which in turn assist in more learning. This is a major benefit of the application of CLT principles.

Examples of extraneous load abound. Continuing with our cash flow example, load would be increased by describing how to convert accrual account balances into cash flow statement balances instead of describing both visually and verbally; combined picture and verbal communication reduces load since working memory processes them separately. (Also, an illustration usually imposes a much lower load than verbal or text, because verbal and text must be processed sequentially, which is more difficult.) Another example is departure from intrinsic load elements, as would occur with the untimely interjection of interesting, related instructor "war stories" that must be temporarily held for the first time in working memory, which increase mental load, even if they do add interest and motivation. Look at your textbook. Does it have a lot of interesting but distracting pictures, shapes, and text? Stories about accountants? Is there a great deal of complex explanatory text on a single page? Are related explanations and illustrations widely separated? Are all the chapters approximately equal length, regardless of difficulty level? All of these are extraneous input elements that create unnecessary effort for working memory.

Finally, the effort that working memory expends to comprehend material and develop schema is called germane load. This is done by much practice and repetition (at least, for most of us) in small incremental amounts that build into larger schema. With sufficient repetition, the newly created schema become automated and part of long-term memory. Germane load, as would be expected, is also a necessary load, because it contributes to, rather than interferes with learning. The activities related to germane load are essentially comprehension, practice, and then repetition and possibly development of metacognitive awareness.

Evaluating Efficiency

As yet, no generally accepted direct method has been developed that provides either an absolute or relative measure of total cognitive load. Also, there is no accepted measurement method for the individual load types. However, an indirect relative efficiency measure has been developed that has received widespread use in CLT research (Paas and van Merriënboer 1993). Essentially, the method uses a formula that compares z-score assessment results to z-score results of a mental effort questionnaire submitted by learners. There are also physiological measures. A positive result indicates improved efficiency, negative indicates decreased efficiency. The main point, however, is that the application of a metric does make it possible to indirectly measure the relative effects of CLT in numerical terms, and make it possible to create statistical tests involving different kinds of treatments. The practical results of this are the general and specific instructional guidelines that CLT can offer to educators.

GUIDELINES FOR APPLYING CLT TO INTRODUCTORY ACCOUNTING

Why try to apply CLT in introductory accounting courses? CLT research repeatedly emphasizes that optimizing total cognitive load will result in improved learning efficiency and less learner stress because the additive combination of loads does not push mental effort past the limits of a student's working memory ability (Schnotz and Kürschner 2007; Clark et al. 2006; Paas et al. 2004). This generally means optimize intrinsic and germane loads (van Merriënboer et al. 2006), and reduce extraneous load to increase efficiency and improve transfer of knowledge to problem applications. Although there are numerous potentially useful CLT research outcomes to consider, for most of us the practical resource limitations of time, money, and personal interest dictate what we can do. Furthermore, at the introductory level we deal with students having the most varied backgrounds, interests, and abilities, unfamiliar with accounting, for whom it is the most difficult to adapt instruction. In that vein, what follows are the most repeatedly validated CLT effects.

In education, of course, no single approach or theory ever resolves all issues. So as with any method, CLT can be another useful tool but does not replace other useful tools. For example, CLT concentrates on procedural efficiency but not on motivational methods. CLT research has demonstrated that many constructivist methods such as discovery learning are not efficient for novice learners. On the other hand, these methods may prove to be very useful for more advanced learners or in circumstances where critical analysis development, relating to personal interests, or broader transfer of knowledge are important, and learning efficiency or stress mitigation are not as important. An example of this in accounting education would be the case study method, in which the problem state can be both complex and ambiguous. In short, CLT improves an instructor's opportunity to rethink, expand, and fine-tune instructional methods depending on goals and circumstances. The following guidelines are presented with these considerations in mind.

Optimize Intrinsic Load with Supplementary Material

Only three possible factors affect intrinsic load: (1) the interactive complexity of the content, (2) the students' previously developed accounting schema, and (3) the students' working memory abilities. As instructors, we realistically have control of just the first variable.

Absent a complex research setting, how do we know on an everyday instructional basis whether intrinsic load is optimal? Is supplemental material necessary? On an individual level, a careful consultation with a student will offer some good clues; however, without this it's unlikely we would know at the individual level. At the class level there are some indicators. Repeated questions in specific areas of content or complaints of difficulty are indicators, as are lack of questions indicating little difficulty, where more content might be indicated. Ask students directly about difficulty or hand out a quick questionnaire. Your own experience with difficult areas in prior classes is a good indicator. You can then create supplemental content (and modify lectures) just for these areas, using CLT methods. Here are some possible guidelines for selecting the content to apply CLT:

1. Do not try to cover everything. Just target the content that you consider to be foundation elements or those that you know will be difficult for most students. Tailor your efforts to specific areas. You are optimizing key areas, not developing or paying for a tutoring system. For example, in a first course I consider initial transaction analysis to be foundational and I also know that many students will have course-critical difficulties with adjusting entries. Therefore, I have designed lecture and reading content especially for these topics.
2. Reconsider total content priorities. Reducing content reduces load. This is difficult. However, perhaps it might be useful to consider that additional content may reduce the acquisition of overall content. One particularly sensitive area may be critical thinking and/or research assignments. What is the balance of priorities between procedure competence such as transaction analysis and adjusting entries, and critical thinking and research development? Will greater or lesser specific knowledge acquisition in fewer areas in this class prove to be a greater benefit for other classes or for other student objectives?

Apply the Chunking Principle

Once targets have been evaluated, intrinsic load can be optimized by applying the chunking principle. Chunking is a way of reducing intrinsic load by carefully segmenting complex content into fewer interacting elements of information, with a manageable chunk generally considered to consist of not more than about 4 +/– elements. Chunking requires something that is not often done: a careful identification of all the interacting elements of a topic, so that they can be separated and sequenced. For written and visual material, this allows the reader to maintain a reduced number of interacting elements in working memory for each part of the schema acquisition.

As an example, let's take just one topic within the very content-rich subject of adjusting entries: prepaid expenses. As a point of reference, take a look at your textbook. What your students probably have to rely on for prepaid expense adjustments is about two pages that include text and perhaps two journal and/or T-account examples. As an instructor, that text coverage seems reasonably clear and logical, especially when reinforced with some lecture. However, for some students, transferring this information into successful problem solutions can be difficult because the required schema consists of many more potential chunks lurking within those two pages than are readily apparent, such as: (1) defining and identifying a prepaid expense; (2) how and when a prepaid expense is created; (3) why prepaid expenses require adjustment; (4) timing of the adjustment; (5) distinguishing prepaid expense account problem states from five other possibilities—unearned revenue, depreciation, accrued revenue, accrued expense, no adjustment required—in various presentation formats; (6) calculating the amount of the adjustment; (7) the structure of the adjusting entry; (8) the effect of the entry on accounts; and (9) the effect and absence of the entry on financial condition (the accounting equation).

Let's take a look at chunk #6. This involves matching a calculation process with a particular type of prepaid expense problem state. Chunk #6 consists of three other possible chunks. The relevant calculation methods can be: (1) the asset cost remaining, (2) the asset cost used up, and (3) the cost per unit of the asset. Further, these elements can be presented in different ways, such as fractions, percent, beginning and ending account balances, physical units, time units, and work units. Does this seem somewhat tedious? Remember, identification and process recall reside within your schema: first your expert schema identifies a familiar problem state, and then it easily recalls the calculation protocol. Yet, for some students—particularly those with minimal schema and lesser multi-element working memory capacity—load will be high and schema formation slow because there is an unfamiliar problem state requiring analysis of many interacting elements. However, once we identify chunk #6, we can create visually simplified figures that separate the elements. The example illustration in Figure 1 facilitates schema development by chunking information and showing an analytical process.

As noted, Figure 1 addressees only prepaid expense chunk #6. The other elements can be chunked into more parts as well, some simple and some more involved, depending on the particular element. For example, #1 should show a series of account names that are examples and non-examples. Chunk #5 is much more complex, requiring a variety of identification examples and identification practice, without any actual calculations.

The Expertise Reversal Effect and Learner Control

One of CLT's interesting and perhaps counter-intuitive findings is that more explanations are not always better, and in fact can add cognitive load and reduce learning efficiency (Kalyuga et al. 2003). Therefore, more chunking is not always better; what is best depends on a student's level of schema development. Although this effect is usually categorized as extraneous load, the effect

FIGURE 1
Look for the Three Information Types

Panel A: First Type

If you have this information ...	then, to calculate the adjustment...
1. The asset cost still remaining...	a. subtract the asset cost actually remaining from the unadjusted account balance. b. ***sometimes*** you first might have to calculate the asset cost remaining or the unadjusted account balance.

Examples

a. "At year end when financial statements are prepared, the balance of prepaid insurance in the unadjusted trial balance is $3,000. The actual amount remaining unused is $300." Calculation:
$3,000 - $300 = <u>$2,700</u> adjustment.

b. "The beginning balance of the supplies account is $700 and $4,500 of supplies were purchased during the year. No uses have been recorded. 20% of the available supplies remain unused at year end." Calculation:
Step 1: $700 + $4,500 = $5,200 unadjusted account balance (debit balance).
Step 2: $5,200 x .2 = $1,040 calculate the asset cost **actually remaining**.
Step 3: $5,200 - $1,040 = <u>$4,160</u> the adjustment.

(continued on next page)

FIGURE 1 (continued)

Panel B: Second Type

If you have this information …	then, to calculate the adjustment…
2. The asset cost used up…	a. the dollars of cost used up is given to you – no further calculation. b. ***sometimes*** you might have to calculate the portion of the asset used up.

Examples

a. "At year end when financial statements are prepared, the amount of supplies used up is $2,700." Calculation:
No calculation is needed. The amount of the adjustment is given to you.

b. "During the year a company purchased $5,200 of supplies. By year-end, 80% of the supplies had been consumed." Calculation:
$5,200 x .8 = $4,160 adjustment (portion of the asset **used up**.)

Panel C: Third Type

If you have this information …	then, to calculate the adjustment…
3. The cost per unit of the asset...	a. multiply cost per unit by the units used up. b. ***sometimes*** you first might have to calculate the cost per unit.

Examples

a. "A company purchased an insurance policy on April 1 for $3,000. The cost of the insurance is $300 per month. Financial statements are prepared only at December 31, year end." Calculation:
9 months used x $300 = $2,700 adjustment.

b. "A company paid $5,200 for 10,000 gallons of lubricating oil supplies. By year end when financial statements are prepared, the company had used 8,000 gallons of oil."
Calculation:
Step 1: $5,200 / 10,000 = $.52 per gallon **cost per unit**
Step 2: 8,000 gallons used x $.52 = $4,160 adjustment.

closely relates to our discussion of chunking. When reading through the chunked detail for prepaid expenses, you might have noticed feelings of impatience or distraction. This is because the level of detail is unnecessary for you and interferes with the further development of your well-developed schema in this context. For a student with well-developed schema (expertise), the benefits of chunking reverse and create inefficiency.

This can be particularly important in an introductory class, which generally contains the widest variety of student backgrounds, including some students with prior accounting or bookkeeping knowledge. Individual schema development will certainly progress at very different rates for different students. Therefore, a single inflexible level of detail (one way or the other) is practically guaranteed to create learning inefficiencies. In order to optimize intrinsic load with chunking while avoiding negative expertise reversal effects, learner control should be built into text/visual content (unfortunately, not possible with lecture). This means that at key points in the standard material, a reader is given the opportunity, but not directed, to move on to problem solving or to new material. A short, targeted problem can also assist the student in the decision.

This may sound somewhat like a tutoring system. However, the requisite factor in this discussion is what we could call "adaptive chunking." A design delivering content in some other manner will not be efficient, although it may still be useful. Recent developments in intelligent tutoring systems, which provide responses based on diagnosis of error types and problem-solving processes, are making progress in this area, including in accounting (Phillips and Johnson 2011; Baxter and Thibodeau 2010). These systems, which do appear to be beneficial, however as yet do not replace textbooks, are expensive to develop, and in some cases are adopted simply to reduce grading time rather than increase learning efficiency. As technology improves, we may hopefully arrive at the "ultimate e-book" in which a well-written online text incorporates adaptive chunking methods and rich problem feedback. Whether we would then have a text, an intelligent tutoring system, or something else may at that point simply be a question of semantics.

Reduce Extraneous Load in Written Material

Reduction of extraneous load provides the greatest opportunity for improved learning efficiency by managing instructional design; this type of load appears in many forms. Common examples are long expository paragraphs, exposition in lieu of illustration, and problem solving that is required too soon. Recent CLT research has identified numerous extraneous load types and corresponding mitigation mechanisms. The discussion of worked examples that follows suggests approaches for incorporating extraneous load reductions that can be useful for developing instructor-designed supplementary content. Extraneous load reduction is also applicable to web content instructional design; however, that is beyond the scope of this paper.

Develop More Worked Examples

The use of worked examples was the first mechanism discovered to reduce extraneous cognitive load. There continues to be extensive CLT research into what is called the "worked example effect." In general, most educators are probably quite familiar with the utility of showing examples. However, what is being suggested here is that because CLT offers evidence that worked examples reduce load while standard exposition and problem solving increase load, it is probable that a material benefit will result by providing more worked examples instead of just more exposition or problem assignments (Kalyuga et al. 2010)—"material benefit" here meaning greater mental processing efficiency as well as a greater generalized understanding resulting from more examples studied. As above, this is subject to learner control in order to adapt to specific learner needs and to avoid the expertise reversal effect. Examples can consist of a stand-alone supplement, or what requires more work, incorporating worked examples with chunked exposition as described above. An important caveat: the same chunking idea applied to exposition should be applied to worked examples. A complex example with a complex, high-element interactivity solution does not reduce extraneous load.

Research suggests two ways to enhance the efficacy of worked examples: identification of process steps and fading. An example of process steps is illustrated in Panel A of Figure 1. "Fading" means following the worked example with a duplicate problem showing the solutions in steps, with solution steps incrementally omitted. There are different fading techniques, but here is one example for Panel B:

> "The beginning balance of the supplies account is $500, and $6,500 of supplies was purchased during the year. No uses have been recorded. 60 percent of the available supplies remain unused at year end." Calculation:

Step 1: $500 + $6,500 = $7,000 unadjusted account balance (debit balance).
Step 2: $7,000 × 0.6 = $4,200 asset cost actually remaining.
Step 3: What is the amount of the adjustment? ________________

The student is shown the solution. If the student correctly calculates the solution, we proceed to the solution of the next step, as below. If the solution is incorrect, the student is shown the solution and referred back to the example and then tries again. This process continues until all steps are successfully completed.

Step 1: $500 + $6,500 = $7,000 unadjusted account balance (debit balance).
Step 2: What is the asset cost actually remaining? ______________.
Step 3: What is the amount of the adjustment? ________________

The greatest benefit occurs when worked examples/fading are paired with an unsolved problem for which a complete solution is available. In this case the student not only efficiently develops a schema in the learning process, but also improves the ability to transfer this knowledge to a wider range of similar situations, particularly if a number of examples and problems contain moderate variability; for example: "No uses have been recorded" is replaced with "There are no credit entries in the account" in a different example (Paas 1992; Cooper and Sweller 1987; Paas and van Merriënboer 1994). Again, it is worth noting that this design is applied before any problems are assigned, since for many novice learners jumping from exposition to attempting problems is not an efficient way to develop schema for a specific problem-solving procedure. As performance improves, the faded examples should be reduced and more stand-alone problems required.

Reduce Extraneous Load in Your Textbook

What has already been described also applies to the evaluation of textbooks when looking at content design. Unfortunately, many of the elements may be unavailable because of development and printing costs, and because most participants in instructor focus groups used by publishers are still unaware of cognitive load theory instructional design. It is for that reason that this paper suggests supplemental material development. However, here are some additional load-reducing tips that should be helpful for evaluating existing textbooks. The following effects have the greatest impact on lower-knowledge, novice learners.

Split Attention Effect

A graphical presentation with a related textual explanation that is presented separately creates extraneous load. If the illustration requires written information, succinct text should be integrated into the illustration (Mayer 1997). The more illustrations that are created in this manner, the lower the overall load will be.

Redundancy Effect

If an illustration can stand alone, related text should be eliminated. In other words, there should not be any restatement in text if an illustration or table is self-explanatory (Chandler and Sweller 1991; Craig et al. 2002). Look for text that repeats what already appears to be clear from an illustration. This will be adding unnecessary load.

Modality Effect

Is a supplement available that presents content in a simultaneous auditory mode with related on-screen illustrations? This is similar to a lecture, but should be clearly targeted to specific procedures, such as "how to . . ." Processing is improved and extraneous load is reduced when an illustration and related auditory input are combined simultaneously (Paas et al. 2004).

Assigning Homework

Feedback Effect

Homework assignments are an integral part of every accounting class. Homework problems reinforce schema and develop the ability to apply content to problem situations (this is called "transfer"). However, the manner in which homework is assigned has a significant impact on learning efficiency. First, as already described, for novice learners it is more effective to first pair faded worked examples with unsolved problems. Second, it is important to provide solutions to the assigned problems unless they are being used exclusively as an assessment tool. The nature of a solution is important. Feedback effect research suggests that minimal "right" or "wrong" feedback is inefficient for schema development, while immediate, fully explanatory "rich" feedback is not only efficient for schema development, but at the same time does not create an expertise-reversal effect for the more advanced learners while clearly helping novice learners. This is called the "feedback effect." In fact, one of the few research papers applying CLT theory in the accounting education context has confirmed this effect in an accounting principles course (Halabi 2006).

Online Homework

Some publishers of introductory textbooks have begun to address homework by developing online algorithmic problems with solutions that they offer when a book is adopted. This is clearly a potential improvement from an instructional design viewpoint; however, there are issues to consider here as well. First, the distractions of the systems at present can impose a significant additional cognitive load for many students, especially those unfamiliar with the medium or the system. Second, the solution feedback remains relatively limited, constraining the benefit provided. References back to text or other data locations increase cognitive load. Finally, although not a pedagogical issue, the development costs of these systems are substantial and are, of course, being recovered as part of increased textbook prices, thereby shifting the cost of the newly created "more productive time" for instructor benefit over to the students. For this reason, among others, numerous university departments still prefer to use student graders.

SOME ACCOUNTING RESEARCH BENEFITS

The existing amount of CLT research plus the widespread application of CLT methods in many contexts are suggestive that CLT may have something useful to offer for accounting education research. Some possible implications follow here.

Possible Research Implications

First and foremost, an understanding of CLT and its research results may strengthen accounting education research. This is not to imply that incorporation of any CLT-type language is necessarily useful; however, an ability to utilize what are potentially valuable research results might be: making an accounting research design more robust and comprehensive, and perhaps even offering additional validation. Second, CLT may spark new accounting research ideas. Possibly looming largest are the instructional design implications created by discoveries concerning differences between novices versus more advanced learners. What are the content and delivery method trade-offs at our different course levels and how can we best adapt? Other possible examples within an accounting context might be applying learning efficiency metrics for particular instructional designs for particular courses, or investigating whether CLT methods can be used to train field-dependent learners to adapt to more unfamiliar problem states (Jones and Wright 2010) in accordance with the AECC emphasis on dealing with unstructured problems. Third, knowledge of CLT research might serve to modify the interpretation of accounting education research results. For example, could an expertise-reversal effect help explain differences in outcomes between groups? Would experimental outcomes with more advanced learners be applicable to novice learners?

Absence of CLT in Accounting Research

Currently, there does not appear to be a widespread awareness or inclusion of cognitive load theory in accounting education research. In order to obtain some indication of the extent to which CLT is currently and has been previously used in accounting education research, the following protocol was used: (1) To determine the extent to which CLT has been applied in recent accounting education research, journal articles from the top journals during the last 10 years were reviewed. (2) To obtain an idea of the current level of interest, accounting education presentations from a the 2010 AAA Annual Meeting were classified by topic (Table 1). (3) As a final step, a general Internet search was conducted.

In order to identify a working approximation of the frequency of use of CLT in recent accounting education research, a journal search was performed. Specifically, the search protocol consisted of review of the following journals: *Issues in Accounting Education*, *The Journal of Accounting Education*, *Accounting Education: An International Journal*, *Advances in Accounting Education*, and *The Accounting Educators' Journal*. All journal titles and abstracts were reviewed for the past ten years, specifically from 2000 to the most recent issue available in 2010. In cases where the title or abstract indicated the possible testing, investigation, or application of a key CLT element, the article itself was reviewed. As a further cross-check to the above journal review, the most recent published accounting literature reviews for the same time period were used as additional sources. These covered 2000–2002 (Watson et al. 2003) and 2003–2005 (Watson et al. 2007). The sources used for these reviews were: *Journal of Accounting Education*, *Issues in Accounting Education*, *Accounting Education: An International Journal*, *Advances in Accounting Education*, and *Global Perspectives on Accounting Education* (for 2003–2005 period). Finally, a general online search was conducted using search terms related to CLT and accounting. The goal of the review and search was an approximation of the degree to which published accounting education research is attempting to first identify, and then directly incorporate or at least evaluate key CLT elements (not the language or vocabulary) in an accounting context, and not to identify every project in which some CLT element may have been coincidentally or indirectly related. No search was conducted for dissertation theses applying CLT principles.

The results of the literature review indicate that despite the CLT advancements during the latest ten-year period, there has been little notice of the CLT data in the world of accounting education research. In fact, the review identified only two articles applying CLT principles to accounting

TABLE 1

Summary of 2010 AAA Annual Meeting Teaching and Learning by Primary Topic

Teaching and Learning Topic	Research Papers	Boards	Total
Case study use (various courses)	14	8	22
Constructivism/active learning	3	10	13
Introductory accounting course content and instruction	3	8	11
IFRS content integration	4	7	11
Managerial course content and instruction	1	9	10
Internships/transition to practice	8	1	9
Computer learning technology	4	5	9
Auditing course content and instruction	3	6	9
Developing hybrid (online) courses	0	9	9
Student self-assessment and meta cognition	5	3	8
Ethics: Integration into content/student behavior	7	1	8
Student motivation	4	2	6
Intermediate accounting course content and instruction	2	3	5
Sustainability content integration	2	3	5
Using research in the classroom	3	1	4
Use of social media	3	1	4
Evaluation of online instruction	3	1	4
Learning styles	3	0	3
Homework	3	0	3
Faculty development	3	0	3
Advanced accounting course content and instruction	2	0	2
Accounting information systems course content and instruction	0	2	2
CLT direct application	2	0	2
Accounting theory course content and instruction	1	0	1
Recruitment of good students	1	0	1
Various other	8	19	27
Total	92	99	191

instructional design. One of these was published in *Issues in Accounting Education* (Halabi et al. 2005) and the other in *Global Perspectives on Accounting Education* (Halabi 2006). There were some additional CLT application articles in other journals, primarily related to auditing, in a non-academic context.

Table 1 shows primary topical areas presented and provides an indication of the most current areas of interest in accounting teaching and learning research as determined by projects submitted and editors' selections. In some cases, there may be a small degree of topic overlap (for example, IFRS can be integrated into various courses). The data were obtained from program listing and abstract reviews, by conference participation, and in some cases review of copies of individual papers to verify the essential research focus. The data relate only to the teaching and learning research elements of the conference that are from papers, panels, boards, and emerging and innovative research project listings. The purpose of the table is to simply indicate areas of interest and activity, and not to judge importance or quality of any topic or item. In this sense, each column is weighted equally by presenting a topic total column. The table indicates that 2 of the 200, or 1 percent, of the total projects contain a direct application of CLT principles as a central element or hypothesis. These two projects considered the constraints of working memory and methods to reduce cognitive load within the context of introductory accounting topics (Johnson et al. 2010;

Phillips and Heiser 2010). Three additional papers primarily addressing other topics coincidentally included elements of CLT that were indirect in nature and may have related to reported outcomes.

CONCLUSIONS

Developing an awareness of cognitive load theory and its research results presents two great opportunities for accounting educators. First, there are validated research results that clearly have classroom potential. This makes it possible to adapt to some key differences in the learning processes between novice and more advanced learners, as well as to increase learning efficiency at any level by reducing extraneous load. Second, an awareness of CLT can strengthen accounting research designs by utilizing applicable CLT research results, can stimulate new accounting research ideas, and possibly provide more reference points to interpret results.

Every theory has its weaknesses and contradictions; CLT, despite its usefulness, is certainly no exception. For example, generally accepted direct measures of cognitive load types have yet to be developed, and more work is needed to clarify how CLT applications might optimize near-, medium-, and longer-term knowledge transfer, possibly in combination with other methods. We can also be sure that over time CLT will change, evolving into newer, better ideas and applications. Therefore, perhaps an additional conclusion for accounting educators should be that in addition to the challenge of maintaining competence within our own domain, we also continue an awareness of the future developments in CLT and the field that created it.

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