Structured Word Inquiry:

Vocabulary instruction that is well adapted to the cognitive architecture of elementary students

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"...[I]n order to be effective, instruction has to be adapted to the structure and functioning of the learners' cognitive architecture." (Shnotz & Kurshner, 2007)

The above quote describes the fundamental claim of Cognitive Load Theory (CLT). This claim also provides the framework for this paper that investigates how well a particular model of vocabulary instruction meets the challenge put forward by this theory of learning and instruction. The instruction in question exploits the consistent and coherent spelling/meaning structure of written morphological structure in English to support vocabulary learning, and was investigated in an intervention study by the author.

In order to investigate how well this instruction fits with the cognitive architecture of learners, a background in this instruction and CLT is needed. First a brief summary of the relevant research on vocabulary instruction is offered along with a short description of the instruction and results of the intervention study. Second is an overview of CLT and what it suggests with regard to understanding of learning and instruction. The presentation of that theory from Shnotz and Kurshner's (2007) review receives particular attention. The key terms and concepts of CLT that are used in the analysis of the vocabulary instruction are addressed in this summary as well.

That background sets the stage for the main body of the paper. In this section, a detailed account of the instructional design and process used in the intervention is interwoven with descriptions of how that instruction links to learners' cognitive architecture as outlined by CLT. It is not claimed that this intervention study provides empirical evidence of CLT, or that the gains that were found in the intervention are necessarily the result of the processes described by CLT. However, it is argued that this instruction meets the challenge it puts to designers of instruction. It will be shown that the instruction about morphological structure as a tool for vocabulary development in this intervention provides a tight fit with structure and functioning of the cognitive architecture of students in the process learning to become effective users of the written word.

It is further suggested that CLT offers researchers an important tool for evaluating literacy instruction. There is great pressure for researchers to identify “best practices” for literacy instruction. In part, this paper suggests that there are two metrics researchers and educators should draw on to better understand and improve literacy instruction that has already been verified by intervention studies. One metric available is to assess how well a given instruction matches, or can be adjusted to better match, the cognitive architecture of the learner. The other is to assess how well instruction about the written word represents, or can be adjusted to represent, the linguistic structure of how English spelling represents meaning.

Background on vocabulary instruction research

The vocabulary children learn during elementary school represents a staggering achievement. A number of researchers (e.g., Anglin, 1993; Biemiller, 2005) estimated that, on average, children at the end of Grade 2 understand about 6000 root word meanings, and that by the end of Grade 6 that number grows to about 10 000. Such estimates are far from exact. Quantifying such information is complicated by many factors including varied definitions of what it means to know a word and what counts as a word or word family. Regardless of the exact quantity, it is clear that children are faced with learning a great number of words in a relatively short period of time.

Two other facts established by the research should be kept in mind when considering vocabulary development and instruction. One is that vocabulary knowledge plays a fundamental role in literacy development and therefore scholastic success (National Reading

Panel, 2000). Secondly, a child's social economic status is critical determinant of vocabulary knowledge (Hart & Risely, 1995; Biemiller, 2005). This dynamic is not hard to understand. The stronger oral vocabulary associated with children of middle and upper class supports reading success (Biemiller & Slonim, 2001). Successful readers are exposed to more text because they read more, which in turn expands those students' written word vocabulary, thus encouraging still more reading success. All the while, students who begin the process of learning to read with an impoverished vocabulary, fall further and further behind their advantaged peers, not only in reading, but in all the content areas that depend more and more on independent reading skills (Beck, McKeown & Kucan, 2002).

A striking feature of the vocabulary learning that children achieve is that it occurs despite the fact that that school curricula appear to place little emphasis on explicit vocabulary instruction (Beck, McKewn & Kucan, 2002). Citing conclusions on the state of classroom vocabulary instruction by the National Reading Panel (2000), Biemiller and Boote (2006) noted critically, "Current reading instruction is apparently premised on the view that children can build the vocabulary they need after learning to read (decode) fluently, as little or no vocabulary instruction occurs during the primary grades" (p. 44). Biemiller also highlighted the lack of effectiveness of schooling for vocabulary development by pointing to research (Cantalini, 1987; Morrison, Williams, & Massetti, 1998) showing that the vocabulary knowledge of similarly aged older kindergarten children and younger Grade 1 children is similar, as is that of older Grade 1 and younger Grade 2 students. They found that unlike other academic skills, attendance at school is not a major source of vocabulary acquisition. "In short, vocabulary levels diverge greatly during the primary years, and virtually nothing effective is done about this in schools (Biemiller, 2004, p. 29).

Although the National Reading Panel (2000) emphasized vocabulary instruction as a crucial aspect of literacy instruction, it cited lack of sufficient research to recommend any particular strategy over another. Currently, two prominent but conflicting vocabulary instructional strategies have garnered substantial interest. On one hand Biemiller and collegues (Biemiller & Slonim, 2001; Biemiller & Boote, 2006) favour explicit shallow instruction of a large quantity of vocabulary judged to be important for understanding grade level content. As evidence, they cite intervention studies using brief word explanations to build knowledge of those words (e.g., Biemiller & Boote, 2006; Nicholson & Whyte, 1992; Senechal, 1997; Senechal & Cornell, 1993; Stahl, Richek, & Vandevier, 1991). The "shallow but wide" view of vocabulary instruction reasons that a brief exposure to a large quantity of words, followed by repeated encounters with those words in the context of typical class work, is the best way to support learning of the massive quantity of vocabulary words children face. It is not assumed that the brief explicit instruction will, in itself, provide a deep understanding, but that this type of exposure will help students begin to integrate many of those word meanings into their understanding more deeply as they run into them in the course of later instruction.

A different recommendation comes from other researchers (e.g., Beck, McKeown & Kucan, 2002; Blachowicz & Fisher, 2000). They emphasize careful selection of a small set of vocabulary words and teaching them repeatedly in rich and meaningful contexts. In part this links to the notion of developing "word consciousness" where students build an awareness and interest in how to learn about words (Blachowicz & Fisher, 2006; Graves, 2006; Scott, 2005). Researchers emphasizing deep, rich instruction of fewer carefully selected words cite evidence showing that instruction that combines definitions with other active processing tasks is more effective than instruction of definitions alone (e.g, Beck & McKeown, 1983; Blachowicz & Fisher, 2000).

There is yet another instructional strategy widely argued to be essential to an overall vocabulary instruction program. Many researchers emphasize the importance of teaching children specific skills for independent word learning (e.g., Baumann, et al., 2002; Henry, 1988, 1989, 2003, Nagy, 2005; National Reading Panel, 2000; Pressley, Disney & Anderson, 2007, Scott, 2005; Templeton, 2004). Two teaching strategies targeting this goal are teaching children how to learn new word meanings (a) from context, or (b) from analysis of meaning cues from word parts (morphological analysis). Given the scale of the vocabulary learning task, these are highly compelling strategies to pursue. While there is research evidence supporting these approaches, it remains limited and inconclusive (Blachowicz, Fisher, Ogle & Watts-Taffe, 2006). This paper focuses on the second form of word learning instruction – the effect of teaching morphological structure as a word learning tool.

Background on instruction under study

The instruction at the centre of this paper, which will be analyzed from a cognitive load perspective, was used in an intervention study (Bowers & Kirby, 2006) that looked at the effect of teaching about the morpho-phonological structure of written words to Grade 4 and 5 students (N = 82). Participants in this study completed a standardized vocabulary pre-test measure as a control and were randomly assigned to treatment and control conditions. Treatment consisted of twenty 50-minute classroom sessions addressing the building-block nature of morphemes (bases and affixes) that use consistent spelling despite pronunciation shifts (e.g. *sign* / *signal*). The three suffixing patterns, and the role of base words and bound bases (e.g. *struct* for *structure*) were taught through a problem-solving approach described as "structured word inquiry" while the control group continued with regular instruction. After controlling for initial vocabulary, a significant instructional effect was found for vocabulary knowledge on words that were taught directly in the intervention, and for novel words that were built on bases that were taught in the context of other derivations. No effect was found for words with an untaught base. Effects for morphological analysis skill were found for all three word categories.

Given the limited evidence of intervention studies successfully teaching word learning strategies, it is important to look closely at instruction that succeeded in improving vocabulary knowledge for words that were not explicitly taught. It may be that the match between this written word instruction and the cognitive architecture as described by CLT provides insight into why these word learning skills were successfully understood and applied by students in this intervention.

Background of CLT

CLT was based on research about how students learn to solve problems (Sweller, 1976). This work questioned a common assumption at the time that the best way for students to learn to solve problems was to have them practice solving problems. Evidence of an improved strategy for teaching problem-solving was identified by Cooper and Sweller (1987) who used "worked out examples" as a strategy for teaching learners how to solve algebra problems. In this approach students were presented with well organized solutions of algebra problems. Studying the structure of a solved problem allowed students to focus on the elements involved in an algebraic solution without simultaneously struggling to solve a complex problem that was new to them. A key finding was that use of worked out examples of algebra problems led to improved solving of *novel* algebra problems. It was reasoned that a benefit of worked out examples was that they greatly reduced the load on working memory brought by novel problem-solving tasks, thus allowing learners to focus cognitive processing on the structure of algebra problems. Sweller (1998) and Sweller, Marrienboer and Paas (1998) introduced *cognitive load* as a term to describe the working memory resources in terms of the memory storage and information processing required to learn particular material or to perform a particular task.

CLT defines learning as a change in long-term memory. Without a change in long-term memory, learning has not occurred. One way to affect long-term memory is to apply enough of the limited processing capacity of working memory on a task in such a way that it results in the formation of coherent “schemas” in long-term memory. Interconnected knowledge in a schema is believed to aid learning of new information by greatly reducing cognitive load. When first brought into working memory, each component unit of information brings a cognitive load equal to one unit of cognitive processing. After schema construction, the understanding represented by those units of information is maintained, but it is integrated into a set that carries only one unit of cognitive processing all together. In this way a learner can bring increased understanding into working memory to make sense of new information with little increase in cognitive load. Because processing capacity in working memory is limited, schema building in long-term memory enables understanding of new and complex information that would not otherwise be possible.

For example, imagine a learner trying to understand the concept of square roots. If that learner does not have easy access to common multiplication and division patterns held in well formed schemas in long term memory, they would have little chance of understanding that square root problem. The constraints of working memory processing would make it impossible to learn the concepts of multiplication, division and square roots simultaneously. However, if knowledge of multiplication and division patterns is well-established in long-term memory, the learner has a much greater chance of success. Knowledge of multiplication and division patterns can be brought into conscious processing in working memory with little additional cost to cognitive load. The learner can focus more conscious processing on making sense of a new concept with the aid of "free" prerequisite knowledge. Successful understanding is unlikely when limited cognitive processing is divided into making sense of multiple unknowns.

Using worked examples of solutions to understand algebra problems, or building automatised knowledge of component math concepts (via well formed integrated schemas of knowledge in long term memory) are both instructional strategies that match the cognitive architecture of learners. They make relevant knowledge for learning a particular task available at a reduced cost to working memory. The learner is able to maximize the limited cognitive resources in working memory to target making sense of fewer unknowns at one time.

(Note: A file with a step by step animated representation of the process described by CLT can be downloaded from: http://web.mac.com/peterbowers1/iWeb/Site%2019/CLT%20PPT.html)

Overview of CLT terms and concepts relevant to the current instruction

Cognitive schemata.

Cognitive constructions held in long-term memory that reduce the cognitive burden when brought into working memory by categorizing multiple elements of information as a single element.

Types of cognitive load.

1 – *Intrinsic load* is the cognitive load imposed by the nature of a task. It is determined by the complexity of the information that must be processed for a given learner's prior knowledge.

2 – *Extraneous load* is unnecessary processing caused by inefficient, inappropriate instruction.

3 – *Germane load* is the cognitive processing required for the formation of schema in long-term memory. Shnotz and Kürschner (2007) expand on this typical definition by defining germane load as, "…the portion of working memory capacity occupied by cognitive processes such as using specific learning strategies, schema abstraction, cognitive restructuring, or meta-cognitive monitoring which exceed the task requirements and are therefore additional cognitive processes intentionally aiming at improving learning" (p. 497).

Constraints on germane load.

Shnotz and Kürschner (2007) describe three constraints on germane load:

1 – Working memory capacity: Since germane load is the working memory processing required to build schema in long-term memory, germane load is constrained by working memory capacity.

2 – Intrinsic load and germane load: Since germane load processing is assumed to require deep meta-cognitive reflection, a simple task will not provide the complexity needed for such processing.

3 – Motivation and germane load: Motivation is seen as a critical component of germane load as a learner 's willingness to apply mental resources for the additional strategic cognitive processing to enhance learning determines whether or not they will choose to engage in the germane load processing necessary for schema construction.

Managing three types of load for effective instruction.

Since learning is seen as change in long-term memory, the goal is to design instruction so that it maximizes germane load and reduces extraneous load for a given learner. Intrinsic load is set by the nature of the task. Shnotz and Kürschner (2007) emphasize that effective instruction will manage intrinsic load by designing, choosing and presenting tasks according to a learner's level of expertise. They draw on Vygotzky's (1963) zone of proximal development (ZPD) as a guide for targeting the appropriate level of internal complexity (intrinsic load) of a task for a given learner. For example, they caution that the intrinsic load brought by the content and presentation of a task may be well suited for a learner with expertise in a given area, but result in extraneous load for another learner with less prior knowledge. Similarly, reducing intrinsic load of a task by means of learning supports (*scaffolding*) may be appropriate for a novice, but reduce the germane load for a more expert learner. Those supports can deny the opportunity for an expert learner to engage in deeper cognitive processing necessary to establish schema in long-term memory (Shnotz & Rash 2005). *Fading* is a strategy used to encourage deeper processing once a novice has gained sufficient knowledge for a given task originally presented with extensive scaffolding.

Scaffolding and fading.

As indicated above, these terms relate to the presentation of a task where initially, support for the conscious processing of concepts involved in a new task (*scaffolding*) allows a novice to successfully perform it, but that support is gradually removed (*fading*) until the learner can perform the same task without support.

Split-attention effects.

If the learner needs to look to far away in time or space for supports for a new learning task, the load on working memory is too great. Instead, effective instruction for novice learners embeds such support fully in the learning task (Chandler & Sweller, 1992).

Presentation and practice.

Continuous mix of presentation and practice supplies the learner with supportive knowledge just as that information is relevant for a given task, thus supporting schema development (Merrienboer, Kirshner & Kester, 2003).

Knowledge compilation and *strengthening.*

The process called *knowledge compilation* constructs automated schemas for procedural information. In this process active information in working memory is embedded in representations that are highly domain specific. *Strengthening* describes the process whereby a schema accumulates strength each time it is successfully applied (Anderson, 1993).

Multiple channels for visual, auditory and motor information into working memory.

It may be that memory is improved by presenting material through multiple modalities. Mousavi, Low and Sweller (1995) found that presenting information in an auditory and visual mode rather than in an only visual mode improved performance. Shnotz and Kürschner (2007) argued that the role of perceptual learning and behavioral learning (motor learning), play an important role even in school learning.

Instruction strategies matching learners' cognitive architecture.

The following activities were listed by Shnotz and Kürschner (2007, p. 496) as tasks that facilitate germane load by aiming at intentional learning beyond simple task performance by forming coherent schema in long-term memory:

- conscious application of learning strategies (i.e. strategies, which are not automated yet),
- conscious search for patterns in the learning material in order to deliberately abstract cognitive schemata (i.e. mindful abstraction) and create semantic macrostructures,
- restructuring of problem representations in order to solve a task more easily (i.e. by 'insight'),
- meta-cognitive processes that monitor cognition and learning.

In the presentation of the word structure instruction that follows, illustrations of each of these instructional activities can be found, along applications of all the concepts described above. Such activities explicitly aim at promoting learning beyond the specific word structure task at hand, thus placing demands on working memory beyond the immediate requirements of simple task performance. Although this cognitive load is not required for the task at hand, it is not considered extraneous load. Instead, because it is specifically designed to facilitate schema construction about knowledge pertaining to that task, this cognitive processing is considered to be germane load.

The actual word structure tasks themselves could be thought of as a kind of scaffolding used to support the deeper, more generative task of causing productive changes in long-term memory (schema building), which in turn can be used for making sense of word meanings in the future. This process of using specific tasks to target deeper understanding echoes a view of education described by Alfred North Whitehead, "The problem of education is to make the pupil see the wood by means of the trees" (Whitehead, 1929/1957, p. 6). This metaphor effectively describes the picture of learning described by CLT. It also describes how the structured word inquiry of this intervention targeted understanding of how the spelling system marks meaning (the wood) by means of teaching the structure of specific sets of words and word families (the trees) which reveal that system.

Structured word inquiry and CLT

First a brief outline of the general instructional design and learning goals of the word structure lessons of the intervention study is provided. With that framework established, a detailed account of the first few lessons is offered. These lessons introduced children to the spelling structure/meaning connection, and took them through the overall pattern of instruction used for each major orthographic concept. Woven into that detailed account are descriptions of how this instruction fits the learner's cognitive architecture as described by CLT.

An integrated macro and micro instructional design

Each lesson in the intervention targeted understanding of written word structure with dual, mutually reinforcing learning (schema building) goals in mind. At a macro level, each lesson aimed at establishing, then deepening and expanding students' understanding of the same fundamental overarching principles of written word structure. Varied learning tasks at the micro level targeting specific, narrower linguistic concepts and patterns (e.g. bases, affixes, suffixing patterns) were used to build that wider general understanding. This can be thought of as an example of instruction targeting germane processing through "conscious search for patterns in the learning material in order to deliberately abstract cognitive schemata (i.e. mindful abstraction) and create semantic macrostructures," noted above. Thus, if successfully integrated into long-term memory, schema developed via these micro learning goals were designed to (a) facilitate the learning of further (micro) linguistic concepts and processes, and (b) act as illustrations or "hooks" to establish, reinforce and deepen understanding of the overarching (macro) learning goals regarding fundamental principles of written word structure.

Expertise in both of these levels of linguistic understanding is mutually reinforcing. As expertise grows, the learner has developed schema that enables understanding of more and more complex features of written word structure. In line with CLT's application of Vygotzky's zone of proximal development, the intrinsic load of the content of instruction was steadily increased in step the learner's growing understanding of word structure.

There were two main macro learning goals of this instruction which were targeted in some way in each lesson. One was to develop a clear understanding of the fundamental linguistic principle that English spelling represents meaning in an ordered and predictable way through the consistent spelling of morphemes despite pronunciation shifts. The second macro learning goal had to do with developing a productive learning attitude with regard to understanding the writing system. The instruction aimed to build children's awareness that this system can be investigated for meaning cues via problem-solving strategies along with the skills to apply these strategies. Optimal integration of these two learning goals would be represented by the establishment of a learning environment where students were regularly internally motivated to engage in skillful productive, word structure investigations independently and/or to actively seek co-learners for such investigations.

Cognitive processing costs of building schema that contradicts prior knowledge

An additional challenge to successful learning of this linguistic content is addressed within the frame of CLT. It is argued that in order for learners to *construct* accurate schema for the linguistic concepts and learning strategies central to this intervention, a certain amount of schema *deconstruction* was a necessary concurrent process, and one which brought substantial cognitive processing demands of its own.

It is argued that successful learning (schema construction) of the basic principles that English spelling is well-ordered and that it can be problem-solved necessitated a schema deconstruction process because this understanding had to be developed despite a common assumption, well established in long-term memory for most, that English spelling is highly irregular. More specifically, learners needed to actively break down the common assumption that the only job of letters in spelling is the representation of sound, and that those letter-sound (grapheme-phoneme) correspondences are frequently irregular. These beliefs result in the deeper assumption that English spelling is often unpredictable. Each of these assumptions have been built into long-term memory over time, posing a substantial challenge in terms of cognitive load for the successful mastery of the linguistic content of the intervention. Presumably a learning task is less cognitively demanding if it poses no conflict with prior understanding.

To address this challenge, the distinction between previous understanding and the new content was addressed over and over through tasks designed to reframe learners' prior understanding about how letter-sound patterns work, with tasks and examples showing how those patterns (grapheme-phoneme correspondences) are constrained and clarified by morphological and other consistent orthographic conventions. It will be demonstrated that the tasks targeting the development of this knowledge were well adapted to the cognitive architecture as described by CLT. To illustrate how the content of this intervention collided with previous understanding, and how that was addressed with the aid of instruction that effectively managed cognitive load, consider a specific example of how the spelling *does* was presented to students in the intervention.

do **go**	es ne ing

Prior knowledge built from typical instruction that teaches letter-sound correspondences, without reference to morphological structure, would see *does* as an irregular spelling. Most students have learned (established long-term memory schema) that such irregularities are common in English, thus reinforcing the wider assumption that English spelling is not reliable. While prior instructed knowledge makes sense of some letter-sound correspondences in this word (e.g., *d* for /d/), it fails to make sense of others. Some educational materials even encourage teachers to explain that if English were more regular, this word would be spelled **duz*. Such direct misinstruction is not necessary for students beginning this intervention to assume that this spelling, like many others, is irregular and simply has to be memorized. It is unlikely any students' prior instruction built an assumption this spelling was regular and could be understood.

To counter these assumptions, the logical structure of the spelling of *does* was presented with the word matrix (Ramsden, 2001) and word sums (Figure 1). Like a worked example, these tools allow students to focus their attention on the solved structure of this spelling. Students can attend to the parallel morphological structure shared by *do+es* → *does* and another common word already assumed to be regular: *go+es* → *goes*. This pattern is reinforced by linking *does* and *goes* with other structurally related words. Both *done* and *gone* would have been taught as irregular in typical instruction, but are revealed in this graphic presentation as ordered with the same logical structure used by *doing* and *going*, words which would have been learned as regular spellings. The matrix helps counter the general assumption of irregular spelling by showing that the same base and suffix word structure works for all of these words, whether or not they were previously assumed to be regular or irregular.

do+es → does	go+es → does
do+ne → done	go+ne → gone
do+ing → doing	go+ing → doing

Figure 1

Word matrix (Ramsden, 2001) and word sums for members of the <do> and <go> word families.

For the novice in morphological word structure, the task of making sense of the spelling structure of *does* in connection with these other words involves numerous integrated tasks, some of which counter prior unerstanding. The learner needs to be able to keep various inflections and their characteristics in mind while scrutinizing the morpho-phonological structure of these words. New concepts of morphological structure need to be integrated with previous understandings of letter-sound correspondences, which themselves need to be reshaped in this new understanding of ordered and meaningful spelling structure.

Dealing with all of these tasks simultaneously places a heavy demand on conscious processing in working memory. The word matrix and word sums alleviate this cognitive load in a way similar to worked examples for algebra problems. Students can study a diagram of a "solved word structure problem". As well, the cognitive load due to the *split-attention* effect is reduced by embedding concrete representations of the morphological structure (the target by the instruction) in a diagram which directly links this novel substructure of words to the to the familiar surface structures of the completed spellings. These schematics allow the learner to identify the base they know with the spelling *do* and pronunciation /do□/while simultaneously considering how that written substructure fits within the surface structure of the word *does*, despite the pronunciation shift. Maximizing working memory capacity for considering this pronunciation shift while simultaneously studying the consistent spelling of the component morphemes is particularly important. Prior knowledge, built through instruction and practice, had marked the pronunciation of this word as in confilict with its spelling. The matrix provides scaffolding enabling the novice learner to attend to this complex information in a diagram that reinforces the regularity of the structure being presented. That same structure simultaneously makes sense of familiar words considered regular (*doing, going, goes*) and words previously assumed to be “irregular” (*does, done, gone*).

Over and over specific examples of words assumed as irregular from a strict ‘letter-sound’ correspondence perspective were shown to be regular by practicing patterns with these tools that reduce extraneous load while presenting how phonological and morphological patterns interact in English spelling. Matrices and word sums consistently pointed learners to the morphological structure of words in such a way that spelling regularity, previously unseen, was made apparent.

This instructional strategy meets the description of the process of *strengthening* the learner’s schema by repeated successful application of a process or procedure. Additionally, as irregular words are seen by most as a frustration that has to be dealt with, being introduced to a way of working with words that consistently makes sense of these words provides an important motivational hook. Presumably those that are most frustrated by irregular spellings are those who struggle most with spelling or reading them. It may be that this instruction provides a particular motivational hook precisely for those who are most frequently unmotivated by word level instruction that has previously failed to make sense of such words. As noted earlier, motivation is considered an important component for germane load that asks learners to engage in deeper metacognitive tasks needed for schema construction.

Ironically then, the previous learned misunderstandings of how the spelling system works can be viewed as having a complex impact for learning during this intervention. Because unlearning long held understandings (schema deconstruction) is not likely quickly accomplished, it is safe to assume that in the main, countering previous knowledge is a hindrance to successful learning of the linguistic content. However, to some degree the interest generated in suddenly making sense of many spellings previously seen as irregular may have some important motivational benefits for germane load.

The presentation of the the *do* and *go* word families provides an illustration of how over and over instruction targeting the micro word and word family level was used to break down previous understandings (schema deconstruction) of spelling as a disordered system that often had to be memorized. Such micro level tasks were designed with the aim of providing students with an experience of investigating patterns in a highly ordered, meaning based system (schema construction). The specifics of how tools like the word sum and word matrices were taught so as to facilitate germane processing by targeting "conscious application of learning strategies" will be made more apparent in the next section.

The process of Structured Word Inquiry framed by CLT

A consistent pattern of instruction was followed for each major orthographic concept introduced in the intervention. An outline of the steps of that pattern, along with links to CLT, is provided before elaborating with a more detailed account of the process of instruction.

Step 1: An interesting spelling problem was presented that highlights a core orthographic concept.

(Motivation for germane processing)

Step 2: Present students with sets of words selected to reveal a pattern that is the focus of the lesson. Encourage the development of student hypotheses for the class to test.

(Scaffolding for word structure knowledge and modelling of problem-solving skills.)

Step 3: Test hypotheses in order to confirm and describe exact orthographic pattern.

(Reinforcing new schemas and modelling word structure problem-solving skills.)

Step 4: Practice newly learned patterns through a systematic application to a set of words chosen to illustrate a given pattern (supported with tools like word sums and flow charts).

(*Knowledge compilation* and *strengthening* to automate new schema for procedures. Practicing new patterns with techniques engaging motor memory via handwriting word sums while spelling out loud and the use of flow charts.)

Step 5: During investigation of one concept, identify interesting spelling questions as sparks for future investigations.

(Set stage to facilitate independent word structure hypothesis and analysis. Student discoveries of patterns are “captured” and highlighted for the class. Scaffolding of student discoveries is very explicit at first, but fades with growing student and class expertise.)

Lesson #1 (See Appendix 1.)

The first lesson attempted to grab students interest with the question "Why is there a *g* in *sign*?" (Step 1). The matrix was used to arrange affixes around the base *sign* in order to help students see an answer to this question as a way of introducing them to the fundamental building block nature of word structure despite pronunciation shifts (Step 2). As discussed with the presentation of word families of *do* and *go*, the matrix is an effective tool for representing the written structure of a morphological family of words from a cognitive load perspective. The learner is presented with a clear picture of how the morphemes interrelate to form at least ten of the derivations of a word family like *sign*. If the same set of derivations were presented in a list instead of a matrix, the learner would be unable to process the underlying structure of those words in the same way. Attempting to teach this complex content to novices without the matrix would increase extraneous load considerably as students attempt to process multiple derivations, pronunciations and written morphemes simultaneously. The matrix provides scaffolding that allows the learner to target working memory processing at building coherent schemas (germane load) of the building block nature of morphemes (bases prefixes and suffixes) and how they combine to form written words.

By placing the matrix on an overhead, the class was able to take time to work through these concrete morphological representations as in a worked example. Active processing of word structure was encouraged by challenging students to produce words from the matrix with specific characteristics. For example, students were challenged to find: a word where the *g* is pronounced; a word with a prefix and a suffix; a word with two suffixes; a word where the pronunciation of the *s* changes from the word *sign.* As each word was successfully identified, its structure and meaning was reinforced by having students simultaneously spell out the word sum orally and in writing as modelled by the instructor using the overhead.

The choice of this particular base and set of affixes for a first lesson in morphological structure was strategic from a cognitive load perspective in a number of ways. So many of the words in this family (e.g., *sign*, *signal*, *assignment* and *design*) are familiar to Grade 4 and 5 students. Familiar words helped maximize cognitive processing on the new information about word structure. Various key schema development goals targeted here include: (a) word parts (morphemes) maintain their spelling despite pronunciation shifts, (b) words previously assumed to be irregular (e.g. *sign*) have logical explanations when word structure is understood, and (c) word structure links surprising connections in meaning (e.g. *sign / assignment / design)*. The *sign* and *signal* pair was chosen as a particularly salient example of connections in spelling structure and meaning despite spelling shifts. The familiar phrases "*traffic sign*" and "*traffic signal*" were used to make the meaning connection very clear. The fact that the common suffix *–al* creates such large pronunciation shift provided a very simple hook about word structure that was used to remind students of the interaction of pronunciation and morphology in future lessons.

The word sum (Figure 1), which was used throughout the intervention, functions as an effective teaching tool from a CLT perspective as well. An important point is that it is used to reinforce the morphological structure of any complex word via multiple modalities. It is a visual representation of word structure, but it is taught explicitly in such a way to capitalize on motor memory. With the support of modelling on the overhead by the teacher, students were instructed to simultaneously write and "spell-out-loud" the morphological structure of words. So for the word sum *sign+ate/+ure--> signature*, the whole class recited together "S-I-G-N-

plus-A-T-E-*plus*-U-R-E *is rewritten as* S-I-G-N-*pause*-A-T-*no* E- *pause* -U-R-E." By using handwriting and spelling out-loud simultaneously to produce word sums, word structure is reinforced in multiple modalities as a way of fixing schema of these structures in the long term memory.

The word sum also provides a means of moving the learner's attention from the general interrelation of morphemes in a morphological family, to the morphological structure of individual words from that family. As with the word matrix, the use of this instructional tool targets a general learning goal via a process designed to integrate a specific example of that deeper goal into the long-term memory. Instruction that directs students to write a series of word sums from a single matrix targets a variety of interconnected learning goals including (a) building general morpho-phonological written structure knowledge, (b) the spelling and meaning of the specific words, and (c) establishing particular morphemes in long-term memory that will be drawn on in the future. Practicing word structure with the support of motor-memory in the writing and spelling-out-loud of word sums aids in this solidifying of word structure schema. Because bases, prefixes and suffixes are used in the formation of many words, the development of coherent schemas of these meaning units, reduces the cognitive load of drawing on these meaningful written representations during future spelling and reading tasks.

Thus, with the aid of scaffolding from the matrix, word sums, explicit instruction and modelling, students were able to use new word structure knowledge to discover that numerous familiar words can be related in meaning and structure but diverge significantly in pronunciation in the first lesson.

Finally, this matrix for the first lesson was designed to include exactly one suffixing change. At this early stage a matrix with multiple suffixing changes would divide cognitive processing among too many problems. However, including *signature* with its replaced single silent *e*, provided an interesting spelling structure problem to motivate the next investigation (Step #5).

Lesson #2 (see Appendix 2)

Steps 2 and 3 of the instructional process outlined above receive particular attention in this lesson. In line with Step 2, words were selected to reveal the main orthographic pattern (the suffixing pattern for replacing the single, silent *e*) in order to generate a student hypothesis explaining that pattern. Next, that pattern was tested in order to help learners clarify and attend to the precise orthographic pattern (Step 3).

The question of when silent *e*'s are dropped was sparked by the word sum for *signature* (and then *packages, packaging* and *packaged* in the second part of lesson 1). A matrix for the *move* word family and a set of worked out corresponding word sums were presented to address this "spelling mystery". This family of words was chosen to reveal the two categories of suffixes: vowel suffixes which are active and consonant suffixes which are inert. These categories are immediately relevant for the silent *e* pattern, but they also support learning for the pattern for doubling final single consonants that follows this first set of lessons.

Shnotz and Kürschner (2007, p. 496) argued that "restructuring of problem representations in order to solve a task more easily (i.e. by 'insight')" is an instructional design well suited to foster germane load processing. This is an accurate description of the structure and purpose of this lesson. Again with the use of the overhead as students worked on the identical handout, students were drawn through the process of organizing the word structure of this word family in such a way to promote strategic problem-solving. Students were told that we were going to act as smart “word detectives” by arranging suffixes in a way to help students come up with a good hypothesis for what kind of suffixes replace single, silent *e*’s.

With a student identified hypothesis established, there was high interest for testing the pattern which focussed attention on modelling of word structure problem-solving. The task of “testing the hypothesis” with a large set of matrices provided a rich opportunity to use word sums which again reinforced the building block nature of word structure despite pronunciation shifts (e.g. *please*, *pleasant*, *pleasure*). Throughout the lesson, writing and spelling word sums out loud strengthened schemas of vowel and consonant suffixes and word structure patterns in an engaging activity.

Precision for the pattern “vowel suffixes replace single, silent *e*’s” was strategically reinforced. Students were warned that as we worked through the word sums on Part 2 of this lesson, we would run into various “traps” that they would have to think about. These more complex morphological problems (higher intrinsic load) were designed to encourage deeper cognitive processing on the orthographic pattern under scrutiny, and introduce them to new patterns that would be reinforced later in the intervention. In line with Chandler & Sweller’s (1992) recommendation to avoid split-attention effects, the target concepts of this instruction are embedded directly in the learning task. The main “traps” used to encourage more germane processing on this suffixing pattern are described below.

1 - At first many children think the pattern had broken down for *agreeing* because they see a final *e*, that is not dropped with a vowel suffix. This “trap” provides a context for a class

discussion highlighting the fact that the precise pattern is that only final *e*'s that are *single* and *silent* are replaced by vowel suffixes.

2- After establishing that <agree> does not end in a single, silent *e*, the word sum agree + ed → *agreeed is used as a dramatic example that something appears to have gone wrong. Students recognize that they've never seen three *e*'s in a row together. This provides the opportunity to teach a deeper orthographic principle that is important for understanding English spelling as ordered, but complex. It was explained that sometimes two spelling conventions run into each other in such a way that it is not possible for both to be realized. There is almost always an ordered solution for such conflicts, but they require additional knowledge. In this case, one of the patterns is a spelling law that no complete English word can use the same letter thee times in a row. The solution to the word sum is then written on the board using the asterisk as the symbol for an impossible spelling, that then has to be rewritten with a double *e* instead of the three *e*'s produced by the first step of the word sum: *agree* + *ed* → **agreeed* → *agreed.* To reinforce that this is part of an ordered pattern, one other example of this structure was described with the word sum *see* + *en* → **seeen* → *seen.*

3 - The matrix for *take* creates the compound *takeout* to distinguish between the processes of suffixing and compounding. A word sum from this matrix like *take/+out* → *takeout* establishes that the base ends in a single, silent, *e*. Many children see the vowel at the beginning of *out* and think that the pattern has broken down. Others notice the bolding of the word *out* as a sign that this is not a suffix, but another base word. The resulting discussion provides the opportunity to teach our second spelling law, that when creating compounds, the spelling of both words remains the same. (That lesson will be reinforced later as one of the reasons not to change a *y* to *i* when adding a suffix.).

4) The matrix for *be* builds on the pattern identified with *agree* by reinforcing that the *e* must be silent, even if it is single to be replaced by a vowel suffix.

Along with the process of investigating the pattern for dropping single, silent *e*'s other patterns are introduced or reemphasized. One example is that the base *please* not only targets the suffixing pattern under study, but also reinforces the fact that pronunciation changes do not mean spelling changes across words related in structure and spelling. This word is helpful for pointing to the digraph *ea* as one used for the 'long' and 'short' *e* that will come up in other investigations like *heal*/*health*.

This lesson directly supports the fundamental goals of (a) helping students learn that, counter to previous assumptions, English spelling is so ordered that it can be effectively investigated by problem-solving, and (b) to support them with relevant problem-solving strategies for future independent investigations of word structure. This instruction is thus targets germane load processing by encouraging conscious pattern searching in order to abstract cognitive schema (e.g. vowel and consonant suffixes) and meta-cognitive processes of monitoring learning (e.g. clarifying precision of the single, silent *e* suffixing pattern with *agree*, *takeout*, *been* and *being*).

This lesson also begins to reveal the interlocking complexity of the patterns they are beginning to study. At this point in the intervention, students' knowledge and interest had grown to the point where questions about words they discovered on their own were frequently discussed. A folder labelled "Spelling questions for Mr. B" was placed on the wall next to the growing chart of bases prefixes and suffixes. Children were invited to write questions and theories about spellings they ran into independently and place them in the folder. The form had students write the word they were curious about, their suggested word sum and a sentence in which it could be found. A section for "Affix Theories" had to be added to the wall as well because students kept wanting to add sticky notes with affixes they found in and out of spelling class. Taking up those student questions and theories was an eagerly anticipated activity. Students were eager to have their affix theory attested by the teacher and added to the official class chart. To be considered, however, students had to offer a word sum for the word in which they found it, and use that affix in at least one other word. As students gained experience with scaffolded word structure problem-solving, they began to take on such challenges independently (an example of *fading*). One of the observations from teachers from both intervention groups was astonishment that students were so frequently independently going to dictionaries. This has been the authors' experience whenever this kind of instruction goes on for even a short period of time. Students were not going to dictionaries to correct a spelling, they choose to go to dictionaries to test their hypothesis for a word sum. Dictionaries became seen as effective tools for finding answers to questions they had posed and in which they were interested. Their teacher frequently explicitly modelled how to use the dictionary during investigations of words that came up in class to spark interest and skill in dictionary use. The other observation that shocked the classroom teachers was that it was the larger dictionaries with Latin and Greek roots which the students saw as the "good dictionaries". The student dictionaries didn't list affixes or have etymological information they needed to answer their questions.

Finally, one example of how students were seen to become active co-investigators of words is offered. On the second matrix of lesson one, a student asked why the word packages used the *–es* suffix instead of the *–s* suffix since this involved removing the *e* of *package* and adding another *e* instead of simply using the *–s* suffix. They noted that either suffix produced the same spelling. This insightful question resulted in adding a lesson in both intervention classes that gave a chance to establish another spelling law that every spoken syllable needs a vowel letter to represent it, along with discussions of phonological patterns of *g* (when it can be 'hard' or 'soft') and other even more subtle points about graphemes and morphemes.

This example brings up an important point in terms of the constraints of germane load due to intrinsic load. The kind of problem-solving, motivation and engagement described above is only possible with complex problem-solving tasks. Unless children are presented with the details of complex, but ordered structure of English orthography, they are constrained from the opportunity of applying germane load to understand the interrelation of meaning, structure and pronunciation represented in the English spelling system. Typical letter-sound correspondence understanding of spelling does not lead to problem-solving activities.

Lesson #3 (See Appendix #3)

The main purpose of this lesson has to do with step #4, relating to practicing newly learned concepts. This lesson also introduces the new tool of the flow chart, which was used for practicing new procedural knowledge that is specifically in line with the concepts of *knowledge compilation* and *strengthening* outlined earlier.

Having established the consistency of the exact pattern for when silent *e*'s are dropped, the flow chart is a tool which supports strengthening this pattern even more – aiming towards eventual automaticity. In this lesson a set of word sums where suffixes are added to words ending in single, silent *e*'s are presented to the learner. Again, making use of the overhead to model the process, the whole class methodically went through the process of drawing one finger along the flow chart to cue the relevant questions, while using a finger from the opposite hand to point to the parts of the word sum that answer each question. The learners have their attention drawn directly to the relevant features of morphological structure, and the series of questions to ask: Does the suffix begin with a vowel letter? Does the base or stem end in a single, silent e? After modelling a number, the class was then instructed to continue on their own.

In most cases the process is clear and schemas for distinguishing between the active vowel suffix and the inert consonant suffix are simply reinforced. However another "trap" like the word sum such as *ice* + *y* --> ______ was used to remind the learner to pay close attention. They have been taught that vowel letters are *a, e, i, o, u* and sometimes *y*. Students were asked how we can know if *y* is a vowel suffix or not? This problem provides an opportunity reinforce the pattern we ran into with *packages.* Every spoken syllable requires at least one vowel letter to represent it. To solve this word sum and question about the –*y* suffix, we practiced a strategy for counting syllables that would be used later in the intervention. We discovered that *ice* uses one syllable, but *icy* two. Thus the suffix -*y* must be a vowel letter in order to represent the second suffix. The –*y* suffix must, therefore, act as a vowel suffix and replace the single, silent *e*. Throughout the intervention, additional linguistic details such as this were embedded within the main thrust of a lesson. With each additional linguistic fact, the students' expertise grew, and the underlying message that English spelling is extremely well-ordered and can be problem-solved was reinforced. By this point we had already begun to run into patterns learned in one context and found them useful for explaining other questions. As the learners gained expertise and integrate more and more features of how the spelling system works, they were able to deal with ever more complex problems. In line with the ZPD, the intrinsic load could be increased again and again to match the germane load of the learners. As a result, by the end of this 20 lesson intervention, Grade 4 and 5 students were working effectively with concepts many would consider too advanced for this age group such as bound bases, twin bases and connector vowels.

Generative vocabulary knowledge from teaching morphological structure: Links to CLT?

To help consider this instruction in light of previous research, a brief summary of the key points made in the introduction is reviewed. First, the vocabulary learning task children face is enormous. Second, many children fall behind in literacy and scholastic success in part due to the compounding effects of beginning school with an impoverished vocabulary, often due to social economic factors. Third, despite a wide consensus that systematic, explicit vocabulary instruction is important for literacy gains, such instruction is not a common feature of schooling. Fourth, there is no research consensus on one vocabulary instruction strategy over others, but there is a growing debate between two seemingly opposite strategies. Some researchers favour shallow teaching of a great number of words, while others favour rich, deep repeated instruction of a much smaller set of words. Both strategies are supported by research findings. Fifth, the strategy of teaching word learning strategies by teaching students to use context or word part cues is recommended by the research community as an important way to deal with the scale of vocabulary children face, but to date interventions using these instructional strategies have been limited in number with equivocal results.

The current study assessed the effect of morphological instruction with two outcome measures. Students completed a written morphological task where they were asked to circle the main part of a multi-morphemic word. After completing that task, participants were asked to provide a definition for each of those same words. There were thirty words in the task, which were divided evenly into three categories in order of transfer. (See Appendix #4.) Word Taught words were explicitly addressed in the instruction (near transfer). Base Taught Words were never explicitly taught, but used bases that were taught in the context of other derivations (mid transfer). Not Taught words used bases that were never taught during instruction (far transfer). After controlling for initial vocabulary, significant effects of instruction were found for the morphological awareness task at all three levels of transfer. For the vocabulary measure, significant instructional effects were found for the near and mid transfer measures, but not for the far transfer measure with bases that were not taught.

In a follow up study to investigate how the skill of identifying the base in multi-morphemic words develops over time with typical instruction, Grade 10 students were given the same “Circle the Base” task. It was found that untaught Grade 10 students were better at this skill than the untaught Grade 4/5 students. However, the *taught* Grade 4/5 students scored significantly higher on this written morphological task than *untaught* Grade 10 students on the Word Taught words and the Base Taught words. The mean score of the taught Grade 4/5 students was higher than the Grade 10 students on the Not Taught words, but that difference did not reach significance. Thus twenty lessons of morphological structure brought Grade 4/5 students to the level of Grade 10 students on this written morphological task for words neither group had studied.

To investigate how morphological knowledge (as measured by the base circling task) relates to vocabulary knowledge more deeply, analysis was conducted to see how well scores on the morphological task predicted scores on the outcome vocabulary measure for the *untaught* Grade 4/5 students in the control group. After accounting for the 15.1% of the variance explained by initial vocabulary knowledge ($p < .01$), scores on the *Base ID* task explained 19.8% of the variance ($p < .001$) for the outcome vocabulary measure. This result for the control group indicates that ability to identify the base of a word need not be gained through explicit instruction for it to significantly predict understanding of the meaning of that word. These results underscore the potential educational importance of the fact that twenty lessons of morphological instruction, through this structured word inquiry approach, resulted in such clear evidence of improvement in students' ability to identify the base of complex words.

Considering the fact that there is little previous evidence of morphological instruction bringing vocabulary gains for words that were not taught explicitly, what was it about this instruction that generated this positive effect for the mid-transfer words? It is not claimed that CLT necessarily provides the explanation, but the results are consistent with that possibility. This paper concludes with speculations on how these results might be explained with the aid of theories of memory, learning and instruction framed by CLT .

The word matrix could be viewed as a kind of "schematic diagram" analogy of the schemas for morphological structure knowledge produced by this instruction. This view corresponds to the finding that students could make use of their learning to help them with the near and mid transfer words, but not the far transfer words. The instruction provided students the opportunity to engage again and again in intrinsically complex tasks designed to engage deeper level cognitive processing. The germane load used in these tasks formed coherent schemas for specific morphemes and how those word parts combine to form words.

Consider the *sign* matrix of lesson one. Students had enough exposure to those elements and their interconnections so that they could provide a better definition for any word from that matrix than untaught students. Using the "worked example" diagram of the word structure revealed in the *sign* matrix built strong schemas in long-term memory for this morphological family of words. Like the fading process described by CLT, students no longer required the physical diagram in order to bring that complex structure/meaning knowledge into working memory. They now had ready access to the knowledge needed to help them read the morphological cues held in words from that morphological family without the aid of the physical matrix.

The instructional effect for mid-transfer words suggests that well established knowledge in long-term memory provides generative knowledge of morphological structure. When a physical word matrix is presented to a student, it is not difficult to think of other affixes that could be added to expand the word family. The diagram provides the scaffolding and reduced working memory load to help them consider other affixes that could be added to build other words.

A similar process may occur for a student who has developed efficient mental representations for the meaning-laden morphological interrelations of words like *signal, signify,* and *assignment* with a word matrix. When that student is presented with an unstudied word like *insignificant*, access to component elements and suffixing patterns can be brought into working memory at a low cost cognitive load. Well developed knowledge of word structure, and problem-solving strategies stored in long-term memory allows more working memory processing to focus on the complex task of working out a reasonable definition of a word that had not been explicitly taught, but is linked with familiar meaningful structures and processes. In effect, using morphological problem-solving skills to develop a well formed schema for a word matrix that covers a part of a morphological word family may provide scaffolding needed for the learner to be able to add to that well established structure. However, unless a learner already has incidentally developed understanding of a base that was not specifically taught, they do not have knowledge that can help them problem solve the meaning of an untaught base. Their knowledge of common affixes and suffixing patterns can help them with untaught words, but only if the meaning of that base has already been established in their long-term memory incidentally. The fact that students in this instruction improved significantly at identifying bases within untaught words increases the chances that they will even note the base of a novel word, but that instruction is not relevant to whether the student recognizes the base when they find it. Thus instructional effects were found for Taught and Base Taught words, but not for Not Taught words.

The generative educational consequences of this instruction for both the morphological analysis skills and the learners affect for investigating words should be considered. The fact the word structure knowledge was gained by practicing problem-solving patterns in a “word detective” context that students appeared to enjoy may have combined to provided the needed confidence to ‘have a go’ at providing educated guesses at words that were not explicitly taught. Faced with novel, large multi-morphemic words, students without that background had less reason to believe there are meaningful patterns to look for in words, less word knowledge skill to bring to the task, and less confidence or interest to try.

The analogy with the word matrix provides another compelling observation with regard to the current views about vocabulary instruction. When a matrix was used during a lesson, the instruction did not give each possible derivation equal attention. For example with the *sign* matrix, *sign, signal, design,* and *assignment* received particular attention. Words such as *signify* and *designate* were touched on, but only briefly. An argument can be made that teaching with the word matrix provides the deep rich processing attention of a smaller number of words as recommended by Beck, McKeown and Kucan (2002), but also provides the quick exposure to a much larger number of words recommended by Biemiller (2006). Additionally, the quick exposure to many words in this instruction has the added advantage of meaning and structural connections to words that did receive close attention.

The other goal of vocabulary instruction identified earlier that is often cited in the research is that of developing a child's word consciousness. The definition offered by Scott and Nagy (2001) seems particularly well suited to the instruction that has been described in this study. They described word consciousness as, "the knowledge and dispositions necessary for students to learn, appreciate and effectively use words...[It] involves several types of metalinguistic awareness, including sensitivity to word parts...." (p. 201).

While more research is needed with regard to the instruction described in this study, it appears to pull together most of the key goals various researchers have been suggesting are critical, but which have not been integrated in such a way before. The potential of gaining the benefit of both the "wide and shallow" and "narrow but deep" views of vocabulary instruction at the same time is an exciting possibility. To meet those goals by way of effectively teaching a word learning strategy that targets the same "word consciousness" goals emphasized for effective vocabulary instruction (National Reading Pannel, 2000) adds yet another element of vocabulary instruction researchers have been seeking out. Still more reason to investigate this instruction is provided by the fact that this instruction seems so well suited to the challenge of adapting instruction to the cognitive structure of learners provided by CLT researchers.

There is one key lynchpin that makes it possible to bring all of these elements together in to one instructional design. That is the fact that this instruction is built directly on the coherent, reliable patterns that drive how the English spelling system is structured to represent meaning. Only instruction that uses accurate linguistic structure as the guiding frame of its content will create lessons which can reliably be problem-solved. Problem-solving raises the intrinsic load and provides motivational hook for the act of studying words, which in turn brings the germane load necessary for schema construction. If schools continue to fail to treat the organizing principle of morphological structure and how it relates to phonology as fundamental curriculum content, spelling will remain a flawed, unreliable system in the mind of the student. Problem-solving of the structure/meaning nature of written words will only happen when the spellings of words keep repaying students with evidence of order and increased understanding. The system will only inspire the germane processing that results in generative word knowledge if teachers are equipped with training that allows them to present students with the accurate linguistic patterns that do not break down on learners.

Finally, the challenge from CLT posed at the outset seems a wise one to follow. This theory was not developed with reading or vocabulary instruction in mind, but it was aimed at understanding the processes involved in learning about complex information. Vocabulary learning, and learning how to read and write in English seems a clear candidate for such a topic. The guidelines for instructional design from CLT have been shown to be effective in areas as varied as algebra (Cooper & Sweller, 1987), learning from multiple sources of information (Yeung, Jin & Sweller, 1997), operating computer programs (Chandler & Sweller, 1996) and learning from animated models (Shnotz & Rasch, 2005). Researchers studying literacy instruction may find important support for instructional design by looking at what is known about teaching and learning of complex information in other content areas.

Currently there is a particular push for reading researchers to identify "best practices" in reading instruction. Typically such a judgement is determined by looking at instruction that has been validated compared to other instruction in intervention studies. While this is a key tool, it can only tell us about practice that has been tested. It doesn't necessarily give us effective guidance on how to improve on instructional strategies that have been shown to be more effective than another. Effective instructional *innovation* needs something more than what has already been tested to guide the way forward.

The current study provides suggestions for two metrics that researchers might do well to include in their efforts to identify best practices. When considering instruction that has already been shown to be effective in intervention studies one can ask, “Which elements of CLT could be incorporated into this instruction in order to help students master this knowledge more effectively?” Another is to look at the instruction and assess how accurately it represents the workings of the spelling system. It was argued that one of the challenges learners faced in this intervention was the fact that the accurate word structure content of the instruction countered previously taught assumptions about the irregularity of English spelling. If that is true, we are likely to help students by using linguistic knowledge to alter instruction such that misunderstandings of the writing system are not built into the long-term memories of learners in the first place.

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Appendix # 1 (Matrix Ramsden, 2001)

Name_______________

Activity Sheet #1

Word Building: Using a Real Spelling Word Matrix

A WORD MATRIX USUALLY ONLY SHOWS ***SOME*** POSSIBLE WORDS, YOU CAN USUALLY FIND MORE IF YOU TRY!

Rules for reading a word matrix:

- Read a matrix from left to right
- Make only single, complete words from a matrix
- If you are unsure that a word you build is a real word, check a dictionary
- You don't have to take an element from every column of a matrix – BUT
- You must not 'leapfrog' over a column
- WATCH THE JOINS – sometimes changes happen where you add a suffix

<table>
<tr><td colspan="2">re
as</td><td rowspan="2">sign</td><td colspan="2">al
ing
ed
ment
ify</td></tr>
<tr><td>re</td><td>de</td><td>ate</td><td>ure</td></tr>
</table>

Build words with your cut out **prefixes** and **suffixes** on the **base** <***sign***>. Once you have built a word, write the **word sum** as modeled in 1 and 2.

Part A:

____

prefix(es)- **base** - suffix(es)

1) sign + al → signal
2) as + sign + ment → assignment
3) ______________________ → ______________________
4) ______________________ → ______________________
5) ______________________ → ______________________
6) ______________________ → ______________________
7) ______________________ → ______________________
8) ______________________ → ______________________
9) ______________________ → ______________________
10) ______________________ → ______________________

Part B: Word sums from <pack> matrix

<table>
<tr><td rowspan="3">re
un</td><td rowspan="3">pack</td><td colspan="2">s
er
ing
ed</td></tr>
<tr><td>age</td><td>es
ing
ed</td></tr>
<tr><td>et</td><td>s</td></tr>
</table>

1) ______________________ → ______________________

2) ______________________ → ______________________

3) ______________________ → ______________________

4) ______________________ → ______________________

5) ______________________ → ______________________

6) ______________________ → ______________________

7) ______________________ → ______________________

8) ______________________ → ______________________

9) ______________________ → ______________________

10) ______________________ → ______________________

Appendix # 2 (Matrix: Ramsden, 2001)

Activity #2

When do Suffixing Cause Changes at the Joins?

Spelling Detectives

A) Investigation: Developing a hypothesis

Study the matrix for <move> and the word sums created from it to see if you can discover a consistent suffixing pattern.

re un	**move**	s ing ed er ment

Word Sums from <move> Matrix

move + s → moves
move + ing → moving
move + ed → moved
move + er → mover
move + ment → movement
re + move + ed → removed
re + move + er → remover
un + move + ed → unmoved

1. What is the change that sometimes occurs at the suffix join?

2. List the suffixes that cause the change: _____ _____ _____

3. List the suffixes that cause no change: ____ _____

4. How are these suffixes different from each other?

5. Our class' hypothesis to explain how you know which suffixes ***may*** force a change at the join:

B) Testing our Hypothesis:

These matrices build on ***base words*** (a one ***morpheme*** word - no ***prefix*** or ***suffix***) that end with the letter 'e'.

- Create word sums from a variety of the matrices to test our class hypothesis. (Only build a few words from each matrix.)
- If you are unsure of the spelling of a word, check with a dictionary or ask for help.
- Be ready to share interesting discoveries with the class. Any surprising findings, or words whose sound changes when you add affixes?

dis	**please**	es ed ant ure

un	**hope**	s ing ed ful less

dis	**agree**	ing ed ment able

re	**take**	s ing en
		away

mis	be	**have**	s ing ed
			i + our (Can) / or (US)

en	**large**	es er ing ed ly ish
		ment + s

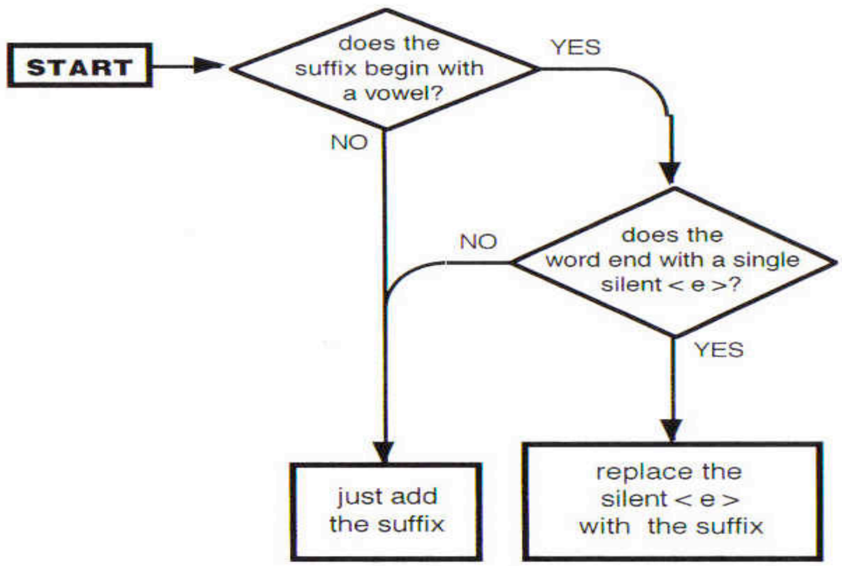
be	ing en

(Matrices: Ramsden, 2001)

Appendix # 3 (flow chart: Ramsden, 2001)

Activity #3

Flow Chart for Dropping the Single, Silent <e> During Suffixing



Instructions:

1) Glue page into your notebook.
2) Copy the word sums, then use the flow chart to complete them correctly. When a silent e is replaced, cross it out as in the example.

Example: dat~~e~~ + ing → dating

Word Sums

1. cave + ed →
2. create + or →
3. require + ment →
4. smile + ing →
5. rude + ly →
6. brave + est →
7. brave + ly →
8. include + ing →
9. lone + ly →
10. close + ness →
11. laze + y →
12. rule + er →
13. imagine + ary →
14. pure + ly →
15 please + ure →
16. operate + ion →
17. smile + ing →
18. amaze + es →
19. amaze + ment →
20 ice + y →

Appendix # 4

Circle The Base Words in order of transfer

Word Taught	Base Taught	Affixes Taught
1. busily	1. reproduce	1. refereeing
2. staring	2. condensed	2. insensitive
3. architecture	3. socially	3. decreasing
4. victoriously	4. ruder	4. precautions
5. adaptation	5. insignificance	5. prearranged
6. educated	6. incorruptible	6. reelected
7. vacuum	7. stared	7. acknowledgement
8. conscious	8. restructured	8. responsibilities
9. condensation	9. vacuous	9. accompanying
10. starring	10. happenstance	10. scarred