A Conceptual Paper on the Application of the Picture Word Inductive Model Using Bruner's Constructivist View of Learning and the Cognitive Load Theory

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Bruner's constructs of learning, specifically the structure of learning, spiral curriculum, and discovery learning, in conjunction with the Cognitive Load Theory, are used to evaluate the Picture Word Inductive Model (PWIM), an inquiry-oriented inductive language arts strategy designed to teach K-6 children phonics and spelling. The PWIM reflects Bruner's constructs of learning and it encompasses the presentation of new information, both novel vocabulary and pictures, which could pose a cognitive overload for students who are unfamiliar with the words and pictures from the viewpoint of Cognitive Load Theory. This paper provides suggestions for attenuating the intrinsic, extraneous, and germane cognitive loads by presenting both novel words and pictures. It concludes with a conceptual model for conducting a systematic experimental study of the PWIM.

Key Words: Picture Word Inductive Model, structure of learning, spiral curriculum, discovery learning, Cognitive Load Theory

This paper presents an analysis of the Picture Word Inductive Model (PWIM) through the lenses of Bruner's (1960, 1967) structure of learning, spiral curriculum, and discovery learning and Sweller's (1988) Cognitive Load Theory. Readers who are not familiar with the PWIM may know and use the Linking Language strategy (Herrera, 2007; Herrera, Perez, & Escamilla, 2010), a well-received English Language Learner (ELL) approach for generating student discussion and introducing new words by linking them to background knowledge and prior experience. Both the PWIM and Linking Language strategy use pictures to illustrate the concepts being introduced and students are asked to identify what they see in the pictures.

ELL teachers who are not familiar with the PWIM may want to consider using this model in their classrooms. Although the PWIM exemplifies Bruner's constructs of learning, its use in the classroom could lead to a cognitive overload, which is explained by the Cognitive Load Theory. Because there are only a few published studies on the effectiveness of the PWIM (e.g., Feng, 2011; Swartzendruber 2007), we offer some suggestions on how a researcher can conduct a randomized control trial study of its effectiveness.

PWIM

The PWIM is an inquiry-oriented inductive language arts strategy, which focuses on early literacy. It is based on Calhoun's (1999) research and is designed to teach K-6 children phonics and spelling, explicitly and inductively. The intent of the PWIM is to capitalize on children's ability to think inductively and generalize the basis of structural and phonetic analysis. The purpose of the strategy is to develop vocabulary word concepts and paragraph and sentence structures in the general education areas of mathematics, reading, science, and social science. A picture word chart is the principal component of the curriculum content and it contains a picture and the words that the students will identify or "shake out" of the picture. The instructional sequence of the PWIM strategy (see Figure 1) calls for the cycling and recycling of pictures and words through various instructional activities.

Figure 1. PWIM Instructional Sequence

1. Select a picture.
2. Ask students to identify what they see in the picture.
3. Label the picture parts identified. (Draw a line from the identified object or areas, say the word, write the word; ask students to spell the word aloud and then to pronounce it).
4. Read and review the picture word chart aloud.
5. Ask students to read the words using the lines on the chart if necessary and to classify the words into a variety of groups. Identify common concepts, for instance, beginning consonants, rhyming words, etc. to emphasize with the whole class.
6. Read and review the picture word chart (say the word, spell it, and say it again).
7. Add words, if desired, to the picture word chart and to the word banks.
8. Lead students into creating a title for the picture word chart. Ask students to think about the information on the chart and what they want to say about it.
9. Ask students to generate a sentence, sentences, or a paragraph about the picture word chart. Ask students to classify sentences; model putting the sentences into a good paragraph.
10. Read and review the sentences and paragraphs. (Calhoun, 1999, p. 23)

According to Calhoun (1999), one of the advantages of the PWIM strategy is that it assists students in seeing and inferring patterns and relationships in the language, which should enable them to apply and transfer this learning to novel words. Another principle of the strategy is that students are given numerous opportunities to make generalizations that will assist them in mastering the rule-governed behavior principles of the language (e.g., draw generalizations).

Relationship of the PWIM to Bruner's Constructs of Learning

Jerome S. Bruner, an American psychologist, made significant discoveries in cognitive psychology and cognitive learning theory. Our inquiry into Bruner's work revealed that the PWIM has positive attributes that are strongly related to three of Bruner's tenets—the role of structure in learning, the spiral curriculum, and discovery learning.

The role of structure in learning. When looking at the role of structure in learning, Bruner (1960) noted that:

> The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer.... If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible. (p. 12)

The PWIM embodies Bruner's role of structure in learning. This model helps learners bridge a transition between old and new knowledge by first identifying what they see in a picture, which activates existing schema (old knowledge) and then by adding words to the picture word chart and to the word banks. In addition, as learners engage in inductive thinking and review the picture word chart, they bridge knowledge "encountered earlier and later" (Bruner, 1960, p. 12).

The spiral curriculum. Based on Bruner's (1960) constructivist theory, the curriculum has a direct impact on learning. Bruner postulated that as a curriculum develops, it "should revisit the basic ideas repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them" (p. 8). This cycling and recycling process is an example of what Bruner refers to as the spiral curriculum, and within the PWIM, there is a process that involves cycling and recycling through the various instructional activities.

Discovery learning. Bruner (1967) developed the construct of discovery learning and described it as an inquiry-based, constructivist learning theory, which holds that learners use existing knowledge and past experiences to discover facts and relationships. As a result, learners are thought to be more likely to remember concepts and knowledge created or discovered on their own. Because the PWIM is an inquiry-oriented strategy that is captioned under the rubric of discovery learning, it is closely related to Bruner's (1976) construct of discovery learning.

The PWIM and Cognitive Load Theory

It is well established that one's working memory is limited in its capacity to process information. Because the PWIM involves presenting both pictures and words in an instructional sequence, new information (including both words and pictures) could pose a cognitive overload for students who are unfamiliar with the words and the pictures. We use the Cognitive Load Theory to explain this cognitive overload. However, before we expound on this theory, we must first introduce some concepts from what is known as the modal memory model.

Atkinson and Shiffrin (1968) developed a multi-store model of memory. This model has several structural components including a sensory store or register, a short-term store (i.e., short-term memory or working memory), and a long-term store (i.e., long-term memory). Incoming information, which comes from all the senses, is stored in the sensory store before being lost. The short-term store receives input from the sensory store and the long-term store. This information is retained for approximately 30 seconds. Information which is not rehearsed (or is no longer needed) is lost. Information that is retained is transferred from the short-term store to the long-term store for permanent or long-term storage.

The importance of the short-term, working memory capacity should neither be ignored nor underestimated in the reading comprehension process. Research has shown that a strong relationship exists between measures of reading comprehension and short-term or working memory (Gathercole, Pickering, Ambridge, & Wearing, 2004). In an analysis of 77 studies of memory and cognition, Daneman and Merikle (1996) reported a correlation coefficient of 0.41 between comprehension and reading. In addition, Adams and Gathercole (2000) suggested that impairment in working memory may underlie problems in reading comprehension.

The notion that a person could hold from five to nine pieces of unrelated information in short-term memory for processing was originally advanced by Miller (1956), but more recent research (Cowan, 2001; Feldon, 2010; Janssen, Kirschner, Erkens, Kirschner & Pass, 2010) indicates that this estimate should be lowered to as few as four. Thus, when cognitive load or the information to be processed exceeds the working memory's capacity to process it, students will experience difficulties in learning the material. In other words, cognitive load is experienced as mental effort; and according to Feldon (2010, p. 18), cognitive load is "conceptualized as the number of separate chunks" or schemas "processed concurrently in working memory" while performing a task, plus "the resources necessary to process the interactions between them" (see de Jong (2010) and Torcasio and Sweller (2010) for additional information on the role of cognitive load in learning). Feldon also posits that there are three different types of cognitive load—intrinsic load, extraneous load, and germane load.

> . . . *Intrinsic load* represents the inherent complexity of the material to be learned. The higher the number of components and the more those components interact, the greater the intrinsic load of the content. *Extraneous load* represents information in the instructional environment that occupies working memory space without contributing to comprehension or the successful solving of the problem presented. *Germane load* is the effort invested in the necessary instructional scaffolding and in learning concepts that facilitate further content learning. (p. 18)

However, it was Sweller (1988) who developed the concept of Cognitive Load Theory (CLT). CLT informs the deliberate management of opportunities for students to engage with content in order to focus their investment of mental effort on key ideas (Feldon, 2010). The central premise of CLT is that learners can only attend to a finite amount of information at a given time due to the limited capacity of the working (short-term) memory system.

Given the above, it is necessary to manage and grade the volume and flow of information carefully with which learners must grapple. Teachers using the PWIM strategy may wish to attenuate the intrinsic, extraneous, and germane loads incurred by presenting both novel words and pictures, by using graphic organizers, graphs, charts, and tables to organize the input vocabulary for learners, thereby reducing the cognitive load demand. Teachers may also elect to use only words to assess learners or perhaps even eschew the use of pictures in the initial stages of the instructional cycle.

Analysis of the PWIM

In our analysis of the PWIM, we compared the PWIM with two vocabulary development strategies—the Preview-Predict-Confirm Strategy (Yopp & Yopp, 2001) and the Focused Discussion Activity (Herrell & Jordan, 2006). We found that while both of these strategies used photographs, they differed from the PWIM in that they did not involve spiraling or an inquiry-based approach.

The Preview-Predict-Confirm Strategy

The Preview-Predict Confirm Strategy involves six steps (see Figure 2). This instructional activity "… elicits vocabulary related to the book, activates and builds background knowledge, encourages active engagement through predictions, and provides a window on the thinking strategies of peers" (Yopp & Yopp, 2001, p. 45).

Figure 2. The Preview-Predict-Confirm Strategy

1. Select a book or chapter to be read.
2. Ask students to preview the text by looking at any titles, bold print headings, or pictures for about three to five minutes.
3. Ask students to close their books.
4. List on the board all the words that the students *predict* will be found in the assigned reading. Be sure to let them explain their reasoning for their predictions.
5. Ask students to read or listen to the assigned reading.
6. Return to the list and discuss which ones were confirmed through the reading. (Govoni, 2011, p. 212)

Focused Discussion Activity

Herrell and Jordan's (2006) focused discussion activity (see Figure 3) involves eight steps. This activity suggests that presenting new vocabulary in various ways such as visuals, seeing the written word, role plays, and oral practice should increase comprehension.

Figure 3. The Focused Discussion Activity

1. Choose a book to be read aloud or independently.
2. Collect any realia, visuals, and pictures that you can that are related to the book. For example, if students are going to be reading a book where the setting takes place on a farm, you could bring in hay and corn, as well as miniature farm animals and pictures of farms.
3. Introduce the story/concept by sharing your realia and visuals while making connections to the text and key vocabulary.
4. Ask students what they know about farms and if they have had any experiences on a farm.
5. Write their responses on the board.
6. During the discussion, take note of their level of background knowledge and experiences.
7. Read the story or begin the unit of instruction.
8. Use the information gathered during the focused discussion to assist in your instructional planning for this story or unit. (Govoni, 2011, p. 214)

Efficacy of the PWIM

Our review of the literature on the PWIM, which included a thorough search of the EbscoHost and ProQuest databases, revealed only a few published studies of its effectiveness. We identified three quantitative studies—Calhoun, Poirier, Simon, and Muller (2001), Joyce, Hrycauk, and Calhoun (2003), and Swartzendruber (2007)—which focused on vocabulary acquisition, and one qualitative study by Feng (2011), which explored the perspectives of teachers and students on both the PWIM and cooperative learning. In the three quantitative studies, the PWIM was not the only intervention used. Moreover, none of the studies focused exclusively on the pedagogical effectiveness of the PWIM in terms of its significance in increasing vocabulary acquisition.

The study by Calhoun et al. (2001) focused on the sight vocabularies of 26 first graders in a French Immersion class, an unreported number of first graders in an English language class, and an unreported number of fourth/fifth graders in a special education class. They found that the average gain for sight vocabularies of the average subgroup of students at the end of their first grade was 2.1 compared to 0.25 for the previous four or five years without the PWMI. They also found no gender differences in the results. The research of Joyce et al. (2003) also focused on the sight vocabularies of kindergarten-age students. Findings from this study (N=141) revealed that the mean percentage of recognized words for these students increased from 30% to 90% after three cycles of the PWIM. All of the participants in this study made progress, which was equivalent to that of students in an average first-grade classroom. Although Swartzendruber's

(2007) study was quasi-experimental in nature, participants (35 second grade English as a Second Language and native English speakers) using the PWIM in the experimental group out-performed those in the control group in relation to vocabulary knowledge and final assessment. Also, there were statistically significant differences in performance between the control and experimental group. However, it should be noted that the PWIM was not the only intervention used with the experimental group. Other scaffolding strategies were also used in addition to explicit connections to concepts.

In the one qualitative study (i.e., Feng, 2011), we found that both the PWIM and cooperative learning were examined. This study, conducted over an 11-month period, involved three elementary English teachers and 71 4^{th}, 5^{th} and 6^{th} graders in Taiwan. Both the teachers and students highly recommended implementing this approach in a Taiwanese, English as a foreign language (EFL) context. However, only two of the teachers reported that their students' English vocabulary had increased as a result of the new approaches and that their students reported that their motivation toward learning English had improved.

A Conceptual Framework for PWIM Efficacy Research

Interestingly, none of the four studies that we found in the literature focused exclusively on the pedagogical effectiveness of the PWIM for 'significantly' increasing vocabulary acquisition. Drawing from this knowledge, we hypothesized that a researcher who conducts a randomized control trial study of its effectiveness that employs the following methodology would yield a more rigorous evaluation of the PWIM as an instructional strategy.

The research methodology we propose requires the researcher to identify two groups of study participants, an intervention group who are taught the PWIM strategy and a control (comparison) group that receives the business-as-usual curriculum. The intervention and comparison groups should be similar on observable characteristics (i.e., grade level and reading ability at the beginning of the project, with the difference between the two groups having a standard deviation of less than 0.25 based on the variation of the reading ability measure in the pooled sample (cf. Ho, Imai, King, & Stuart, 2007). The researcher should use the last digits of an identification code or other similar approach to assign classrooms randomly to form the intervention group and the comparison group. The researcher could assess the intervention's effect based on student-level *t*-tests (two-tailed test with an alpha of 0.05), assuming group equivalence on pre-intervention measures based on random assignment.

The effect size of the intervention could be estimated with the standardized mean difference between the mean outcome of the intervention group and the mean outcome of the comparison group divided by the pooled within-group standard deviation of the outcome measure. This effect size, known as Hedge's *g* (Hedges, 1981), is used to estimate the magnitude of an intervention, and is not affected by sample size. To compute an improvement index for the intervention, the researcher could convert Hedge's *g* to Cohen's (1977) U3 index, which represents the percentile rank of a control group of students who performed at the level of an average treatment group of students.

Attrition bias is a potential problem for a study of this nature because research has shown that children change schools at rates as high as ten percent per year (Goldenberg, Gallimore, Reese,

& Gardiner, 2001; Lindsey, Manis, & Bailey, 2003; Manis, Lindsey, & Bailey, 2004). Differential and overall attrition can bias the effect of an intervention; therefore, the researcher will want to ascertain if the outcomes are biased due to differential and overall attrition.

There are four phases in conducting such a study as we have conceptualized above — enrollment, allocation to intervention, follow-up, and data analysis (Schulz, Altman & Moher, 2010). According to Schulz et al., enrollment involves assessment for eligibility and randomization. Allocation to intervention involves assigning those students identified as belonging to the experimental group to supplemental instruction and intervention in addition to and in alignment with core instruction. Follow-up involves ascertaining if the intervention caused a positive, significant increase in the mastery of the learning objectives. And, data analysis involves determining if the experimental/intervention group performed significantly better than the control/non-intervention group.

To analyze variance in the outcome measures at multiple hierarchical levels, we recommend Hierarchical Linear Modeling (HLM). HLM is an appropriate modeling procedure for analyzing nested data (e.g., students nested within classrooms; classrooms nested within schools). When repeated measures data are collected (pre- and post-assessment), the researcher can treat time as another level, which occurs within participants (Raudenbush & Bryk, 2002).

Conclusion

We presented a discussion of the PWIM from the perspective of Bruner's constructs of learning and the Cognitive Load Theory. Our exploration of this model revealed that it exemplifies the tenets of Bruner's structure of learning, spiral curriculum, and discovery learning. We also found that the model requires presenting novel words and pictures, which might lead to a cognitive overload for learners who are unfamiliar with the pictures or vocabulary being presented. Because of the language challenges faced by ELL students, instructional alternatives were suggested for ELL classroom teachers based on the Cognitive Load Theory, which we perceived would attenuate the cognitive demand imposed by the learning task. Because of our inability to uncover a substantial number of evidence-based effectiveness studies of the PWIM in the literature, we concluded our discussion with a carefully thought-out conceptualized protocol for researchers to conduct a rigorous, systematic assessment of its effectiveness.

AUTHOR NOTES

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