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Authors
Cammack, Dana W.
Hoffman, Daniel
Kapur, Manu
et al.

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Assessing Preservice Teachers' Conceptual Change in an Internet-Based, Case Instructional Environment

Charles K. Kinzer (Kinzer@tc.columbia.edu)
Teachers College, Columbia University, 525 West 120th St., 322 Thompson Hall (CCTE)
New York, NY 10027 U.S.A.

Manu Kapur (mkapur@nie.edu.sg)
National Institute of Education, Nanyang Technological University
Singapore

Sarah Lohnes (scl2103@columbia.edu)
Teachers College, Columbia University, 525 West 120th St., 322 Thompson Hall (CCTE)
New York, NY 10027 U.S.A.

Dana W. Cammack (Cammackd@mail.montclair.edu)
Montclair State University, One Norman Ave., University Hall Room 3200
Montclair, NJ 07043 U.S.A.

Stavroula Kontovourki (sk2322@columbia.edu)
Teachers College, Columbia University, 525 West 120th St., 322 Thompson Hall (CCTE)
New York, NY 10027 U.S.A.

Daniel Hoffman (dlh2109@columbia.edu)
Teachers College, Columbia University, 525 West 120th St., 322 Thompson Hall (CCTE)
New York, NY 10027 U.S.A.

Selen Turkay (st2282@columbia.edu)
Teachers College, Columbia University, 525 West 120th St., 322 Thompson Hall (CCTE)
New York, NY 10027 U.S.A.

Abstract

This paper (1) presents an argument that anchored, multimedia case-based instruction, delivered interactively over the Internet, has benefits for the conceptual development of preservice teachers, (2) argues that a commonly-used measure can be modified to provide insights into conceptual change, and (3) suggests needed, additional analyses to examine change in depth/complexity of knowledge. Evidence and insights from a two-group, large-scale experimental study of preservice teachers using multimedia, anchored cases in their preservice literacy methods courses support the discussion.

Keywords: Case-based Instruction; Teacher Education; Teacher Cognition; Conceptual Change

CTELL Project Overview

To examine the differences in learning outcomes among participants in pre-service literacy courses that used Internet-based multimedia cases and those that relied on more traditional methods (e.g., lectures, field experiences, and readings), our research team implemented a pre-posttest experimental design. Thus, the nature of instruction (case-based vs. traditional instruction) and the change in learning outcomes across time (pre-posttests) constituted the dependent variables included in the design. Case-based instruction relied on the use of the Case Technologies to Enhance Literacy Learning (CTELL) project, described briefly below. A discussion of the instruments, design, and analysis used to examine learning outcomes by preservice teachers in CTELL follows the project description.

The CTELL project is an effort to enhance pre-service teachers' knowledge and skills relevant to best practices for literacy instruction. The construction of the CTELL cases was theoretically grounded in twelve principles of effective reading instruction. These emerged from an extended review of research on early literacy instruction and encompassed teacher knowledge; relevance of instruction to students' cultural backgrounds; development of foundational literacy skills; phonemic awareness, decoding and comprehension instruction; independent reading; development of fluency; integration of reading and writing; incorporation of computer and Internet technology into early literacy instruction; early assessment; and enthusiasm for and engagement in reading (Teale, Kinzer, Labbo, & Leu, 2002; Shrader et al., 2003). These principles guided

decisions regarding the CTELL curriculum, the collection of video, audio, and visual information incorporated in the cases, and the coding of data during the analysis process.

The principles were not embodied in the cases as isolated items, but rather combined in ways that allowed learners to examine their interplay in classroom events over time. The principles also formed the basis for later analysis of conceptual change. We argue that if the multimedia instructional cases embody the principles of effective instruction, then learners who use these materials should reflect greater knowledge of effective reading instruction than learners receiving de-contextualized instruction, which constitutes the norm in traditional preservice methods courses and relies on lectures and readings that are not placed in an anchored, situated instructional context.

The CTELL cases were designed to form an online, multimedia, interactive environment, wherein pre-service teachers developed content knowledge while being exposed to the complexity of classroom instruction. Drawing on notions of situated cognition and anchored instruction (CTGV, 1990) and case-based design and methodology (Merseth, 1991; Kaste, 2004), a 20-minute anchor video that illustrated the overall orientation and literacy activities in a primary-grade classroom was central to this design. This anchor video provided the common basis for instructors and learners to construct knowledge through discussion and critical analysis of theory, research, and practice.

To scaffold pre-service teachers' understanding of the complexities of classroom instruction, the CTELL cases addressed factors that influenced instruction and exist both within and beyond the physical boundaries of classrooms. In addition to the anchor video, each of the cases included short video clips that focused on various principles as implemented in that classroom, student profiles consisting of data from running records, writing samples, results from standardized tests, parent-teacher conferences, interviews with students, teachers and principals, as well as school and classroom demographic statistics.

While participants in the control group implemented their regular instructional strategies (e.g., assignment of readings, in-class presentations, discussions, field experiences), the CTELL instructors (experimental group) participated in training sessions leading to integration of the cases in their classroom instruction (Kinzer et al., 2004). CTELL instructors were encouraged to view and discuss the anchor video with their students in their first class session, and then pose questions to guide learners' interactions with the cases and help them make explicit connections between the cases and other course content. However, it was made clear that the cases were a flexible teaching tool, to be used in ways best suited to the context defined by the instructor's teaching style, the students, and his/her course (Teale et al., 2002).

Case use by particular instructors was influenced by multiple factors, including their beliefs about the cases' usefulness, the availability of technology in and out of their classrooms (Sanny, 2005), and the overall organization of their courses (e.g., their approach to literacy learning,

organization of topics, etc.). These factors contributed to the variance of CTELL case use in particular classrooms. This variance is similar to that found in non-CTELL classrooms.

Theoretical Background of Concept Mapping as an Assessment Tool

To examine the impact of the CTELL environment on preservice teachers' learning and conceptual change, data were collected through concept maps, a Likert-scale confidence measure of students' beliefs about their ability to teach reading effectively, journal entries from professors, student interviews, and professor interviews. The analysis of concept web data constitutes the focus of this paper.

As a measurement tool concerned with addressing students' conceptual understanding for a given topic, concept webs appear to be better suited to assess inquiry or project-based learning than more traditional assessments such as multiple-choice tests (Stoddart et al., 2000; Novak & Gowan, 1984; Markham, Mintzes, & Jones, 1994). As described below, concept webs can reveal students' conceptual understanding, here defined as the learning process that includes weak and/or strong revisions of prior knowledge upon acquisition of new information (Tyson et al., 1997). Furthermore, a concept map contains both visual (the structure and hierarchy of the map) and verbal information (the concepts), thus offering opportunities for both quantitative and qualitative analysis (Zele et al., 2004).

In a concept-mapping task, students are asked to visually represent the structure and organization of their conceptual knowledge by creating a series of interlinked circles or nodes, with each node representing a concept. This task may take a number of forms. Stoddart et al. (2000) identify three: constrained tasks, where students are given a map structure and a list of words to use; open-ended tasks, which provide an initial prompt but leave the construction of the web to the student; and intermediate tasks, which draw on elements of the first two (p. 1224). The CTELL concept web task was open-ended; students were presented with a central node, "effective reading instruction," and asked to construct a web around it. Initial examples and discussion about what constituted a concept web and how it should represent knowledge were provided prior to the webbing task.

The process of creating a concept map requires students to engage in knowledge construction. Thus, each map is unique, as it represents a student's mental model of a topic at the time of its construction (Kinchin et al., 2000). Research has also shown that concepts maps can be effective for measuring the change in students' conceptual understanding over time (e.g., see Morine-Dershimer, 1993), implying that changes across concept maps represent a progression in the differentiation of students' knowledge (Kinchin et al., 2000; Trent et al., 1998; Zele et al., 2004).

Data Analysis

The concept web assessment was administered to 365 students (n=199 experimental, using CTELL cases; n=166 control, receiving traditional instruction) at the beginning

(pre) and the end (post) of a semester. These students were enrolled in pre-service literacy instruction courses at universities and colleges across the United States, both public and private. After discussing sample concept webs, they were asked to draw a central node labeled "effective reading/literacy instruction," and were given ten minutes to draw a concept web around that node.

Treating the concept map as the data unit, two commonly used measures for conceptual change were examined: the degree of differentiation (total number of discrete nodes) and the degree of hierarchical organization (maximum number of subordinate levels) (Beyerbach, 1988; Jensen & Winitzky, 2002; Morine-Dershimer, 1993). In this paper, we refer to the former as intensity and the latter as depth. Beyerbach (1988) argued that change in intensity and depth corresponds to conceptual change. More formally, counting the central node as level 0, if there were n_1 nodes at level 1, n_2 nodes at level 2, and so on up to n_l nodes at level l, then intensity, $I = n_1 + n_2 + ... + n_l$ and depth, $D = l$. Figure 1 illustrates levels within a prototypical web.
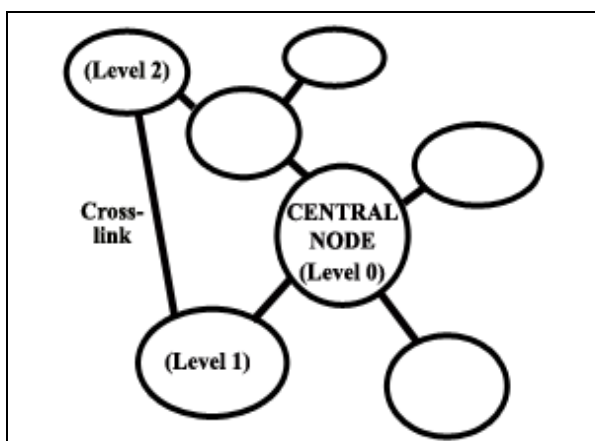

Figure 1: Levels on a Prototypical Web

In the scoring process, a web was assigned an overall intensity number (equal to the number of nodes), and an overall depth number (equal to the number of levels within the web). Each node on a web was then evaluated for content and assigned to one of thirteen categories, corresponding to the 12 principles of effective literacy instruction noted earlier, plus a category called "Other." A node was assigned to a category based on its content, and on the cluster of nodes to which it was attached. For example, if attached to a level 1 node "comprehension," level 2 node "student-centered" would be coded as Comprehension; if the same level 2 node was attached to the level 1 node "teaching styles," it would be coded as Teacher Knowledge. Nodes of a very general nature and/or nodes unconnected to other nodes or to one of the 12 principles were coded into the category "Other." The coding continued until all the nodes on a web were assigned to a category.

Additionally, each category was assigned a centrality number based on the depth of the first node encountered under that category. The centrality of each category was determined by looking across all nodes on the web for a given category. Two raters independently scored all concept webs (with a reliability of 85% for category assignment across 100 randomly-selected webs). Discrepancies between the two raters were resolved by discussion. Coding the nodes on the web by content, as well as by total number and number of levels, allowed us to begin to understand shifts in specific areas of literacy knowledge.

Our analysis of the concept webs also involved a third measure of conceptual change, dealing with the number and character of cross-links present in a web. A cross-link refers to a link between two nodes that crosses clusters of concepts. While a simple concept web without cross-links reveals the concepts present in a student's knowledge, the presence of cross-links in a web suggests that the student is integrating and synthesizing concepts (Hanrahan & Tate, 2001). Furthermore, Kitchin et al. (2000) suggest that a cross-linked web reveals more flexibility in a student's understanding, given that concepts can be accessed in a number of ways, not just in relationship to the central node on the web. In short, a concept web that contains cross-links reveals a more complex and integrated conceptual understanding of the subject under study.

Discussion of the Intensity and Depth Analysis

Our initial analysis examined change in conceptual growth as a function of intensity and depth. Treating gain in intensity and depth as the two dependent variables, a MANOVA did not reveal any significant difference between the control and experimental groups ($F = 1.275$, $p = .281$). Univariate analysis also did not reveal any differences on gains in intensity ($F = .469$, $p = .494$) or depth ($F = 1.235$, $p = .267$). Thus, one may conclude that on these two measures of conceptual change—total number of nodes and maximum depth—there was no significant difference in the conceptual change of students who were taught with vs. without CTELL cases.

However, a limitation of this analysis is that it considers intensity and depth as separate measures of conceptual change. It is reasonable to argue that a more powerful measure of conceptual change would combine the differentiation and hierarchical organization characteristics of a concept web. Insofar as we are aware, such measures do not exist. Thus, using the mathematical principle of rearrangements, two adjusted measures were developed.

In a traditional analysis, the number of times a principle is mentioned (its intensity) and its distance from the central node (or hierarchy) are analyzed separately. For example, a principle that is mentioned 3 times in a concept web would contribute 3 nodes to the total number of nodes (or total intensity) regardless of how far each node is from the central node. The principle of rearrangements allows us to adjust for the intensity of a node vis-à-vis its hierarchy from the central node. The idea being: nodes that are closer to the

central node (higher up in the hierarchy) have greater centrality in the conceptual schema (as captured in the concept web) than those that are further away. Thus, they should contribute more to the overall intensity. Gain/loss on this measure better captures an overall movement up or down a concept map's hierarchy, providing evidence for cognitive reorganization (Jones & Vesilind, 1996).

The intensity of a node was adjusted for its hierarchy. Recall that counting the central node as level 0, if there were n_1 nodes at level 1, n_2 nodes at level 2, and so on up to n_l nodes at level l, then intensity, $I = n_1 + n_2 + ... + n_l$ and depth, $D = l$. For a node that occurs l levels away from the central node (the center node being level $l = 0$), its hierarchical leverage is $1/l$, i.e., the further it is away from the center node, the lower its leverage. Thus, by multiplying the number of nodes at a particular level with their hierarchical leverage, we obtained an adjusted measure of intensity, $I' = \dfrac{n_1}{1} + \dfrac{n_2}{2} + ... + \dfrac{n_l}{l}$.

What does this adjusted measure of intensity capture? In answer, consider an ordered set of l positive integers $m_1, m_2, ..., m_l$ such that $m_1 > m_2 > ... > m_l$. On one extreme is the concept web with m_1 nodes at level 1, m_2 nodes at level 2, and so on up to m_l nodes at level l. Such a concept web will have an adjusted intensity of $I_{max} = \dfrac{m_1}{1} + \dfrac{m_2}{2} + ... + \dfrac{m_l}{l}$ with the most nodes in level 1, fewer in level 2, even fewer in level 3 and so on. In other words, such a concept web will display more breadth than depth. On the other extreme, is the concept web corresponding to an adjusted intensity of $I_{min} = \dfrac{m_l}{1} + \dfrac{m_{l-1}}{2} + ... + \dfrac{m_1}{l}$ with the least number of nodes in level 1, greater numbers in level 2, even more in level 3, and so on. In other words, such a concept web will display more depth than breadth. By the principle of rearrangement, all other combinations will necessarily lie between these two extreme cases.

Why this occurs can be illustrated with a "layperson's" example that captures the principle's essence. Suppose we want to pick 10, 7, and 5 bills from piles of $100, $20, and $10 bills. How could we choose the most (or least) money? Intuitively, the choice that makes the most money is 10 $100 bills, 7 $20 bills, and 5 $10 bills, while choosing 10 $10 bills, 7 $20 bills, and 5 $100 bills captures the least money. Any other choice would fall between these two extremes. The principle of rearrangements establishes the above intuitive notion mathematically. Thus, one extreme is established by assigning the largest number (10) to bills with the maximum value ($100), the next largest to the next bill value, and finally the smallest number to the bill with the least value. Similarly, assigning the largest number to bills with the least value, the next largest to the next bill value, and finally the smallest number to the bill with the

largest value, results in the other extreme. All other rearrangements lie between these two extremes. The same principle applies to the adjusted measure of intensity as operationalized earlier.

Thus, any change in the value of adjusted intensity corresponds to a change in the balance between breadth and depth in a concept web. As one adjusts this balance from one extreme to the other, the entire continuum of possible concept webs is considered, and gain/loss on this measure arguably captures and provides evidence for conceptual reorganization.

Finally, to get a more accurate measure of hierarchical organization, the depth of a concept web was normalized by its un-adjusted intensity to give adjusted depth, $D^1 = \dfrac{l}{n_1 + n_2 + ... + n_l}$. It is easy to see that a given number of nodes distributed over fewer levels imply lower depth in the concept web whereas the same number of nodes distributed over many levels implies greater depth.

When the previous statistical analysis was repeated with the adjusted measures of intensity and depth, results suggested a significant multivariate difference between the control and experimental groups ($F = 6.799$, $p = .001$). Univariate analysis revealed that experimental groups ($M = 2.31$, $SD = 4.39$) had significantly ($F = 6.540$, $p = .011$) greater adjusted intensities than control groups ($M = 1.08$, $SD = 4.79$). Furthermore, experimental groups ($M = -.043$, $SD = .11$) had significantly ($F = 11.696$, $p = .001$) lower depth in their concept maps than the control groups ($M = -.0063$, $SD = .09$). These results—using both unadjusted and adjusted measures—provided confirmatory evidence for an exploratory analysis (unreported here due to space constraints) of experimental data from the previous year ($n = 166$ control, $n = 201$ experimental). Thus, by using these measures of intensity and depth in place of the more commonly-used measures noted earlier, one can find previously undiscovered differences in conceptual changes.

The results of this analysis indicate that the literacy principles became more central to preservice teachers' conceptual understanding, implying that the CTELL cases prove a potential vehicle to broaden their understanding. While there were no differences in the number of discrete nodes, nodes were closer, in terms of ordination, to the central node in the concept webs of experimental groups. This provides evidence of cognitive reorganization in terms of movement up the hierarchy of the concept map. Because there was also no difference in the maximum number of sub-ordinate levels, this implies that the upward movement was accompanied with a spreading across the levels. Our results using the reconceptualized measures to analyze concept webs imply that CTELL cases are effective in providing an understanding of the centrality of concepts related to the principles of effective reading instruction.

Discussion of the Cross-Links Analysis

As noted earlier, our concept web analysis involved a third measure of conceptual change: the number and character of cross-links present in a web. That is, while the previous analysis indicated that CTELL case-based learners better understood the centrality of concepts related to effective reading instruction, it did not assess the complexity or integration of conceptual knowledge. In making our decision to include this additional analysis, we noted that Novak and Gowin (1984) gave points for cross-linked nodes; we also noted arguments that only "valid" cross-links should be counted for analysis (e.g., Dorough and Rye, 1997), while others suggested that all links on a web are valid, given that "invalid" links highlight misconceptions in a student's understanding (Kitchin et al., 2000). We found Kitchin et al.'s (2000) arguments compelling, and thus all links on a web were counted in the present analysis. Cross-links were given a distance score based on the shortest path between the two linked nodes, determined as follows.

All links between nodes (both cross-links and regular links) were initially counted. As webs were complex and lent themselves to the possibility of counting errors, each link was highlighted with a marker as it was counted, ensuring that all links were counted, but not more than once. Subtracting the total number of links from the number of nodes (not counting the given, center node in the node count), logically yields the number of cross-links. That is, if each node had a single link between it and another node, the number of links would equal the number of nodes, minus one (the originating or central node). However, if a web contained a cross-link (more than one link going from a given node), the difference between total number of nodes and total number of links would yield the number of cross-links (i.e., multiple links between nodes).

Once cross-linked nodes were identified, each pair present on the web was given a distance score. This was accomplished by choosing one of the cross-linked nodes, and tracing the shortest route to the other linked node in terms of the number of links traversed via a superordinate node. Assigning a distance score in this way takes into account the fact that nodes may be cross-linked across levels, thus accounting for the depth of the web.

The distance score between two cross-linked nodes was seen as a measure of the strength of the cross-link; the greater the distance, the greater the strength, and the deeper the conceptual understanding. Thus, for the cross-links analysis, each web had a total number of links, and a distance score for each cross-link.

Treating gains in the number of cross-links and the corresponding distance scores as the two dependent variables, a MANOVA did not reveal a significant difference between control and experimental groups ($F = 1.256$, $p = .286$). Univariate analysis also did not reveal differences on gains in number of cross-links ($F = .937$, $p = .334$) or distance scores ($F = 1.995$, $p = .159$). Thus, one may conclude that on these two measures of conceptual change, there was no significant difference in the conceptual change of students who were taught with vs. without CTELL cases.

Somewhat surprisingly, the cross-link analysis in and of itself was unable to pick up differences in conceptual change between control and experimental groups. This result meant that there was no weighted linear combination of cross-links and distance scores that significantly separated the control from the experimental groups. Seen this way, a possible explanation could be that these two measures by themselves do not capture sufficient information contained in the concept web over and above what is captured by the adjusted measures of intensity and depth reported earlier in this paper.

Consequently, a reasonable step was to investigate if there was a linear combination of the four measures of conceptual change—adjusted intensity, adjusted depth, gain in number of cross-links, and distance scores—that maximally separated the control from the experimental groups. In treating these four measures as the dependent variables, a MANOVA was significant ($F = 3.826$, $p = .005$) thereby confirming that such a linear combination indeed existed. Consistent with the results reported earlier, univariate analysis revealed that experimental groups had significantly greater adjusted intensities ($F = 4.581$, $p = .033$) as well as lower depth ($F = 10.518$, $p = .001$) in their concept maps than the control groups. However, there were no statistically significant gains in the number of cross-links ($F = .444$, $p = .506$) and distance scores ($F = 1.715$, $p = .191$).

This confirms the explanation that while the typical measures of number of cross-links and their corresponding distance scores add to the overall effect, by themselves they carry insufficient weight in measuring conceptual change. This is a significant finding for measuring conceptual change through the use of concept webs. An obvious and important implication and way forward, as with the adjusted measures for the initial node analysis, is the need to rethink the way that we measure cross-links in concept webs.

Implications

The practices employed in this project—throughout the delivery of instruction in pre-service literacy methods courses and the data analysis process—lead to methodological and theoretical implications. The process of data analysis indicates that using concept webs as measurement tools is valuable, but needs to be expanded to overcome the limitations of normally-employed analyses.

Specifically, previous work on concept-mapping (e.g., Beyerbach, 1988; Jensen & Winitzky, 2002; Morine-Dershimer, 1993) proved useful at the initial stages of the analysis, as it led us to measure both the intensity and the depth of students' concept webs. However, our analysis moved further to consider learners' conceptual development as evident through the interplay of different measures (i.e., the combination of intensity and depth measures as well as the combination of cross-link measures with the former). This is indicative of the complexity of the research process when concept webs are involved, and points to the pursuit

of adjusted measures that were fruitful in our analysis of intensity and depth for future analyses.

Recent research in using concept webs as an assessment tool has moved to address the complexity inherent in capturing pre-service teachers' conceptual change through qualitative measures for scoring webs (e.g., Kinchin et al., 2000; Van Zele et al., 2004). A mixed-method approach, as employed here, that takes into account the various levels of complexity may be another avenue for future research to reveal students' conceptual understanding through concept webs. To further understand the nature of learners' conceptual development and the ways this development is influenced by the learning environment, future analyses by the CTELL project will focus on combining the results obtained through concept mapping with other measures.

The fact that preservice teachers became more aware of the centrality of concepts related to principles of effective reading instruction suggests that case-based, anchored instruction through CTELL cases effectively scaffolded learners' conceptual and professional development. This resonates with arguments that case-based instruction can provide models of how to think professionally about problems, thereby facilitating reasoning and decision-making in teaching (e.g., Hewitt et al., 2003; Kinzer et al., 2006; Kurz et al., 2005; Lundeberg, 1999). We argue that the adjusted measures for concept web analysis described herein were not only fruitful in the analysis of our data, but point to a need for measures and analyses that capture the complex nature of preservice teachers' conceptual change.

Acknowledgements

References

CTGV (Cognition and Technology Group at Vanderbilt) (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19*(6), 2-10.

Hewitt, J., Pedretti, E., Bencze, L., Vaillancourt, B. D., & Yoon, S. (2003). New Applications for Multimedia Cases: Promoting Reflective Practice in Preservice Teacher Education. *Journal of Technology and Teacher Education, 11*(4), 483-500.

Jones, G. M., & Vesilind, E. M. (1996). Putting practice into theory: Changes in the organization of preservice teachers' pedagogical knowledge. *American Educational Research Journal, 33*(1), 91-117.

Kaste, J. A. (2004). Scaffolding through cases: Diverse constructivist teaching in the literacy methods course. *Teaching and Teacher Education, 20*(1), 31-45.

Kinzer, C. K., Cammack, D. W., Labbo, L. D., Teale, W. H., & Sanny, R. (2006). Using technology to (re)conceptualize pre-service literacy teacher education: Considerations of design, pedagogy and research. In M. C. McKenna, L. D. Labbo, R. E Keiffer, & D. Reinking

(Eds.), *International handbook of literacy and technology* (Vol. 2, pp. 212-233). Mahwah, NJ: Lawrence Erlbaum.

Kinzer, C. K., Labbo, L., Leu, D. J., Teale, W., & Cammack, D. W. (April, 2004). C*ase technologies to enhance literacy learning: An overview and description of CTELL cases and project implementatio*n. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Kurz, T. M., Llama, G., & Savenye, W. (2005). Issues and challenges of creating video cases to be used with preservice teachers. *TechTrends, 49*(4), 67-73.

Lundeberg, M. (1999). Discovering teaching and learning through cases. In M. Lundeberg, B. Levin & H. Harrington (Eds.), *Who learns what from cases and why?* (pp. 3-23), Mahwah, NJ: Lawrence Erlbaum Associates.

Markham, K., Mintzes, J., & Jones, M. (1994). The concept map as a research and evaluation tool: Further evidence of validity. *Journal of Research in Science Teaching, 31*(1), 91-101.

Merseth, K. (1991). *The case for cases in teacher education*. Washington, DC: American Association of Colleges for Teacher Education.

Morine-Dershimer, G. (1993). Tracing conceptual change in preservice teachers. *Teaching and Teacher Education, 9*(1), 15-26.

Novak, J., & Gowan, D.B. (1984). *Learning how to learn*. Cambridge: Cambridge University Press.

Sanny, R. (2005). Exploring web-based case use in literacy teacher preparation: Realities, complexities, possibilities. *Dissertation Abstracts International, 66*(05), 1622. (UMI No. 3174211).

Schrader, P. G., Leu, D. J., Kinzer, C. K., Ataya, R., Labbo, L. D., Teale, W. H., & Cammack, D. W. (2003). Using Internet delivered video cases, to support pre-service teachers' understanding of effective early literacy instruction: An exploratory study. *Instructional Science, 31*, 317–340.

Stoddart, T., Abrams, R., Gasper, E., & Canaday, D. (2000). Concept maps as assessment in science inquiry learning-- a report of methodology. *International Journal of Science Education, 22*(12), 1221-1246.

Trent, S., Pernell, E., Mungal, A., & Chimedza, R. (1998). Using concept maps to measure conceptual change in preservice teachers enrolled in a multicultural education/special education course. *Remedial and Special Education, 19*(1), 16-31.

Teale, W. H., Kinzer, C. K, Labbo, L. D., & Leu, D. J., Jr. (2002). *Beginning reading instruction*. Athens, GA: University of Georgia.

Tyson, L. M., Venville, G. J., Harrison, A. G., & Treagust, D. F. (1997). A multidimensional framework for interpreting conceptual change events in the classroom. *Science Education, 81*, 387-404.

Van Zele, E., Lenaerts, J., & Wieme, W. (2004). Improving the usefulness of concept maps as a research tool for science education. *International Journal of Science Education, 26*(9), 1043-1064.