Chapter 2
Cognition and Student-Centered, Web-Based Learning: Issues and Implications for Research and Theory

Michael J. Hannafin and Kathleen M. Hannafin

Abstract During student-centered learning, the individual assumes responsibility for determining learning goals, monitoring progress toward meeting goals, adjusting or adapting approaches as warranted, and determining when individual goals have been adequately addressed. This can be particularly challenging in learning from the World Wide Web, where billions of resources address a variety of needs. The individual must identify which tools and resources are available and appropriate, how to assemble them, and how to manage the process to support unique learning goals. We analyze the applicability of current cognitive principles to learning from Web-based multimedia, review and critically analyze issues related to student-centered learning from Web-based multimedia, and describe implications for research and theory.

2.1 Introduction

The effectiveness of didactic methods has been demonstrated, but significant recent interest has been evident in user-centered, Web-based multimedia. This chapter focuses on student-centered learning in Web-based environments wherein the individual determines goals, selects or devises approaches to address the goals, and interprets and constructs meaning. We emphasize primarily research on learning from and/or with the Web, as well as related cognitive and multimedia research with implications for Web-based learning. We compare the cognitive demands of ill-structured and externally structured learning, review and analyze research and practice related to student-centered learning from Web-based multimedia, and describe implications for research, theory, and practice.

While many research-based learning and cognition principles are readily applicable to student-centered, Web-based learning, epistemological shifts and advances in

M.J. Hannafin (✉)
Learning and Performance Support Laboratory, University of Georgia, Athens, GA, USA
e-mail: hannafin@uga.edu

J.M. Spector et al. (eds.), *Learning and Instruction in the Digital Age*,
DOI 10.1007/978-1-4419-1551-1_2, © Springer Science+Business Media, LLC 2010

technologies raise important and unanswered questions. Constructivists suggested basic shifts in both beliefs as to the locus of knowledge and educational practices (Jonassen, 1991). Technologies have extended, augmented, and/or supplanted individual cognitive processes, reflecting a shift from delivery to tools that support and enhance thinking (Iiyoshi, Hannafin, & Wang, 2005). Thus, the role of technology in student-centered approaches has become increasingly dominant in the efforts of Web-based learning theorists, researchers, and practitioners.

Hannafin, Land, and Oliver (1999) described student-centered activity during open learning where the locus of activity and control shifts from external to individual responsibility for establishing learning goals and/or determining learning means. As a result, the cognitive demands shift from selecting and processing externally organized stimuli to anticipating and seeking based on individual needs and goals. In many cases, the associated cognitive shifts have proven problematic when students lack requisite self-regulation skills (see, for example, Azevedo, Guthrie, & Seibert, 2004; Kauffman, 2004; Whipp & Chiarelli, 2004). Researchers have noted that students failed to develop theories or explanations and retained initial misconceptions (de Jong & Van Joolingen, 1998), to reflect or enact metacognitive processes (Atkins & Blissett, 1992; Azevedo, 2005; Hill & Hannafin, 1997; Wallace & Kupperman, 1997), and to develop coherent, evidence-based explanations (Nicaise & Crane, 1999). Land (2000) concluded that without effective support, "misperceptions, misinterpretations, or ineffective strategy use . . . can lead to significant misunderstandings that are difficult to detect or repair. When learners have little prior knowledge. . .metacognitive and prior knowledge are needed to ask good questions and to make sense out of the data and events being modeled" (pp. 75–76).

According to Hill and Hannafin (2001), "Predigital educational resources conveyed meaning consistent with and supportive of established goals and standards" (p. 38), but a digital resource's "meaning is influenced more by the diversity than the singularity of the perspectives taken" (p. 40). In effect, the potential for increased and largely unregulated granularity alters the cognitive demands associated with resource access and use. Accordingly, self-regulation, metacognitive, and navigation capabilities vary widely across a vast and ill-structured array of Web resources. Thus, student-centered, Web-based learning reflects fundamental shifts in cognitive requirements as well as the foundations and assumptions underlying design and use (Hannafin & Land, 1997). In this chapter, we briefly highlight key assumptions, discuss several issues that have emerged through efforts to design and validate, and identify implications for research and theory related to student-centered, Web-based learning.

2.2 Assumptions Underlying Student-Centered Learning

With the resurgence of constructivism, many researchers have shifted from objectivist models that emphasize external mediation and meaning to uniquely individual perspectives (Land & Hannafin, 1996). According to constructivists, meaning is derived from and interpreted through individual beliefs, experiences, and social contexts. Thus, individual meaning is constructed through personal interactions with the world rather than assimilations (Phillips, 1995). Building from extensive cognition and learning research and theory, the American Psychological Association published learner-centered psychological principles (APA Work Group of the Board of Educational Affairs, 1997) wherein they delineated criteria for effective student-centered learning design and implementation (Alexander & Murphy, 1998). Several assumptions differentiate constructivism from externally based perspectives. We focus on assumptions regarding the locus and nature of knowledge, role of context, and prior experiences.

2.2.1 Locus and Nature of Knowledge

Constructivists assert that learners construct meaning uniquely based on personal interactions with society, individuals, and objects; constructivist-inspired learning environments often provide resources for learners to manage their own learning through exploration, hypothesis formation, and student-relevant feedback. Papert (1993), for example, employing student manipulation of a Logo Turtle, fostered deeper mathematics understanding than directed classroom activity. Among college-age students, Uribe, Klein, and Sullivan (2003) reported collaborative dyads outperformed individuals working alone and spent more time investigating ill-defined problems in an online course. Using online supports and group collaboration, learners explored ill-defined problems, considered and tested hypotheses each might have individually overlooked, and improved their understanding of problem-solving processes.

Although student-centered learning environments are purported to foster exploration and hypothesis formation, validation has proven problematic. McCombs and Whisler (1997) described learner-centered environments as places where learners engage in complex and relevant activities, collaborate with peers, and employ resources to collect, analyze, and represent information. However, Remillard's (2005) synthesis of research indicated that teachers' content knowledge, pedagogical content knowledge, beliefs, and their interpretation of the curriculum influenced and often dominated how presumed learner-centered activities were enacted. Researchers have documented similar instances where teachers undermined learner-centered activities by supplying rote algorithms for students (Doyle, 1988).

It has also proven difficult to establish conclusive relationships between technology and student learning (e.g., Roschelle, Pea, Hoadley, Gordin, & Means 2001). Some researchers have documented positive effects using technology to facilitate problem solving, conceptual development, and critical thinking (Ringstaff & Kelley, 2002; Sandholtz, Ringstaff, & Dwyer, 1997). Wenglinsky (1998) reported that where teachers used technology in conjunction with learner-centered pedagogies, students scored significantly higher on the mathematics portion of assessments of educational progress than students that did not: Eighth graders who used technology for mathematics drill and practice scored significantly lower than peers who used no technology.

Although some research suggests that Web-based approaches can promote deeper learning when intended strategies are followed, these strategies are often not utilized. In an effort to deepen understanding of mathematics through investigation, Orrill (2006) created an extensive Web site including open-ended investigations, a mathematics dictionary, discussion board, and electronic portfolios. Teachers explored available resources, selected problems, and identified their own instructional paths (combined with attendance in face-to-face workshops). Improvements in mathematics skills and depth of knowledge were expected, but teachers typically focused on technology skills and did not refine their understanding or skills.

2.2.2 Role of Context

Student-centered learning environments often rely on authentic experiences or realistic vignettes to facilitate interaction and learning. In the Jasper Woodbury Series (CTGV, 1992), students watch a short video to provide context and orient learning before solving mathematics problems situated in realistic settings (e.g., determining how much gas is needed and what route to take to navigate a boat to desired locations). Thus, contexts may help students to identify learning goals, form and test hypotheses, and situate learning in authentic experiences (Land & Hannafin, 1997). Knowledge is constructed while individuals engage in activities, receive and provide feedback, and participate in multiple forms of interaction. When authentic, active engagement enables learners to gain access (i.e., enculturation or identify formation) to the ordinary practices of a culture from a real-world perspective (Brown, Collins, & Duguid, 1989).

In externally directed contexts, "an external agent (e.g., teacher, instructional designer) typically establishes the venue (real or virtual), meters the pace and sequence of resource use, facilitates the interactions and related learning activities, and establishes goals for the learner to achieve" (Hill & Hannafin, 2001, p. 43). While student-centered learning may occur, the basic environment is designed to ensure that goals considered to be important to others are addressed. In learner-generated contexts, typical of student-centered learning environments, the individual establishes his/her goals which influence where to seek resources and what resources are needed (as well as when those goals have been attained). Guidance (scaffolding) may be sought from humans or support technology, but assistance is provided when sought. Negotiated contexts, perhaps most typical of student-centered learning in formal settings, emphasize partnerships in the learning process. While context is established to support predefined goals, interpretation guides "the learner in establishing individual meaning, defining sub-problems, and selecting and implementing strategies. In determining which resources are best suited to the problem or need, the participants negotiate the relative value of the resources, generate additional questions to pursue, and consider alternative approaches" (p. 43).

2.2.3 Role of Prior Knowledge and Experience

Prior knowledge and experience uniquely influence how individuals interact with and acquire meaning during student-centered learning (Schuh, 2003). They affect not only how constructed knowledge emerges, but the individual's goals, knowledge-seeking activity, cognitive repertoire, cognitive load associated with learning, metacognitive awareness, and cognitive monitoring (Land & Hannafin, 2000). Prior knowledge and experience provide the capacity to assess and evaluate information, to detect inconsistencies and contradictions between new and existing understanding, and to determine when learning goals have been achieved (Shapiro, 2008). Prior experiences shape beliefs about both learning generally and the value associated with given learning tasks and demands. Prior knowledge and experience shape the formative, often naïve and incomplete theories in action learners employ as they attempt to interpret, make sense, and understand.

2.3 Nagging Issues

2.3.1 Technical System Knowledge and Familiarity

Research suggests that familiarity with Web-based tools may play a significant role in individual success or failure. Song and colleagues (2004) found that college students who preferred online learning reported greater previous knowledge of online tools and managed their time more efficiently than students preferring traditional instruction. Hill and Hannafin (1997) asked teachers to locate Internet content and grade-appropriate materials on a subject of their choosing and reported that those with previous experience with the Internet were more successful and reported greater confidence in the task – regardless of their prior teaching experiences. In both studies, prior tool expertise facilitated learning more than prior domain knowledge or experience. In some student-centered learning contexts, familiarity with available Web-based tools may better predict success than prior domain knowledge and experience.

2.3.2 Disorientation

Becoming *lost in hyperspace*, initially described for hypertext navigation (e.g., Edwards & Hardman, 1999), has become increasingly problematic during Web-based, student-centered learning. Learners need to identify, select, and evaluate available resources based on their unique tasks and goals (cf. Hodges, 2005). Often, Web resources provide physical locations and narrative descriptors to convey their contents, but recently metadata have emerged to catalog and describe functionality. Different metadata mechanisms and standards (e.g., Dublin Core, SCORM) have emerged. While beneficial in cataloging Web-based materials based on designer-intended goals and objectives, current metadata methods may be insufficient to support student-generated goals. Cataloging systems often rely on content creators to generate metadata tags for online materials (Maule, 2001). Intelligent tutoring systems have used prior assessment results, individually selected learning goals (limited to those embedded within the system), and learning traits to personalize instruction (Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002). While potentially effective, truly adaptive tools are rarely available in Web-based learning environments (Azevedo, Cromley, & Seibert, 2004; Kauffman, 2004). Thus, current metadata technology may provide generic, cursory references and prove insufficient to support unique learner goals.

2.3.3 Canonical Versus Individual Meaning: Misconceptions

Constructivists learning environments often emphasize personal investigation, hypothesis formation, and testing. Without explicit support, however, in such environments learners may be unable to detect inaccurate information or reject erroneous hypotheses even in the face of contradictory evidence (Kirschner, Sweller, & Clark, 2006). In Land and Zembal-Saul's (2003) student-centered labs and computer-based inquiries into the nature of light, participants obtained evidence during experiments, stored it in portfolios with their findings, and generated hypotheses to orient future inquiries. While some groups benefited from computer-assisted inquiry, others relied on faulty results from prior experiments and subsequently misdirected future inquiries and retained erroneous results even when later studies contradicted them. The authors suggested that student-centered inquiry functioned as anticipated only when students had sufficient background knowledge, self-evaluated their knowledge limitations, engaged in critical questioning and clarification, and challenges faulty explanations. The "situated learning paradox" suggests that prior knowledge, important for orienting and helping learners to make sense of phenomena, is often based on incomplete and inaccurate misconceptions. Without support, misinformation and disinformation may go undetected; fundamental misunderstandings may become reified rather than reconciled.

2.3.4 Knowledge as Accretion Versus Tool

Whitehead (1929) distinguished between knowledge as a tool and inert knowledge. Tool-based knowledge, valued in student-centered learning, is presumed to facilitate goal acquisition and transfer: When students grasp the underlying reasoning behind the algorithms and their application to authentic problems, knowledge becomes a tool to facilitate problem solving in related contexts. Yet, researchers suggest that tools touted to support student-centered learning are often used inappropriately and foster inert knowledge (CTGV, 1992). Because learners select individual goals, resources, and activities, existing metadata may fail to support student-centered Web-based learning and the resulting knowledge may or may not prove transferable.

2.3.5 To Scaffold or to Direct

Several frameworks have been proposed to account for similarities and differences between human and technology-enhanced scaffolds (see, for example, Dabbagh & Kitsantas, 2004, 2005; Jacobson, 2008; Masterman & Rogers, 2002; Puntambekar & Hubscher, 2005; Quintana et al., 2004; Shapiro, 2008). Traditional scaffolding supports the learning of externally defined concepts, but the shift to individually mediated learning has become increasingly process oriented. Saye and Brush (2007) distinguished between *hard* and *soft* scaffolds. Hard scaffolds are presumed to support common learning needs across students, freeing the instructor to provide adaptable, on-demand, and contextually sensitive support based on emergent, individual needs (cf. Azevedo, Cromley, & Seibert, 2004). Kim, Hannafin, and Bryan (2007) proposed a scaffolding framework to optimize the interplay between and among technology, teachers, and students in everyday student-centered, Web-based learning contexts. However, little progress has been made in scaffolding the individual's unique learning efforts in open, largely ill-structured learning environments.

2.3.6 Attitudes, Beliefs, and Practices

In student-centered environments, the individual assumes responsibility for goal attainment and resource selection, thereby increasing the cognitive demands associated with learning. Similarly, engagement is influenced by individual prior beliefs, goals, and expectations, which affect how learners approach and interact with learning activities. According to Song, Hannafin, and Hill (2007), conflicts arise when learners encounter resources that are inconsistent or incompatible with their individual goals and beliefs – especially when they are unable to identify and reconcile the differences. Thus, while designers and instructors of Web-based multimedia may assume that extending the array of resources will enhance learning, the individual's familiarity, beliefs, motivations, and practices may influence the extent to which available resources complement or confound student-centered learning.

2.3.7 Cognitive Load

Many researchers have concluded that hyperlinked learning materials can significantly increase extraneous cognitive load (Brunken, Plass, & Leutner, 2003; Niederhauser, Reynolds, Salmen, & Skolmoski, 2000). Eveland and Dunwoody (2001), for example, compared the performance of students assigned to browse a Web site with different hyperlinking and navigation structures with a paper-only format. The paper-based control group outperformed two of the online groups, indicating that hyperlinking may increase extraneous cognitive load. Given the unusual demands associated with student-centered, Web-based learning, the ability to meter or manage cognitive load may prove essential for online students (Bell & Akroyd, 2006; Hill, Domizi, Kim, Kim, & Hannafin, 2007; Hill, Hannafin, & Domizi, 2005; van Merriënboer & Ayres, 2005). Nonlinear Web sites may increase germane cognitive load for particular types of learning, while simultaneously increase extraneous load for text-based learning (Eveland & Dunwoody, 2001). Eveland, Cortese, Park, and Dunwoody (2004) concluded that students learned facts best from linear Web sites, but understood relationships better from nonlinear Web sites.

2.3.8 Metacognitive Demands

Students who have, or develop, metacognitive strategies tend to perform more successfully than those who do not (Shapiro, 2008). Smidt and Heigelheimer (2004) interviewed high-, middle-, or low-performing adult learners regarding their Web learning strategies; only advanced learners used strategies (as well as cognitive ones). Intermediate and lower-level students relied on cognitive strategies only, suggesting that advanced metacognitive abilities may be associated with effective online learning. Land and Greene (2000) suggested that metacognitive knowledge can compensate for limited subject understanding, noting that a few participants demonstrated metacognitive knowledge based on their domain knowledge, but those with low domain knowledge did not.

2.4 Implications for Research, Theory, and Design

2.4.1 Can Student-Centered, Web-Based Learning Be Scaffolded?

While research has yielded useful guidelines for supporting externally specified learning, research on scaffolding student-centered learning has only begun to emerge. Since individual prior knowledge, goals, and intents are not known in advance, and they can vary dramatically across learners using the same Web-based multimedia, scaffolding often focuses on cognitive processes. Research is needed to examine where and when to provide process scaffolding, the types of scaffolding needed, and the extent to which individual goals and intents are addressed effectively.

2.4.2 Will Students Critically Assess the Legitimacy, Veracity, and Accuracy of Resources?

Web resources are largely unregulated, with quality varying widely in terms of accuracy, authority, and completeness. Web resources have been criticized not only for containing naïve and ill-informed information, but also for propagating deliberate misinformation, disinformation, and propaganda. Since students must assess veracity and relevance while attempting to address their individual learning needs and monitoring their understanding, research is needed to examine how students' evaluate and adapt based on perceptions of a resource's integrity.

2.4.3 Will Scaffolding Help Students to Manage Cognitive Complexity?

Existing research suggests that soft scaffolding technologies have the potential to address the varied needs of individual student-centered learners. Unlike domain supports, soft scaffolding provided by teachers, peers, and other human resources is thought to accommodate real-time, dynamic changes in learner needs and cognitive demands. Given that research on learning strategies has provided little evidence of transfer, this claim needs to be validated.

2.4.4 Will Students Negotiate Their Individual Learning Needs?

Web-based resources have been developed for a broad array of needs and purposes. Some intact resources may address student-centered learning needs effectively, but many will not. Understanding is often derived by examining individual resources that provide partial, potentially contradictory information. Their meaning must be interpreted and derived. Research is needed to examine how negotiation occurs, meaning is assembled differentially based on unique needs and goals, and the extent to which individual needs are addressed.

2.4.5 Will Students Identify Appropriate and Relevant Resources?

Despite increases in availability and improved accessibility, metadata standards offer only limited pedagogical utility for student-centered, Web-based learning. The fundamental student-centered learning task – identifying candidate resources appropriate to an individual's need – is complicated by the raw number of false hits generated by typical search engines. Research is needed to develop and refine alternative metadata standards that support student-centered learning and to refine and customize search engine technology capable of identifying user-relevant resources.

References

Alexander, P. A., & Murphy, P. K. (1998). The research base for APA's learner-centered psychological principles. In N. M. Lambert, & B. L. McCombs (Eds.), *Issues in school reform: A sampler of psychological perspectives on learner-centered schools* (pp. 33–60). Washington, DC: American Psychological Association.

APA Work Group of the Board of Educational Affairs. (1997). *Learner-centered psychological principles: A framework for school reform and redesign*. Washington, DC: Author.

Atkins, M., & Blissett, G. (1992). Interactive video and cognitive problem-solving skills. *Educational Technology*, *32*(1), 44–50.

Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology*, *29*, 344–370.

Azevedo, R., Guthrie, J. T., & Seibert, D. (2004). The role of self-regulated learning in fostering students' conceptual understanding of complex systems with hypermedia. *Journal of Educational Computing Research*, *30*(1), 87–111.

Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist*, *40*, 199–209.

Bell, P. D., & Akroyd, D. (2006). Can factors related to self-regulated learning predict learning achievement in undergraduate asynchronous Web-based courses? *International Journal of Instructional Technology and Distance Learning*, *3*(10), 5–16.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–41.

Brunken, R., Plass, J., & Leutner. D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 53–61.

Cognition and Technology Group at Vanderbilt (CTGV) (1992). The Jasper experiment: An exploration of issues in learning and instructional design. *Educational Technology Research and Development*, *40*(1), 65–80.

Dabbagh, N., & Kitsantas, A. (2004). Supporting self-regulation in student-centered Web-based learning environments. *International Journal on E-Learning*, *3*(1), 40–47.

Dabbagh, N., & Kitsantas, A. (2005). Using Web-based pedagogical tools as scaffolds for self-regulated learning. *Instructional Science*, *33*, 513–540.

De Jong, T., & Van Joolingen, W. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, *68*(2), 179–201.

Doyle, W. (1988). Work in mathematics classes: The context of students' thinking during instruction. *Educational Psychologist*, *23*(2), 167–180.

Edwards, D. M., & Hardman, L. (1999). 'Lost in hyperspace': Cognitive mapping and navigation in a hypertext environment. In R. McAleese (Ed.), *Hypertext: Theory into practice*, (2nd ed., pp. 90–105). Oxford: Intellect Books.

Eveland, W. P., Cortese, J., Park, H., & Dunwoody, S. (2004). How Web site organization influences free recall, factual knowledge, and knowledge structure density. *Human Communication Research*, *30*(2), 208–233.

Eveland, W. P., & Dunwoody, S. (2001). User control and structural isomorphism or disorientation and cognitive load? *Communication Research*, *28*(1), 48.

Hannafin, M.J., Land, S., & Oliver, K. (1999). Open learning environments: Foundations and models. In C. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (pp. 115–140). Mahwah, NJ: Erlbaum.

Hannafin, M. J. & Land, S. (1997). The foundations and assumptions of technology-enhanced, student-centered learning environments. *Instructional Science*, *25*, 167–202.

Hill, J., Domizi, D., Kim, M., Kim, H., & Hannafin, M. J. (2007). Teaching and learning in negotiated and informal environments. In M. Moore (Ed.), *Handbook of distance education* (2nd ed., pp. 271–284). Mahwah, NJ: Erlbaum.

Hill, J., & Hannafin, M. J. (1997). Cognitive strategies and learning from the World-Wide Web. *Educational Technology Research and Development*, *45*(4), 37–64.

Hill, J., & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology Research and Development*, *49*(3), 37–52.

Hill, J., Hannafin, M. J., & Domizi, D. (2005). Resource-Based learning and informal learning environments: prospects and challenges. In R. Subramaniam (Ed.), *E-learning and virtual science centers* (pp. 110–125). Hershey, PA: Idea Group, Inc.

Hodges, C. B. (2005). Self-regulation in web-based courses: A review and the need for research. *Quarterly Review of Distance Education*, *6*, 375–383.

Iiyoshi, T., Hannafin, M.J., & Wang, F. (2005). Cognitive tools and student-centered learning: Rethinking tools, functions, and applications. *Educational Media International*, *42*(4), 281–296.

Jacobson, M. (2008). A design framework for educational hypermedia systems: Theory, research and learning emerging scientific conceptual perspectives. *Educational Technology Research and Development*, *56*(1), 5–28.

Jonassen, D. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development*, *39*(3), 5–14.

Kauffman, D. (2004). Self-regulated learning in web-based environments: Instructional tools designed to facilitate self-regulated learning. *Journal of Educational Computing Research*, *30*, 139–162.

Kim, M., Hannafin, M. J., & Bryan, L. (2007). Technology-enhanced inquiry tools in science education: An emerging pedagogical framework for classroom practice. *Science Education*, *96*(6), 1010–1030.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*, 75–86.

Land, S. (2000). Cognitive requirements for learning with open-ended learning environments. *Educational Technology Research and Development*, *48*(3), 61–78.

Land, S. M., & Greene, B. A. (2000). Project-based learning with the World wide web: A qualitative study of resource integration. *Educational Technology Research and Development*, *48*(1), 45–67.

Land, S., & Hannafin, M. J. (1997). Patterns of understanding with open-ended learning environments: A qualitative study. *Educational Technology Research and Development*, *45*(2), 47–73.

Land, S., & Hannafin, M. J. (1996). A conceptual framework for the development of theories-in-action with open learning environments. *Educational Technology Research and Development*, *44*(3), 37–53.

Land, S., & Hannafin, M. J. (2000). Student-centered learning environments. In D.H. Jonassen, & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 1–23). Mahwah, NJ: Erlbaum.

Land, S. M., & Zembal-Saul, C. (2003). Scaffolding reflection and articulation of scientific explanations in a data-rich, project-based learning environment: An investigation of Progress Portfolio. *Educational Technology Research and Development*, *51*(4), 65–84.

Masterman, E., & Rogers, Y. (2002). A framework for designing interactive multimedia to scaffold young children's understanding of historical chronology. *Instructional Science*, *30*(3), 221–241.
Maule, R. W. (2001). Framework for metacognitive mapping to design metadata for intelligent hypermedia presentations. *Journal of Educational Multimedia and Hypermedia*, *10*, 27–45.
McCombs, B. L., & Whisler, J. S. (1997). *The learner-centered classroom and school: Strategies for increasing student motivation and achievement*. San Francisco: Jossey-Bass.
Nicaise, M., & Crane, M. (1999). Knowledge constructing through hypermedia authoring. *Educational Technology Research and Development*, *47*(1), 29–50.
Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, *23*(3), 237–255.
Orrill, C. H. (2006). What learner-centered professional development looks like: The pilot studies of the InterMath professional development project. *The Mathematics Educator*, *16*(1), 4–13.
Papanikolaou, K. A., Grigoriadou, M., Magoulas, G. D., & Kornilakis, H. (2002). Towards new forms of knowledge communication: The adaptive dimension of a Web-based learning environment. *Computers in Education*, *39*, 333–360.
Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. New York: Basic Books.
Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher*, *24*(7), 5–12.
Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist*, *40*(1), 1–12.
Quintana, C., Reiser, B., Davis, E., Krajcik, J., Fretz, E., Duncan, R., et al. (2004). A scaffolding design framework for software to support science inquiry. *The Journal of the Learning Sciences*, *13*, 337–386.
Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, *75*, 211–246.
Ringstaff, C., & Kelley, L. (2002). *The learning return on our educational technology investment*. San Francisco: WestEd.
Roschelle, J., Pea, R., Hoadley, C., Gordin, D., & Means, B. (2001). Changing how and what children learn in schools with computer-based technologies. *The Future of Children*, *10*(2), 76–101.
Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.
Saye, J. W., & Brush, T. (2007). Using technology-enhanced learning environments to support problem-based historical inquiry in secondary school classrooms. *Theory and Research in Social Education*, *35*, 196–230.
Smidt, E., & Hegelheimer, V. (2004). Effects of online academic lectures on ESL listening comprehension, incidental vocabulary acquisition, and strategy use. *Computer Assisted Language Learning*, *17*(5), 517–556.
Schuh, K. L. (2003). Knowledge construction in the learner-centered classroom. *Journal of Educational Psychology*, *95*, 426–442.
Shapiro, A. M. (2008). Hypermedia design as learner scaffolding. *Educational Technology Research and Development*, *56*, 29–44.
Song, L, Hannafin, M.J., & Hill, J. (2007). Reconciling beliefs and practices in teaching and learning. *Educational Technology Research and Development*, *55*(1), 27–50.
Song, L., Singleton, E. S., Hill, J. R., & Koh, M. H. (2004). Improving online learning: Student perceptions of useful and challenging characteristics. *Internet and Higher Education*, *7*(1), 59–70.
Uribe, D., Klein, J. D., & Sullivan, H. (2003). The effect of computer-mediated collaborative learning on ill-defined problems. *Educational Technology Research & Development*, *51*(1), 5–19.

van Merriënboer, J. J. G., & Ayres, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research & Development*, *53*(3), 5–13.

Wallace, R., & Kupperman, J. (1997, April). *On-line search in the science classroom: Benefits and possibilities*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics*. Retrieved November 28, 2008 from http://searcheric.org/ericdc/ED425191.htm

Whipp, J. L., & Chiarelli, S. (2004). Self-regulation in a web-based course: A case study. *Educational Technology Research and Development*, *52*(4), 5–22.

Whitehead, A. N. (1929). *The aims of education*. New York: MacMillan.

http://www.springer.com/978-1-4419-1550-4

Learning and Instruction in the Digital Age
Spector, M.; Ifenthaler, D.; Kinshuk (Eds.)
2010, XVI, 404 p., Hardcover
ISBN: 978-1-4419-1550-4