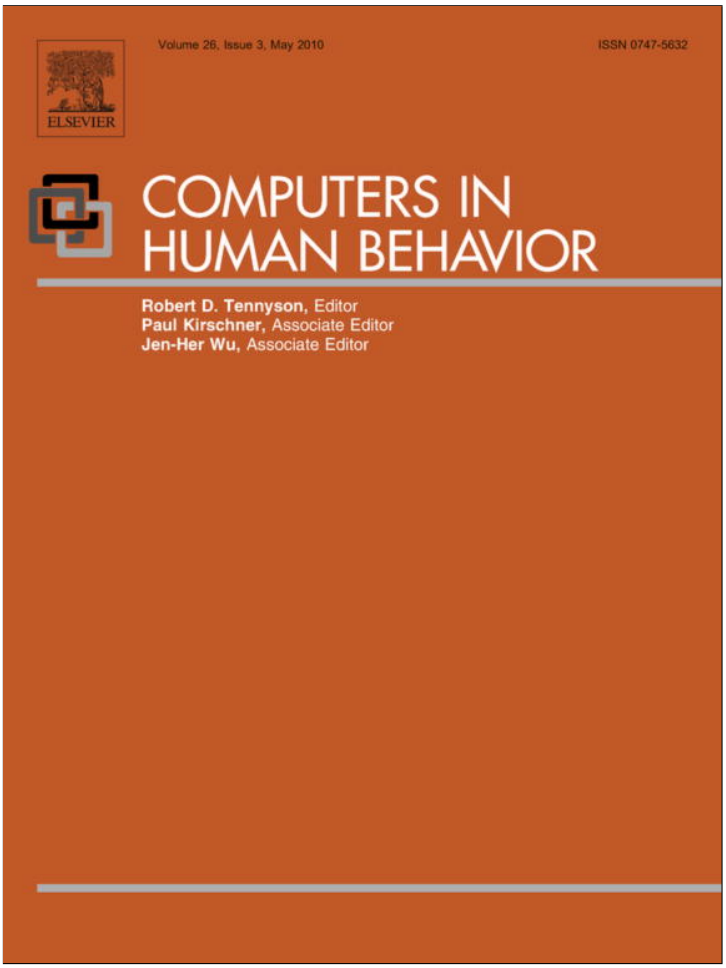

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Review

Multimedia, hypermedia, and hypertext: Motivation considered and reconsidered

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ABSTRACT

Computer-based instruction (CBI) is becoming increasingly popular in the classroom, particularly because the latest technological advancements allow for visually rich and interactive environments. While the inherent nature of CBIs is often thought to engage learners, research examining the role of motivation in learning with these environments has resulted in mixed findings. These findings are further complicated by unique design characteristics of distinct CBIs. This literature review synthesizes research that has examined the role of theoretically-grounded constructs of motivation in the context of three popular CBIs, multimedia, hypermedia, and hypertext. Specifically, this literature review considered empirical studies that examined the effect of these CBIs on motivation, in addition to the effect of motivation on learning outcomes and the learning process within the context of these environments. The literature review concludes with a theoretical consideration of previous research and a discussion of a framework for future directions.

1. Introduction

Computer-based instruction (CBI) is becoming increasingly popular in the classroom, particularly because the latest advancements allow for visually rich and interactive environments. The popularity of these environments is partially founded on the assumption that providing learners with multiple representations and instructional designs that meet individual needs represent the panacea of learning (Kimmel & Deek, 1995). This open-armed embrace of CBIs in the classroom persists despite the documented challenges these environments can present to learners. While researchers have empirically demonstrated the need for learners to engage in processes related to cognition and metacognition with CBIs, the most surprising findings concern motivation. The inherent nature of technology is often thought to engage learners, yet research examining the relationship between learning and motivation with CBIs has resulted in mixed findings. These findings are even more complicated by the fact that various CBIs have distinct design characteristics, an issue that calls for a systematic examination across these learning environments. This literature review addresses this issue by synthesizing and analyzing research that has examined theoretically-grounded motivation constructs within the context of learning with three of the more popular CBIs, multimedia, hypertext, and hypermedia. The following section identifies the key design features of these three environments and discusses the potential challenges of learning with them. Next, this section highlights the importance of considering theoretically-grounded constructs of motivation when examining learning within multimedia, hypertext, and hypermedia. Lastly, this section provides the research questions guiding this literature review.

1.1. Overview of multimedia, hypermedia, and hypertext

Multimedia is operationally defined as an environment that offers learners access to information in a variety of formats, which can include text, still images, animation, video, and audio presentations. Several theoretically-based assumptions, including seductive augmentation and seductive detail, have been used to promote the pedagogical validity of multimedia environments. These concepts relate to a primary assumption of learning, which suggests that instruction should be designed so that learners' attention is captured as soon as possible during the learning task (Gagne & Briggs, 1974). Stimulating multimedia presentations can effectively serve this role by presenting highly interesting but peripherally relevant information that initially engages the learner (Schraw & Lehman, 2001). Thus, various presentations of material in a multimedia environment are augmented to "seduce" the individual into learning.

In addition to the potential benefit of seductive augmentation, the design of multimedia can be consistent with the assumptions put forth by the Cognitive Load Theory. This theoretical perspective has often been used to guide the instructional design of multimedia based on the theoretical assumption that working memory consists of two independent systems for processing verbal and audio information (Baddeley, 1992). A central executive system

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coordinates these two systems, one of which is a phonological loop for verbal information and the other is a visual-spatial sketchpad. Central to the assumption is that each system has a limited capacity to process information, which suggests that multimedia can facilitate learning by reducing cognitive load through simultaneously presenting information to both systems (i.e. audio and text).

While the design of multimedia is consistent with theoretically-grounded explanations of learning, this environment does not offer the interactivity found in other CBIs, such as hypertext and hypermedia. These two environments have also been the focus of much theoretical and empirical consideration, in part due to their popularity in the classroom. *Hypertext* is defined as an "analog to traditional reading environments" (Lawless & Kulikowich, 1996, p. 385) in which text is presented on a computer screen. Interlinked nodes of information, which allow the learner to determine the instructional path, are an inherent characteristic of the hypertext design (Scheiter & Gerjets, 2007). These nodes of information are connected through electronic hyperlinks and the user is able to decide which hyperlink to access during the learning process (Conklin, 1987; Rouet, Levonen, Dillon, & Spiro, 1996). Hypertext environment differ from multimedia environments in terms of learner control; learners can control the sequencing of information while using hypertext (Scheiter & Gerjets, 2007). It has been proposed that allowing learners to make navigational choices facilitates reading comprehension because this autonomy accounts for certain diversity, including learners' cognitive needs. However, research has also highlighted the potential challenges learners face when asked to make these instructional decisions, an issue that is furthered described in the next section.

Hypertext environments lack presentation of information in multiple formats, a design issue that may limit learning according to Mayer's theory of Multimedia Learning (Mayer, 2003; Mayer, 2005). A third CBI, *hypermedia*, is considered an augmentation of hypertext and multimedia. This type of CBI includes both multiple representations of information as well as a nonlinear design. These design characteristics are assumed to facilitate learning for the same reasons articulated above. The nonlinear design allows learners to access information in a manner that best meets their needs, while presentation of information in multiple formats can be seductive and reduce cognitive load. However, as with research on multimedia and hypertext, theoretical and empirical based explanations have articulated the challenges learners can face with hypermedia. The below section outlines these challenges, and is followed by a section that describes the need to carefully consider the role of theoretically-grounded constructs of motivation in these CBIs.

1.2. Challenges of learning with multimedia, hypermedia, and hypertext

Identifying the challenges of learning with multiple representations has been guided by the Cognitive Load Theory, which assumes that working memory has limited capacity and may be affected by three types of cognitive load – intrinsic cognitive load, extraneous cognitive load, or germane cognitive load (Sweller, 2004; van Merriënboer & Sweller, 2005). Extraneous cognitive load is of particular concern while learning with multimedia (Gerjets & Scheiter, 2003; Kester, Kirschner, & van Merriënboer, 2005). For example, extracting information from both a diagram and text may overload a students' visual subprocessor of his/her working memory (Mayer & Moreno, 2003; van Merriënboer & Ayres, 2005). Research has also examined the potential benefit of animation and audio in multimedia environments, with some research finding that simultaneous animation and audio narration is more effective than either alone or noncurrent audio narration and animation (Mayer & Anderson, 1991; Mayer & Sims, 1994).

Hypertext environments do not include the multiple representations found in multimedia, but its nonlinear design may create distinct challenges for learners using this environment. Lawless and Kulikowich (1996), for example, suggested that the ability to select the sequencing of information during hypertext learning is a "double-edged sword." Though this autonomy may allow learners to make instructional decisions that best meet their needs, learners need to have a requisite amount of domain knowledge in order to make informed decisions about which hyperlinks to access. While the positive relationship between prior domain knowledge and learning has been long documented (Alexander, 2003; Alexander & Jetton, 2003; Alexander, Jetton, & Kulikowich, 1995; Alexander & Murphy, 1998; Dochy & Alexander, 1995), the lack of an explicit structure within hypertext magnifies the importance of prior domain knowledge during learning. Hypertext environments typically do not provide an explicit structure, and thus navigation is critical to developing text comprehension. Learners with limited prior domain knowledge will have little to guide their interaction with hypertext, and thus will have difficulty effectively navigating within this environment (Shapiro, 2004). Furthermore, Lawless and Kulikowich (1996) argue that the effectiveness of hypertext environments is contingent on the extent to which learners are personally involved with the information found in the environment. The necessity of choosing an instructional path creates an added burden during hypertext learning and a lack of interest will make it quite challenging for a learner to overcome this burden.

Given these documented difficulties of learning with multimedia and hypertext, it is not surprising that research has also identified potential challenges of learning with hypermedia. Scott and Schwartz (2007) suggested that hypermedia requires the need to balance effective navigation and content comprehension during hypermedia learning. This need is best met through the use of monitoring processes, including monitoring an emerging understanding (i.e. judgment of learning [JOL]; Azevedo, Cromley, & Seibert, 2004; Azevedo, Cromley, Winters, Moos, & Greene, 2005; and feeling of knowing [FOK]; Moos & Azevedo, 2006; Moos & Azevedo, 2008a; Moos & Azevedo, 2008b); (2) the relevancy of the information in the environment (i.e. content evaluation; Azevedo, Guthrie, & Seibert, 2004); and (3) progress towards the learning goal (Azevedo et al., 2005). Use of these monitoring processes better enables learners to manage the high degree of control when learning with hypermedia (Greene & Azevedo, 2007; Schwartz, Anderson, Hong, Howard, & McGee, 2004). However, research has also demonstrated that many learners have difficulty using these processes, as indicated by substantial individual differences in how learners use hypermedia environments. As suggested by Eccles and Wigfield (2002) and Zimmerman (2008), considering the role of theoretically-grounded constructs of motivation is a fruitful direction in examinations of individual differences.

1.3. Overview of motivation

The field of academic motivation has enjoyed a long and rich history and has typically defined motivation as physiological processes involved in the direction, vigor, and persistence of behavior (Eccles, Wigfield, & Schiefele, 1998; Wigfield & Eccles, 1989). This operational definition is a broad umbrella for different intellectual traditions (Weiner, 1992), which have given rise to various motivation theories. In turn, these theories have identified a number of conceptually distinct motivation constructs. As highlighted by several researchers (see Murphy & Alexander, 2000 for a review), research should examine various motivation constructs when considering the complexities of the learning process. Furthermore, it has been suggested that motivational theories have distinct per-

spectives, which can include focusing on beliefs, values, and goals (Eccles & Wigfield, 2002). Based on this previous research, this literature review was guided by the conceptual framework for considering motivation put forth by Murphy and Alexander (2000). Their work resulted in a systematic literature review, which identified a corpus of 20 fundamental motivation terms relevant to academic motivation. Guided by Murphy and Alexander's (2000) work, this current literature review focused on the following categories: Goal orientation (including mastery goal and performance goal), Intrinsic and Extrinsic motivation, Interest (including individual interest and situational interest), and Self-shema (including self-efficacy).

As highlighted by Murphy and Alexander (2000), it is critical that fundamental lexicon within a field of study is clearly articulated and defined. This approach will result in a shared understanding of operational definitions. In that vein, this current literature review used the following operational definitions for the specific motivation constructs:

- *Mastery Goal* (sub-component of Goal; also called learning goal, task goal, or task-involved goal): Represents a desire to gain competence or master a new set of skills or knowledge (Archer, 1994)
- *Performance Goal* (sub-component of Goal; also called ego, ego-involved goal): Represents a desire to perform better than others, particularly through minimum effort, and achieving normative-bases standards (Dweck & Elliot, 1983)
- *Individual Interest* (sub-component of Interest): Represents a deep, long-term interest that results from a history of interactions related to the targeted field (Alexander, Murphy, Woods, Duhon, & Parker, 1997)
- *Situational Interest* (sub-component of Interest): Represents a short-lived interest that results from a interactions with specific aspects of context (Alexander et al., 1997)
- *Intrinsic Motivation*: Represents an internal desire to engage in a behavior due to pleasure, interest, enjoyment, and/or challenge (Berlyne, 1960; Hunt, 1965; White, 1959)
- *Extrinsic Motivation*: Represents an internal desire to engage in a behavior due to external incentives, such as money, grades, and praise (Berlyne, 1960; Hunt, 1965; White, 1959)
- *Self-efficacy* (sub-component of Self-schema): Self-perception of one's capabilities to meet situational demands based on current states of motivation, courses of actions needed, and cognitive resources (Wood & Bandura, 1989).

1.4. Overview of literature review

As noted in the preceding sections, multimedia, hypermedia, and hypertext offer distinct environments that present unique challenges to learners. Multimedia offers multiple representations, but limited learner control. Hypertext, on the other hand, allows learners to choose their own navigational path during learning, but includes text and lacks the multiple represents found in multimedia. Hypermedia can be viewed as an augmentation of these other two environments because of its nonlinear design and multiple representations. This literature review aims to systematically consider how research has considered theoretically-grounded motivation constructs within the context of these three CBIs. In order to frame the examination of these studies, the following research questions were used: (1) To what extent does learning with hypermedia, multimedia, and hypertext affect distinct motivation variables? (2) To what extent do distinct motivation variables affect learning outcomes within hypermedia, multimedia, and hypertext? (3) To what extent do distinct motivation variables affect the learning process within hypermedia, multimedia, and hypertext?

2. Method

2.1. Criteria for inclusion

The studies selected for this literature review broadly considered the role of motivation while learning with CBIs. Specifically, this literature review includes research examining three CBIs, multimedia, hypermedia, and hypertext environments, in an educational setting (e.g., classroom) and/or research setting (e.g., laboratory). After the initial selection of articles, inclusion criteria were used to identify which studies would be examined for this literature review. These criteria focused on three main areas: (1) Research questions; (2) Theoretical framework; and (3) Methodology.

First, studies were chosen that addressed one of the three research questions in this review. Second, a study needed to clearly articulate a theoretically-grounded motivation construct within one of the three selected CBIs (multimedia, hypermedia, and/or hypertext) in order to be included in this review. A study was excluded from this review if it focused on a motivation construct that was not clearly articulated, theoretically-grounded and/or a CBI other than multimedia, hypermedia, and/or hypertext. Third, the methodology of each study was evaluated in order to determine the validity of its statistical analyses. In addition, the sample of the study needed to be described appropriately in order to be included.

2.2. Search procedures

Based on a suggested framework for developing literature reviews (see Hart, 1999), the literature search was comprised of two stages: (1) identify all relevant articles in an initial search; (2) select articles to review based on inclusion criteria. First, a search for articles from the PsycInfo database was performed, and concluded in June of 2009. During this initial literature search, a variety of keywords[1] were used in order to identify articles most relevant to the research being examined. The keyword search focused on specific theoretically-grounded motivation constructs in relationship to multimedia, hypermedia, and/or hypertext. As articulated in the introduction, these specific motivation constructs are consistent with those highlighted in Murphy and Alexander's (2000) review on academic motivation. In the first stage of the search, dissertations, chapters, and technical reports were excluded. The search produced 123 articles from peer-reviewed journals. After

[1] "goal and multimedia"; "goal and hypermedia"; "goal and hypertext"; "ego and multimedia"; "ego and hypermedia"; "ego and hypertext"; "ego-involved goal and multimedia"; "ego-involved goal and hypermedia"; "ego-involved goal and hypertext"; "mastery goal and multimedia"; "mastery goal and hypermedia"; "mastery goal and hypertext"; "performance-avoidance goal and multimedia"; "performance-avoidance goal and hypermedia"; "performance-avoidance goal and hypertext"; "performance-approach goal and multimedia"; "performance-approach goal and hypermedia"; "performance-approach goal and hypertext"; "task and multimedia"; "task and hypermedia"; "task and hypertext"; "task-involved goal and multimedia"; "task-involved goal and hypermedia"; "task-involved goal and hypertext"; "work avoidance goal and multimedia"; "work avoidance goal and hypermedia"; "work avoidance goal and hypertext"; "interest and multimedia"; "interest and hypermedia"; "interest and hypertext"; "individual interest and multimedia"; "individual interest and hypermedia"; "individual interest and hypertext"; "situational interest and multimedia"; "situational interest and hypermedia"; "situational interest and hypertext"; "extrinsic motivation and multimedia"; "extrinsic motivation and hypermedia"; "extrinsic motivation and hypertext"; "intrinsic motivation and multimedia"; "intrinsic motivation and hypermedia"; "intrinsic motivation and hypertext"; "self-schema and multimedia"; "self-schema and hypermedia"; "self-schema and hypertext"; "agency and multimedia"; "agency and hypermedia"; "agency and hypertext"; "attribution and multimedia"; "attribution and hypermedia"; "attribution and hypertext"; "self-competence and multimedia"; "self-competence and hypermedia"; "self-competence and hypertext"; "self-efficacy and multimedia"; "self-efficacy and hypermedia"; and "self-efficacy and hypertext."

the inclusion criteria were applied to the studies collected in the first stage of the search, 35 articles remained for examination.

These remaining articles were then grouped based on the three research questions (see Table 1 for complete list of articles, by research question). Twenty of these articles addressed the first research question, which considered how multimedia, hypermedia, and/or hypertext affect motivation variables. Eight studies examined findings related to the second research question of this literature review, which considered how motivation variables affect learning outcomes. Lastly, seven articles were related to the third research question of this literature review, which considered how motivation variables affect the learning process.

3. Results

3.1. To what extent does learning with hypermedia, multimedia, and hypertext affect distinct motivation variables?

This section synthesizes studies that have examined how learning with multimedia, hypermedia, and/or hypertext affects interest, self-efficacy, intrinsic motivation, and extrinsic motivation. None of the reviewed studies examined this relationship with respect to goals. Not surprisingly, some research has found a positive relationship between interest and learning with these CBIs. For example, Fitzgerald, Hardin, and Hollingsead (1997) also found that exposing students to hypermedia significantly increases their interest. Using a myriad of measures, including semi-structured interviews, questionnaires, and pre-and-posttest measures, these researchers examined the relationship between exposure to hypermedia authoring and the participants' interest in these environments. The participants (36 pre-service teachers) reported interest in using hypermedia in the future. Research focusing on multimedia has also found that these environments positively affect interest. Korakakis, Pavlatou, Palyvos, and Spyrellis (2009) focused on the potential benefit of providing 3D animations for science learning within multimedia environments. The participants, which included 212 eighth grade students, reported significant increases in interest with the domain of study, a finding that the researchers attribute to the benefit of static 3D illustrations in science learning. Koroghlanian and Klein (2004) also found a positive relationship between the presentations of science material through a multimedia format. This study used high school biology students and employed several measures, including a measure of interest and spatial ability. Results indicated that participants with low spatial ability actually reported higher interest in the program, a finding that may be explained by the effect of spatial ability on multimedia learning. Learning in this context may be more challenging for those participants with low spatial ability and thus may be more interesting, if the appropriate external support is provided during learning (Koroghlanian & Klein, 2004).

In addition to Middle School and High School students, undergraduates may also demonstrate increased interest when learning with these CBIs. Moneta and Kekkonen-Moneta (2007) found that multimedia environments, in the form of e-learning modules, increased intrinsic engagement for 414 college students in a computing course. Research has also found similar patterns with different populations of learners. For example, Dimitriadi (2001) used a case study approach to explore the potential benefits of multimedia for children with specific learning difficulties. This study examined learning with a multimedia authoring and found that the open-ended, multi-mode presentation of multimedia environments offer certain creative avenues that may be otherwise limited for children with specific learning disabilities. Similarly, Liu and Rutledge (1997) also found that this approach of "learner as a multimedia designer" offers unique opportunities, particularly for learners with special needs. These findings have been explained by the impact of the inherent design characteristics of multimedia and hypermedia. Multiple presentations in multimedia and the nonlinear nature of hypermedia can accommodate for a certain diversity within learners, including their varied interest levels (Howard, Ellis, & Rasmussen, 2004; Pedersen & Williams, 2004).

However, there has also been research that suggests these findings need to be carefully considered within the context of the individual learner and the specific CBI design. For example, Saye and Brush (1999) examined the effect of providing high school students a multimedia environment during problem-based instruction. The findings found that the multimedia environment increased the participants' interest, possibly due to the fact that the multimedia environment is a more authentic setting when compared to traditional methods of teaching US history. However, the researchers also note that the benefit of multimedia on learners' interest is contingent on external scaffolding; that is, teachers still need to provide expert guidance even when learners are using multimedia environments. In the absence of this external support, learners may become overwhelmed with the multiple representations in multimedia. Furthermore, while research has found that these CBIs have the potential to increase interest during learning (Moos & Azevedo, 2008a), other lines of research have suggested that this positive effect may be limited, possibly due to a novelty effect.

Deaney, Ruthven, and Hennessy (2003) highlighted the possibility of a novelty effect with multimedia and hypermedia. These researchers examined three cohorts (8th, 10th, and 12th grade) from six different schools. Interviews from 27 focus groups re-

Table 1
Complete list of review studies, by research question.

Research question 1: To what extent do hypermedia, multimedia, and hypertext differentially affect distinct motivation variables? (n = 20)
- Chan and Ahern (1999)
- Choi and Clark (2006)
- Cockerton and Shimell (1997)
- Deaney et al. (2003)
- Dimitriadi (2001)
- Eom and Reiser (2000)
- Fitzgerald et al. (1997)
- Howard et al. (2004)
- Jenny and Fai (2001)
- Korakakis et al. (2009)
- Koroghlanian and Klein (2004)
- Liu and Rutledge (1997)
- Moneta and Kekkonen-Moneta (2007)
- Moreno (2004)
- Moos and Azevedo (2008a)
- Moos and Azevedo (2008b)
- Park and Jung (2007)
- Pedersen and Williams (2004)
- Saye and Brush (1999)
- Trautwein and Werner (2001)

Research question 2: To what extent does distinct motivation variables affect learning outcomes within hypermedia, multimedia, and hypertext? (n = 8)
- Akbulut (2008)
- Christoph et al. (1998)
- Lawless and Kulikowich (1996)
- Lawless et al. (2003)
- Liaw (2008)
- Liaw et al. (2007)
- Mayer et al. (2008)
- Salmerón et al. (2006)

Research question 3: To what extent does distinct motivation variables affect learning process within hypermedia, multimedia, and hypertext? (n = 7)
- MacGregor (1999)
- Moos (2009)
- Moos and Azevedo (2009)
- Moos and Azevedo (2006)
- Müller-Kalthoff and Möller (2006)
- Nesbit et al. (2006)
- Protopsaltis (2008)

vealed that learners tended to perceive multimedia-based lessons as conducive to a more relaxed atmosphere and less boring classrooms, which, in turn, increased interest. However, these focus groups also revealed that the learners believed these positive effects might decrease as the novelty of learning with multimedia fades. This careful consideration of interest should also be extended to learning with both hypertext and hypermedia environments. The nonlinear design of hypertext and hypermedia is assumed to increase interest as it allows the learner to choose an instructional path that best meets his or her own needs. However, Eom and Reiser (2000) found that the learner control found in these environments may have little, of no, positive effect on interest. This study examined 37 seventh and eighth graders and included the following measures: A 15 question multiple choice posttest, the IMMS (a Likert motivation assessment), and amount of time spent on work related to the study. Results found that the relationship between learner control, as found in environments such as hypermedia and hypertext, and interest was not significantly detectable. This finding questions the notion of putting forth the blanketed assertion that learning with CBIs, such as hypermedia and hypertext, unquestionably increases learners' interest.

This study is not alone in questioning the relationship between learner control in hypermedia/hypertext environments and interest. Cockerton and Shimell (1997) observed children learning about a history topic with both a hypermedia environment and a paper-version of this environment. Surprisingly, results suggested that while the children rated the hypermedia environment more positively in reference to ease of use, they did not report significantly higher levels of interest after using the hypermedia environment. This finding contradicts the assumption that a nonlinear environment best meets the needs of diverse learners, particularly in terms of interest. Other studies have mirrored this finding with situational interest, a differentiation that is consistent with the suggestions put forth by Murphy and Alexander (2000). Trautwein and Werner (2001) examined this construct of motivation in the context of a sophisticated multimedia environment, which included motion, fading, zooming, dissolving, and narrated text. The researchers examined the role of multimedia applications in art education for 64 non-arts college majors. The study examined participants' interest, situational interest, and viewing time with the multimedia environment. While the results found that the visually rich multimedia environment facilitated the participants' knowledge acquisition, it did little to enhance their interest in the domain. The researchers concluded that extensive visual presentation in multimedia environments is of little instructional benefit. This assertion can be explained by the rich line of research grounded in the Cognitive Load Theory, which is furthered explored in Section 4 of this manuscript. Other research has also found that the provision of visually rich stimuli may have minimal effect on learning outcomes, as evidenced in a study conducted by Park and Jung (2007). This study included 36 college level participants from an Educational Technology course, who were randomly assigned to learn about hurricanes with one of three multimedia environments differentiated by three types of illustrations: (1) Cognitive interest illustrations, designed show to scientific principles with corresponding illustrations; (2) Emotional interest illustrations, designed to provide interesting but minimally relevant information; and (3) Text-only, designed to provide text but no illustrations. While results found that participants in the two conditions with illustrations reported significantly higher interest, they did not perform significantly better on recall and comprehension measures. Thus, the researchers concluded that the while illustrations in multimedia environments may increase interest, they may have little effect on knowledge acquisition.

In attempt to facilitate knowledge acquisition and interest within multimedia environments, research has also explored the effects of providing learners with external support. One line of research has examined the Persona Effect (Lester et al., 1997), which suggests that CBIs with embedded animated agents will motive learners because interaction with the environment will be more socially engaging. Choi and Clark (2006) explored this hypothesis by examining how 74 college level English as Second Language (ESL) learners interacted with two distinct multimedia environments, one that had an animated pedagogical agent and one with an electronic arrow and voice narration. Results found no significant difference, in terms of learning outcomes and interest, between learners using these two multimedia environments. The researchers argue that these results support the claim that the most effective support for learning comes from the instructional method and not the delivery medium (see Clark, 2001).

Research has also examined the relationship of other types of external support, such as feedback, and interest in learning with multimedia. Moreno (2004) conducted two studies to examine the differential effect of providing undergraduates with explanatory feedback and corrective feedback during learning with a multimedia-based game. Results were consistent across both studies; the participants who received explanatory feedback performed significantly better on a transfer test and demonstrated comparable interest levels. These findings led Moreno (2004) to suggest that learners with limited prior domain knowledge benefit from explanatory feedback when using multimedia environments because this type of feedback reduces cognitive load. However, it should be noted that while participants in both conditions reported comparable interest levels, the results did not indicate whether these interest levels changed when learning with multimedia environments.

While less research has focused on the conceptually distinct construct of intrinsic motivation, the findings are consistent with some lines of research that have examined interest. Chan and Ahern (1999), for example, used the Flow theory to examine how presentations in a hypermedia environment affect motivation. Csikszentmihalyi (1975, 1990) originally proposed the Flow Theory, which is a holistic approach to motivation. This approach describes a flow experience as one in which the learner is so immensely engaged in an activity that nothing else matters. In other words, learners in this state are fully engaged in activity because of intrinsic interest. Chan and Ahern (1999) argued that Csikszentmihalyi's Flow Theory provides "a theoretical bridge between the concerns of instructional design and motivational design theory" (p. 153) and thus can be used to guide the design of hypermedia environments. Chan and Ahern (1999) used this theoretical approach to examine eighty students from a pre-service teacher preparation course in computer science. Participants were asked to learn about dinosaurs in hypermedia environments that had varying content relevance. The results indicated, among other things, that the benefit of providing high quality presentations in hypermedia enhances intrinsic motivation only during unchallenging activities. In other words, the benefit of these presentations in hypermedia is negligible if the content is adequately challenging, relevant, and the learner is provided a clear goal. These researchers highlight that the potential advantages of hypermedia needs to be carefully considered within the context of both the learner and the instructional design.

The theoretically-grounded construct of self-efficacy has also received empirical attention within the context of hypermedia, though these studies have found mixed results. For example, Jenny and Fai (2001) found that learning with hypermedia does not significantly affect self-efficacy when compared to learning with more traditional approaches to learning. These researchers examined how 48 adult learners interacted with computer-assisted instruction in the form of a hypermedia environment, and how another 48 adult learners interacted with conventional tutorial meth-

od. While results demonstrated that participants from both groups significantly increased their knowledge of the domain and self-efficacy, there was not a significant difference between these groups on either of these measures. Research has even demonstrated that use of hypermedia may actually lead to a decrease of self-efficacy. Moos and Azevedo (2008b) used product and process data to examine the fluctuation of self-efficacy as undergraduates used a hypermedia environment to learn about a science related topic. Results from this study indicated that participants actually reported decreased levels of self-efficacy as they progressed through the learning task. The researchers concluded that the participants' understanding of the cognitive and metacognitive demands of learning in a nonlinear and visually rich environment, such as hypermedia, evolved as they spent more time in this environment. This heightened understanding of the difficulties resulted in decreased levels of self-efficacy as the participants progressed through the hypermedia-learning task.

3.1.1. Summary

The above studies addressed the question concerning the extent to which learning with multimedia, hypermedia, and hypertext affects theoretically-grounded constructs of motivation. The vast majority of the reviewed articles (n = 18; 85%) focused on the construct of interest (see Table 2 for the number and percentage of studies, by motivation construct and CBI), though the findings are mixed. Some research suggests that learning with hypermedia or multimedia is related to an increase in interest. These findings can be explained, in part, by Keller's ARCS motivational model (Keller & Kopp, 1987). This model identifies the importance of "motive matching", which, in essence, suggests that learners will feel as though they are linked to the instructional content when they have a personal interest. This model can be extended to environments that offer opportunities for learners to match their personal learning style with the instructional content. Multimedia may be an ideal environment for this type of "motive matching" due to its multiple forms of presentation. Learners can choose a type of presentation that best meets their learning style, thus positively affecting their interest. Additionally, personal interest is enhanced in student-centered environments that offer learners opportunities to feel a sense of autonomy. Hypermedia offers this opportunity due to its nonlinear nature. Learners can choose an instructional path that best meets their personal interest, an assumption that is consistent with "motive matching" and explains, to some degree, the positive relationships between interest and learning with hypermedia.

However, research has also provided findings that call the positive relationship between learning with hypermedia/multimedia and interest into question. This research has identified the need to account for novelty effects, in which the appealing nature of these environments diminishes over time. Learners' increased interest while learning with these environments may decrease over time as the appealing components (nonlinear and multiple representations) become less novel. Additionally, a number of studies highlighted the importance of factoring in prior domain knowledge when considering the impact of hypermedia/multimedia on learners' interest. Learners with minimal prior domain knowledge have little to guide their choices regarding their decisions about the instructional path and/or multiple representations. Thus, learning in these environments may actually have a detrimental effect on learners' interest if they have low prior domain knowledge.

Research considering the effect of these environments on intrinsic motivation highlighted the importance of the relationship between the instructional content and the individual learner. Visually rich presentations in multimedia and opportunities for autonomy in the instructional path during hypermedia learning do little for a learner's intrinsic motivation if the content is too challenging. This assertion stems from those studies that have examined self-efficacy in the context of learning with hypermedia and multimedia. These studies suggest that it is not only important to consider an individual learner's prior domain knowledge when studying theoretically-grounded constructs of motivation, but it is also critical to account for the changing level of self-efficacy. Learning with hypermedia may result in the fluctuation of self-efficacy, which can be explained by learners' evolving understanding of the challenges of learning with this environment. Initially, learners may not understand the difficulties of needing to choose the instructional path and which representation to access. Once they are engaged in the learning process with hypermedia, this understanding evolves as the challenges become more apparent.

3.2. To what extent do distinct motivation variables affect learning outcomes within hypermedia, multimedia, and hypertext?

This section summarizes studies that have examined how theoretically-grounded constructs of motivation are related to learning outcomes with multimedia, hypermedia, and hypertext. None of the reviewed studies examined this relationship with respect to goals or intrinsic/extrinsic motivation. Surprisingly, research has suggested that the effect of interest on learning outcomes with these CBIs may be limited, due to both contextual and personal factors. Mayer's line of research has examined interest with respect to contextual factors; specifically, he has considered how the interestingness of details affects learning outcomes with multimedia. This line of research suggests that high interest details may actually produce seductive details, which impede learning. For example, Mayer, Griffith, Jurkowitz, and Rothman (2008) research examined the role of interesting details in learning about how a cold virus infects the human body. Across two experiments, these researchers found that highly interesting details were related to lower learning outcomes, a finding consistent with the assumption that seductive details consume valuable processing space from working memory that could otherwise be used for deeper cognitive processing. Research has also suggested that the relationship of contextual features and learning outcomes is moderated by prior domain knowledge, particularly in environments that allow the learner to choose which contextual feature to access. Salmerón, Kintsch, and Cañas (2006) demonstrated that learners with low prior domain knowledge do not benefit from choosing more interesting text during hypertext learning. Rather, comprehension for these learners is facilitated when they choose text that is semantically related to what they read in a previous section, regardless of the interestingness of the text. However, this relationship does not hold true for learners with higher prior domain knowledge, who benefit from a selection of the most interesting text.

While these two lines of research considered the interestingness of contextual features in multimedia and hypertext, other

Table 2
Number (and percentage) of studies, by motivation construct and CBI (research question 1).

Motivation construct	Type of CBI		
	Multimedia 11 (52%)	Hypermedia 10 (48%)	Hypertext 0 (0%)
Interest 18 (85%)	11 (52%)	7 (33%)	0 (0%)
Intrinsic/extrinsic 1 (5%)	0 (0%)	1 (5%)	0 (0%)
Self-efficacy 2 (10%)	0 (0%)	2 (10%)	0 (0%)
Goal 0 (0%)	0 (0%)	0 (0%)	0 (0%)

lines of research have examined the role of individual interest in learning outcomes. Lawless, Brown, Mills, and Mayall (2003) examined the role of prior domain knowledge and interest on information recall during hypertext learning for 34 undergraduates. The findings were inconsistent with traditional research from the field of reading comprehension; the results indicated that while prior domain knowledge significantly predicted recall, interest was not a significant predictor. This finding can be explained by the nonlinear nature of hypertext. Learners who are interested in the topic of the hypertext learning task, but do not have sufficient prior domain knowledge, will have difficulty making effective decisions during their navigation within this nonlinear environment (Lawless & Kulikowich, 1996). However, it should be noted that this research does not dismiss the role of interest in learning with nonlinear environments. Rather, it suggests that interest positively affects hypertext learning outcomes if accompanied by requisite prior domain knowledge. Researchers have also explored the relationship between interest and learning outcomes with hypermedia. Akbulut (2008), for example, examined how 54 senior foreign language teaching learners interacted with a hypermedia environment. Findings suggest that several variables, including the participants' topic interest, significantly explained reading comprehension in a hypermedia environment.

Research examining the role of self-efficacy in learning outcomes with these CBIs has focused on recent multimedia developments, such as e-Learning and Blackboard. Liaw (2008) surveyed 424 university students using a questionnaire that tapped into their perceived self-efficacy, learners' satisfaction, behavioral intentions, and the effectiveness of the Blackboard e-learning system. Results found that the participants' self-efficacy was a significant predictor of their satisfaction of the Blackboard e-learning system, a finding that was similar to one of Liaw's earlier studies (Liaw, Huang, & Chen, 2007). In this study, the researchers included an additional measure, which examined the instructors' perceptions of multimedia in e-learning. Results indicated that instructors have positive perceptions of e-learning as an effective pedagogical tool and that undergraduates' self-efficacy was a significant predictor in their intention to use e-learning. These results have been replicated with multimedia environments. Christoph, Schoenfeld, and Tansky (1998) examined 295 students in 5 business classes: Two classes did not use multimedia-instruction while three classes used multimedia-instruction. The researchers differentiated between developed and existing self-efficacy and found that learning outcomes with the multimedia-instruction was significantly predicted by these motivation constructs.

3.2.1. Summary

Research examining research question 1 considered the role of motivation in learning outcomes with multimedia, hypermedia, and hypertext. As with research question 1, the vast majority of studies for research question 2 focused on the motivation construct of interest (see Table 3; $n = 63\%$). However, while the findings for research question 1 were mixed, findings for research question 2 were more consistent. Most of the research highlights the importance of individual interest, particularly with hypermedia and hypertext environments. Within these environments, learners need to make decisions about the instructional path and these decisions can be facilitated by the learners' interest in the topics. These decisions, though, are also dependent on the learners' prior domain knowledge. Learners who have high interest, but minimal prior domain knowledge, will have difficulty making decisions about an appropriate navigational path, which, in turn, will negatively affect learning outcomes. Research examining the interestingness of contextual features (as opposed to the learners' interest), though, suggests a slightly different story. Highly interesting, but peripherally related, features in hypermedia or multimedia may actually impede learning outcomes because they consume valuable working memory.

Table 3
Number (and percentage) of studies, by motivation construct and CBI (research question 2).

Motivation construct	Type of CBI		
	Multimedia 4 (50%)	Hypermedia 1 (12.5%)	Hypertext 3 (37.5%)
Interest 5 (62.5%)	1 (12.5%)	1 (12.5%)	3 (37.5%)
Intrinsic/extrinsic 0 (0%)	0 (0%)	0 (0%)	0 (0%)
Self-efficacy 3 (37.5%)	3 (37.5%)	0 (0%)	0 (0%)
Goal 0 (0%)	0 (0%)	0 (0%)	0 (0%)

3.3. To what extent do distinct motivation variables affect learning process within hypermedia, multimedia, and hypertext?

This section summarizes studies that have examined how theoretically-grounded constructs of motivation are related to the learning process with multimedia, hypermedia, and hypertext. While there is a paucity of research that has considered how theoretically-grounded constructs of motivation affect the process of learning within these CBIs, the existing research has been fairly consistent in its findings. In particular, a body of research has considered how interest affects navigation within hypermedia and hypertext environments. One line of research has found a positive relationship between personal interest and reading strategies during hypertext learning. Protopsaltis (2008) used a think-aloud method to examine how learners selected hypertext links. Data revealed that several factors affected hyperlink selection, including the location of the hyperlink as well as the participants' personal interest in the topic of the hyperlink. Hyperlink selection can lead to a learners' disorientation within a hypertext and/or hypermedia environment, particularly if they have little prior domain knowledge. The structure of hypertext/hypermedia environments (i.e. reduced versus free browsing), as well as learners' subject-related interest, has been empirically linked to the extent to which learners become disorientated during hypertext and/or hypermedia learning (Müller-Kalthoff & Möller, 2006).

Research has also demonstrated that other theoretically-grounded constructs of motivation affect navigation and the extent to which learners become disorientated during hypertext/hypermedia learning. MacGregor (1999) analyzed navigational patterns of 7th and 11th grade learners while they used a hypermedia environment. Results identified distinct navigational patterns, resulting in the researchers identifying those who were "concept connectors", "video viewers", and "sequential studiers". These navigational patterns were differentiated by several of the measured variables, including the participants' self-efficacy. MacGregor (1999) concluded that the advantage of hypermedia will only be realized if the learner is efficacious. Other research has revealed the importance of self-efficacy during hypermedia learning. Moos and Azevedo (2009) used data from a self-report questionnaire, a pretest, a posttest, and a think-aloud protocol to examine the extent to which self-efficacy was significantly related to specific monitoring processes during hypermedia learning. Results indicated that the relationship between self-efficacy and the extent to which participants' monitored their understanding, environment, and progress towards goals was significantly detectable. Furthermore, the relationship between self-efficacy and learning outcomes was significantly mediated by these monitoring variables.

While monitoring is a critical process in hypermedia and hypertext learning, processes related to planning and strategy use also facilitate learning in these environments. Research has demonstrated that the goal structure of these environments can affect the extent to which learners plan. Moos and Azevedo (2006) used think-aloud and posttest data from 60 undergraduates to explain how the goal structure in a hypermedia-learning task is related to the use of planning processes. Results indicated that participants learning with a hypermedia environment that had n a performance-avoidance goal structure used a different proportion of planning processes when compared to participants learning in a performance-approach or mastery goal structure. Nesbit et al. (2006) also found a positive relationship between goal orientations and how learners interact with a hypermedia environment. These researchers used information from an achievement goal questionnaire and data tracing from 80 undergraduates in an introductory Educational Psychology course. Findings suggest that learners with either an approach or avoidance mastery goal orientation typically used the strategy of highlighting less frequently during multimedia learning. This finding was not surprising to the researchers, though, given the assumption that highlighting is a low-level strategy that may be less effective than other strategies such as summarizing.

Research has also considered how extrinsic and intrinsic motivation affects the use of strategies during learning with CBIs. For example, Moos (2009) collected think-aloud, pretest, and posttest data from 53 undergraduates to examine the relationship between motivation and note-taking during hypermedia learning. Interestingly, learners with extrinsic motivation tended to have more conceptual information in their notes compared to those who were intrinsically motivated. Moos (2009) argues that the formal education system in the USA emphasizes note-taking and thus there is a positive association between performance and note-taking. Furthermore, note-taking may be an effective strategy to offload information, particularly when learners are interacting with environments such as hypermedia and hypertext that offer quick access to substantial amount of information. However, findings also indicated that note-taking, in the absence other processes related to planning, monitoring, and strategy use, did not facilitate learning with hypermedia.

3.3.1. Summary

The majority of the studies described for this research question have considered how self-efficacy and interest affect navigation (see Table 4), most of which produced findings that are consistent with research highlighted in research questions 2 and 3. Namely, interest is an important variable to consider when examining how learners navigate; however, the role of interest needs to be consider in conjunction with the learner's prior domain knowledge. These studies also highlight the effect of self-efficacy on navigation and seem to address that learners, to some degree, understand the potential challenges of needing to make instructional decisions during learning with hypermedia or hypertext. Learners' navigational paths can be distinguished by both their interest and self-efficacy. Another line of research has considered how motivation constructs, including goal orientation and extrinsic/intrinsic motivation, are related to the extent to which learners use processes related to strategies, planning, and monitoring. These findings are furthered explored in the following section, which contextualizes these findings within theoretical frameworks and then puts forth directions for future research.

Table 4
Number (and percentage) of studies, by motivation construct and CBI (research question 3).

Motivation construct	Type of CBI		
	Multimedia 0 (0%)	Hypermedia 5 (71.4%)	Hypertext 2 (28.6%)
Interest 2 (28.6%)	0 (0%)	0 (0%)	2 (28.6%)
Intrinsic/extrinsic 1 (14.2%)	0 (0%)	1 (14.2%)	0 (0%)
Self-efficacy 2 (28.6%)	0 (0%)	2 (28.6%)	0 (0%)
Goal 2 (28.6%)	0 (0%)	2 (28.6%)	0 (0%)

4. Discussion

This intention of this literature review was not to identify which CBI (multimedia, hypermedia, or hypertext) is preferable in terms of theoretically-grounded motivation constructs. In many ways, such an approach represents an "apples and oranges" discussion due to the distinct characteristics of the three environments, and couching a discussion in terms of relative effectiveness will not advance the field in a meaningful manner (Mayer, 1997, 2001). Rather, acknowledging the inherent differences in these three environments, and then discussing the role of motivation within these environments based on these differences is a more fruitful direction for research. This approach lends itself to productive conversations of how to best address issues of motivation within multimedia, hypermedia, and hypertext, and will result in a better understanding of how to facilitate learning within these environments. This literature review assumed this approach by addressing three questions. The first research question focused on how the three environments affected motivation. While some research found that these CBIs positively affected learners' interest, other research suggested that this relationship is contingent on learners' characteristics, such as prior domain knowledge. Research question 2 examined the effect of motivation constructs on learning outcomes in these environments. As with research question 1, these findings were mixed with some identifying a positive relationship between motivation constructs and learning outcomes (i.e. reading comprehension with hypertext), while others reporting the positive relationship between motivation and learning outcomes is contingent on prior domain knowledge. Lastly, the third research question addressed the role of motivation in the process of learning with multimedia, hypermedia, and hypertext. Findings for this research question were more consistent with the majority of the reviewed studies, highlighting a positive relationship between motivation constructs and the process of learning. In order to further explore these mixed findings, the following section will present some theoretical considerations. Lastly, a section describing future directions will be presented.

4.1. Theoretical considerations

As noted in the introduction, much of the research considering the challenges learners face with multimedia, hypermedia, and hypertext has been theoretically grounded. While this line of research has relied on the assumptions of various theoretical frameworks, two theories have recently received considerable attention, Self-regulated Learning Theory (SRL) and the Cognitive Load Theory. SRL is an umbrella for distinct theoretical perspectives that explain how students are active participants in their own learning. Pintrich (2000) and Winne and Hadwin's (1998) theoretical perspectives have dominated research examining how learners process information with multimedia, hypermedia, and hypertext. Pintrich's (2000) theoretical perspectives characterizes SRL as four different phases and four different areas. The four phases include:

planning, monitoring, control, and *reflection.* In phase one, the learner plans, sets goals, and activates knowledge about the context, text, and self. Phase two is defined when the learner exhibits metacognitive awareness and monitoring of cognition. In phase three, the learner selects cognitive strategies and regulates different aspects of the context, task, and self. Lastly, in phase four, the learner makes cognitive judgments and reflections on the context, task, and self. The four phases can occur across the following four areas highlighted in this SRL theory, *cognition, behavior, motivation,* and *context*. These phases and areas are intended to reflect common assumptions shared by many SRL models (Zimmerman, 2001). Close examination of research that has used Pintrich's (2000) framework reveals that these studies have focused on the *cognitive* and *metacognitive* areas to explain learning with hypermedia (e.g., Azevedo & Cromley, 2004; Azevedo, Greene, & Moos, 2007; Azevedo, Guthrie et al., 2004; Greene, Moos, Azevedo, & Winters, 2008). The theoretical perspective of self-regulated learning with CBIs calls for a consideration of cognition, metacognition, *and* motivation. Studies in this literature review have highlighted the importance of considering motivation constructs, yet there is a paucity of research using the SRL theory that simultaneously examines cognitive, metacognitive, *and* motivational variables in learning with multimedia, hypermedia, and/or hypertext.

A similar issue can be found with an alternative SRL perspective that has been used to guide research with these environments, Winne and Hadwin's (1998) model. Winne and Hadwin (1998) present an SRL model which proposes the following four phases of SRL: (1) Understanding the task, (2) goal-setting and planning how to reach the goal(s), (3) enacting strategies, and (4) metacognitively adapting studying. In the first phase, the learner develops a perception of a learning task, which is partly dependent on the retrieval of prior domain knowledge. Prior domain knowledge, drawn from long-term memory into working memory, facilitates the definition of the task and task performance (Winne, 2001). However, the perception of the task is related to various constructs of motivation. In many ways, a learners' motivation sets the stage for the other phases involved in self-regulation. In the second phase, the learner frames multifaceted goals and plans how to reach the goal(s) (Winne & Hadwin, 1998). In phase three, the learner enacts tactics and/or strategies, while phase four includes monitoring activities and cognitive evaluations about discrepancies between goal(s) and current domain knowledge (Winne, 2001; Winne & Hadwin, 1998). Thus, the use of processes related to planning, enacting tactics and/or strategies, and monitoring is partly hinged on the learners' initial motivation. Yet again, however, a close examination of research that has used this theory to examine learning with CBIs reveals that a limited body of work includes measures of motivation. Rather, the measurement of strategies, tactics, and monitoring activities has been the focus of this research.

Another line of research has used the Cognitive Load Theory to explain learning with these environments. A guiding assumption of this theory is that working memory has limited capacity, which has led to a considerable amount of research examining design principles of multimedia environments. While this line of research has produced incredibly informative findings that have greatly advanced the field, this theoretical approach does not account for the role of motivation constructs. Questions regarding the effect of cognitive overload while learning with multimedia, hypermedia, and/or hypertext on various motivation constructs remain unanswered. For example, how might an overload in a visual processor due to the process of extracting information from both a diagram and text differentially affect self-efficacy and interest? Including considerations of theoretically-grounded motivation constructs while examining cognitive load will further advance the extent to which the Cognitive Load theory explains learning with CBIs.

4.2. Directions for future research

While the research highlighted in this literature review has greatly advanced the field, there are unresolved issues that should be addressed in future research. Examining the distribution of the studies from Table 5 reveals that certain pertinent areas have received considerably less attention. Learning with hypertext, for example, has been the focus of fewer studies, which may be explained, at least in part, by the increasing popularity of hypermedia environments. Inclusion of multiple representations in nonlinear environment is often considered an effective combination for facilitating deep learning (Kimmel & Deek, 1995). More advanced trace methodologies (i.e. eye-tracking, log-file analyses, think-aloud protocols) have allowed for finer-grained analyses to better identify how the instructional design of multiple representations in hypermedia affects learning. However, clearly articulating the distinct benefits and challenges of unique design features (e.g., nonlinearity versus multiple representations) requires the examination of hypermedia and hypertext. Future research should consider simultaneously examining hypermedia and hypertext so that the effect of the instructional design on learning (including motivation) can be isolated.

In a similar vein, the vast majority of research highlighted in this literature review addressed research question 1, with much less considering the effect of motivation on learning processes. In the absence of empirical data that explains how learners use multimedia, hypermedia, and hypertext, research is required to make inferences about how motivation affects the process of learning with these environments. This field will advance with a more robust body of empirical data that explains how theoretically-grounded constructs of motivation affect the process of learning. This line of research requires process data, such as the think-aloud protocol, an on-line trace methodology that has an extensive history in cognitive psychology (see Ericsson, 2006; Ericsson & Simon, 1994; Newell & Simon, 1972 for extensive reviews). Cognitive psychology and cognitive science have used both concurrent and retrospective think-aloud protocols as data sources for cognitive processes during learning (Anderson, 1987). While the think-aloud protocol has been most popular in reading comprehension (Dreher & Guthrie, 1993; Pressley & Afflerbach, 1995), it has been shown as an excellent tool to gather verbal accounts of how individuals engage in the learning process. Some researchers have utilized this methodological approach to capture process data during learning with CBIs (see Azevedo and colleagues work). Log files, another methodology to capture process data, have been used in research examining navigation within hypertext and hypermedia. This ap-

Table 5
Number (and percentage) of studies, by motivation construct and CBI (all research questions).

Research question	Motivation construct	Type of CBI		
		Multimedia	Hypermedia	Hypertext
1	Interest	11 (30.5%)	7 (19.4%)	0 (0%)
	Intrinsic/extrinsic	0 (0%)	1 (2.8%)	0 (0%)
	Self-efficacy	0 (0%)	2 (5.6%)	0 (0%)
	Goal	0 (0%)	0 (0%)	0 (0%)
2	Interest	1 (2.8%)	1 (2.8%)	3 (8.3%)
	Intrinsic/extrinsic	0 (0%)	0 (0%)	0 (0%)
	Self-efficacy	3 (8.3%)	0 (0%)	0 (0%)
	Goal	0 (0%)	0 (0%)	0 (0%)
3	Interest	0 (0%)	0 (0%)	2 (5.6%)
	Intrinsic/extrinsic	0 (0%)	1 (2.8%)	0 (0%)
	Self-efficacy	0 (0%)	2 (5.6%)	0 (0%)
	Goal	0 (0%)	2 (5.6%)	0 (0%)

proach uploads log files to server, which allows the examination of the learner's interaction with the system (e.g., accessing various representations), navigational patterns (e.g., instructional path through pages and sections), and learning session information (e.g., time spent with a particular representation). This process data can then be used to explain how motivation affects interaction with multimedia, hypermedia, or hypertext.

Lastly, future research should more fully consider the pragmatic issue of cost versus benefit of these three environments. In many ways, hypermedia represents an augmentation of multimedia and hypertext, and there can be added expense of designing visually rich environments that also offers the learner control over the sequencing of information. These added instructional designs should not be blindly accepted, particularly given the associated cost. Do learners significantly benefit from these more expensive instructional media, in terms of learning and motivation outcomes? Some research has addressed this question, suggesting that more simplistic instructional designs are often as effective, if not more effective. This consideration relates to the notion of "Cognitive Efficiency", a term used to explain the extent to which one medium requires more or less mental effort in comparison to another medium (Cobb, 1997).

Choi and Clark (2006) examined Cognitive Efficiency in the context of a multimedia programs with relative unsophisticated support (in the form of simple electronics arrows and voice) and multimedia program with more sophisticated support (in the form of animated pedagogical agents). Their findings indicated that the sophisticated multimedia environment was not significantly more effective, in terms of learning outcomes and motivational outcomes. However, this study did not provide empirical evidence explaining the cognitive efficiency between these two environments. Future research would be well-served to empirically examine cognitive efficiency among various types of environments (see Paas & van Merriënboer, 1993 for an overview of cognitive efficiency). While research has typically examined the relationship between cognitive efficiency and performance, the importance of motivation in this relationship has been recently articulated. Paas, Tuovinen, van Merrienboer, and Darabi (2005), for example, identified motivation as an important construct to consider, particularly with complex e-learning environments. Instructional conditions in these environments present new challenges to cognitive efficiency research, and require perspectives that consider motivation in the relationship between mental effort and performance.

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