
Volume 55, issue 4, December 2010
ISSN 0360-1315
ELSEVIER
Computers & Education
An International Journal
Editors:
Rachelle S. Heller
Jean D.M. Underwood
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MAKE AN IMPACT
Impact Factor
2.059
GET READ
Available online at www.sciencedirect.com
ScienceDirect

Computers & Education 55 (2010) 1640–1650

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Nonlinear technology: Changing the conception of extrinsic motivation?

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A R T I C L E I N F O

Article history:
Received 2 May 2010
Received in revised form
12 July 2010
Accepted 14 July 2010

Keywords:
Multimedia/hypermedia systems
Human–computer interface
Extrinsic motivation
Intrinsic motivation
Self-regulated learning

A B S T R A C T

Think-aloud and self-report data from 84 undergraduates were used to examine the relationship between intrinsic motivation, extrinsic motivation, and use of self-regulated learning (SRL) processes. Participants individually learned about the circulatory system with a hypermedia environment for 30 min. During this experimental session, three measures were used to examine the research questions guiding the study. Participants completed a self-report questionnaire that measured their extrinsic and intrinsic motivation. They also completed a pretest and posttest, which assessed learning outcomes. Lastly, think-aloud data were collected to determine the frequency in which participants used SRL process related to planning, monitoring, and strategy use. Results indicate that participants who had high extrinsic and high intrinsic motivation used significantly more planning and monitoring processes when compared to participants who had lower motivation scores for either the extrinsic or intrinsic category. Additionally, participants who had high extrinsic and high intrinsic motivation significantly outperformed those who had low extrinsic and low intrinsic motivation.

1. Introduction

Long gone are the days when technology was primarily used as productivity tools that embraced the notion of “tutor, tool, and tutee” (see Taylor, 1980). These earlier technology environments were designed to facilitate knowledge acquisition in well-defined tasks (e.g., Anderson, Corbett, & Koedinger, 1995). The result of this approach often led to a standardized interpretation of knowledge to the student (Jonassen & Reeves, 1996). However, research has identified pedagogical flaws of standardizing instruction, particularly because a number of individual factors can affect how students process information and a standardized approach may not account for these individual differences. For example, prior domain knowledge has been shown to be a powerful predictor in the process of learning (Alexander, 2003; Alexander & Jetton, 2003; Alexander, Jetton, & Kulikowich, 1995; Alexander, Kulikowich, & Schulze, 1994; Alexander & Murphy, 1998; Dochy & Alexander, 1995). Students with distinct levels of prior domain knowledge engage in the learning process differently (Moos & Azevedo, 2008a; Shapiro, 2004), and thus standardized presentation of information may not be the most effective design for a variety of students.

In response to the growing body of literature on individual differences, the design of more recent computer-based learning environments (CBLEs) reflects *personalized learning* (Robinson & Sebba, 2010; Underwood & Banyard, 2008). This approach maintains that the learning environment should be structured such that it is highly responsive to each individual student. CBLEs that are designed with personalized learning in mind offer increased opportunities for collaboration among a more diverse group of individuals, can promote lifelong learning, and allow students to pursue personal goals and determine the instructional path that best meets their needs (Jonassen & Reeves, 1996). This approach assumes that users will actively participate in the construction of knowledge (Duffy & Jonassen, 1992; Jonassen & Reeves, 1996; Lajoie, 2000; White & Frederiksen, 2005; Williams, 1996) because they are learning *with* the CBLE. Thus, the process of learning is personalized through this interaction. Hypermedia, a specific type of CBLE that is designed to foster active participation in the learning process, has received considerable empirical and theoretical attention.

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doi:10.1016/j.compedu.2010.07.006

1.1. Overview of hypermedia

Hypermedia is considered an augmentation of hypertext and multimedia in the sense that this CBLE offers both interactivity and information presented in multiple formats. This design approach offers many tantalizing promises for facilitating deep student learning, and many of the arguments supporting the pedagogical benefit of these environments are theoretically grounded. First, a guiding assumption of hypermedia's design is that the interactivity affords students the opportunity to develop their own meaning from the information, as opposed to being a passive recipient in a system-controlled environment (McGuire, 1996). Second, Landow (1992) suggests that, "students benefit from the experience of experts in a field without being confined to them" (p. 127). In other words, the linked information provided by the electronic hyperlinks models the connective thinking of experts. Furthermore, this accessibility to information addresses a diverse set of student needs, including cognitive needs. For example, students with low prior domain knowledge can choose a different instructional path from those who already have existing cognitive structures (Moos & Azevedo, 2008a).

Despite these promises of hypermedia, recent research has identified potential challenges of learning with this environment. One challenge concerns the need for students to engage in a number of effortful cognitive and metacognitive processes in order to make meaning and develop a situational model of the text (Kintsch, 1998). In particular, they need to engage in the following processes during hypermedia learning: Activate prior knowledge (Moos & Azevedo, 2008a) and integrate it to their developing construction of a mental representation (Kintsch, 1998); monitor the relevancy of the content in the various presentations of information (Azevedo, 2008, 2009; Azevedo, Greene, & Moos, 2007; Greene, Moos, Azevedo, & Winters, 2008; Moos, 2009, 2010; Moos & Azevedo, 2008a, 2008b, 2008c); and monitor their emerging understanding of the topic (Azevedo & Cromley, 2004; Azevedo, Guthrie, & Seibert, 2004; Moos & Azevedo, 2006). Despite the documented importance of these processes, empirical research has also revealed significant individual differences in how these processes are used during the learning process. A promising direction for exploring these differences is to look towards the field of academic motivation. This current study attempts to examine the relationship between two theoretically grounded constructs of motivation (extrinsic and intrinsic motivation) and cognitive and metacognitive processes related to self-regulated learning (SRL) during hypermedia learning. The following section will briefly outline the SRL theory guiding this study, followed by an overview of extrinsic and intrinsic motivation. Lastly, the rationale for this current study will be articulated.

1.2. Self-regulated learning with hypermedia

Though the field of SRL has given rise to various theoretical perspectives, SRL is generally defined as processes involved in actively constructing an understanding of a topic/domain by using strategies and goals, regulating and monitoring certain aspects of cognition, behavior, and motivation, and modifying behavior to achieve a desired goal (Pintrich, 2000; Zimmerman, 1998). Research in the field of SRL indicates that academic learning can be explained, in part, by cognitive and metacognitive factors related to self-regulation (Alexander, 2004; Azevedo, 2007, 2009; Bransford, Zech, & Schwartz, 1996; Greene & Azevedo, 2007; Pressley, Wharton-McDonald, & Allington, 2001; Shraw & Sinatra, 2004). The relationship between SRL processes and learning is magnified in nonlinear environments such as hypermedia (Azevedo & Witherspoon, 2009; Greene & Azevedo, 2009; Greene et al., 2008; Moos & Azevedo, 2009, 2008a, 2008b, 2008c). Interactivity and access to multiple representations in hypermedia can create cognitive and metacognitive demands necessitating the use of SRL processes.

In order to measure use of SRL processes during hypermedia learning, recent research has advocated viewing SRL as an *event*, which is defined as dynamic processes that unfold within particular contexts (Boekaerts et al., 2000). This assumption of SRL requires methodologies that capture processes during learning. A variety of protocols have been used to collect SRL data during learning, including *error detection tasks* and *log files*. A third type of methodology is the *think-aloud* protocol, which has an extensive history in cognitive psychology (see Ericsson, 2006; Ericsson & Simon, 1994 for extensive reviews). While this protocol has been most popular in the field of reading comprehension (Dreher & Guthrie, 1993; Pressley & Afflerbach, 1995), it has been shown to be an extremely effective methodology to capture processes during learning. However, the validity of this protocol is dependent on the application of it during the learning task and the developmental group of the participants. From a theoretical standpoint, thought processes are a sequence of states that are relatively stable (Ericsson, 2006; Ericsson & Simon, 1994). Consequently, verbalizing thoughts during learning will not disrupt the learning process. Appropriate application of the think-aloud protocol, though, requires "that [participants] verbalizing their thoughts while performing a task do *not* describe or explain what they are doing (Ericsson & Simon, 1994, p. xiii)." If participants are not asked to reflect, describe, and/or explain their thoughts during learning, but rather are asked to simply verbalize thoughts entering their attention, then it is assumed that the sequence of thoughts will not be disrupted. Empirical evidence has supported this assertion that appropriate application of the think-aloud protocol does not disrupt the learning process (see Veenman, Elshout, & Groen, 1993). However, research has also demonstrated that the participants' age may have an effect on the validity of this measure (see Robinson, 2001), with the probability of a concurrent think-aloud disrupting the learning process increasing with younger individuals. Careful consideration of the context, application, and development group will increase the validity of this measure, as demonstrated by a growing body of research in the field of SRL with hypermedia (e.g., Azevedo, 2008, 2009; Greene & Azevedo, 2007; Moos, 2009, 2010; Moos & Azevedo, 2009). These lines of research have substantially advanced the field by using a think-aloud protocol to identify *what* SRL processes are used during hypermedia learning. However, there is currently limited research that has used think-aloud protocols (Ericsson, 2006; Ericsson & Simon, 1994) in conjunction with self-report measures to examine *why* students use SRL processes. Zimmerman (2008) suggests that examining theoretically grounded constructs of motivation, such as extrinsic and intrinsic motivation, is a fruitful direction for this line of research.

1.3. Extrinsic and intrinsic motivation with hypermedia learning

While a number of theoretically grounded constructs of motivation have received considerable empirical attention in the past half-century (see Murphy & Alexander, 2000), extrinsic and intrinsic motivation have provided the grounds for discussions regarding the relationship between academic motivation and learning. Intrinsic motivation has been traditionally defined as an internal desire to engage in a behavior due to pleasure, interest, enjoyment, and/or challenge, while extrinsic motivation refers to the engagement of behavior due to external incentives, such as money, grades, and praise (Berlyne, 1960; Hunt, 1965; White, 1959). The long history of these two motivation constructs has resulted in a number of debates, though the relationship between them has been one of the more critical issues. Some researchers advocate that extrinsic and intrinsic motivation should be conceptualized as mutually exclusive, opposing poles. Harter (1981) set the stage for this debate by putting forth a motivation scale that categorized these two constructs as mutually exclusive. This scale, which asks students to indicate the extent that they engage in a specific activity based on intrinsic or extrinsic reasons, has been used in a wide variety of studies (e.g., Guay, Boggiano, & Vallerand, 2001; Newman, 1990). It has been cited as a valid method of differentiating between motivational and informational components when addressing extrinsic and intrinsic motivation (Lepper, Corpus, & Iyengar, 2005). Early research conceptualizing extrinsic and intrinsic motivation as mutually exclusive has typically found that intrinsic motivation is often undermined in the presence of extrinsic rewards (Deci, 1971; Lepper, Greene, & Nisbett, 1973).

Recent research has questioned the earlier conceptualization of these two motivation constructs. One criticism stemming from this line of research concerns the wording of Hater's (1981) scale, which forces participants to choose either intrinsic motivation or extrinsic motivation as an explanation for why they engage in behavior. As suggested by Lepper et al. (2005), students may in fact engage in behavior because it both interests them (intrinsic motivation) and it will better enable them to earn a high grade (extrinsic motivation). These researchers provided empirically-based evidence that supports the categorization of these constructs as potentially independent. This research included a modified version of Harter's (1981) original scale, which asked participants to rate the degree to which extrinsic and/or intrinsic motivation explained their behaviors (see Lepper, Sethi, Dialdin, & Drake, 1997). This scale was administered to 797 elementary and middle school students from the San Francisco Bay Area of California. The findings indicated only moderate correlations between intrinsic and extrinsic motivation, suggesting that these two constructs may coexist. The researchers further argued that simultaneously considering the external consequences of an inherently enjoyable activity might be the most effective approach in academic settings. In fact, they suggested that learning outcomes might be negatively affected if the student disregards external contingencies and instead focuses on the immediate enjoyment of the activity. While this study highlights the importance of conceptualizing intrinsic and extrinsic motivation as potentially independent, there has been limited research examining the relationship between these constructs of motivation and learning with hypermedia. The need for research examining this relationship is heightened given the increasing prevalence of this technology environment in the classroom and its somewhat unique design features.

1.4. Current study

The preceding section highlighted that while the design of hypermedia offers tantalizing promises due to a nonlinear design and multiple representations, learning with these environments often requires the use of complex cognitive and metacognitive processes related to SRL. Furthermore, research has demonstrated individual differences in how students use these processes with hypermedia. The field of academic motivation offers a fruitful direction for research attempting to explain these differences. In particular, the motivation constructs of extrinsic and intrinsic motivation have enjoyed a half a century of theoretical and empirical consideration. Recently, some research has suggested the importance of considering these two constructs as independent, and even put forth the possibility that extrinsic motivation may offer unique benefits to the learning process. However, the role of these two constructs in the use of cognitive and metacognitive processes related to SRL with hypermedia has been largely unexplored.

This study examined this issue by using a concurrent think-aloud protocol and a self-report questionnaire in order to address the following research questions: (1) What groups emerge using cluster analysis on extrinsic and intrinsic motivation for learning with a hypermedia environment?; (2) To what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to planning?; (3) To what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to monitoring?; (4) To what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to learning strategies?

2. Method

2.1. Participants

Participants ($N = 84$) were education majors from a liberal arts college in the USA. This sample included 45 females (54%) and 39 males (46%), two of which were freshmen (2%; $M_{age} = 18.00$ years), eighteen of which were sophomores (20%; $M_{age} = 19.18$ years), 37 of which were juniors (44%; $M_{age} = 20.80$ years), and 26 were seniors (31%; $M_{age} = 21.61$ years). One participant did not report his class standing. Overall, their average age was 20.54 (SD = 1.50), and their average Grade Point Average (i.e. mean grade over all courses taken at this liberal arts college) was 3.30 (SD = 0.45). All the participants were education majors and received minimal extra credit for participation in the study.

2.2. Measures

A pretest and posttest was used to measure *learning outcomes*. The pretest and posttest, which are identical, is comprised of an essay that asks participants to, "Please write down everything you can about the circulatory system. Be sure to include all the parts and their purpose, explain how they work both individually and together, and also explain how they contribute to the healthy functioning of the body." Both the pretest and posttest essays were scored with a coding scheme developed by Azevedo and colleagues (see Azevedo, Cromley, & Seibert, 2004) and is based on Chi and colleagues' research (Chi, 2000, 2005; Chi, de Leeuw, Chiu, & LaVancher, 1994). The range of this coding scheme is one to 12, with higher scores representing a transition from a low mental model to a high mental model of the circulatory system. For example, a participant's essay would receive a score of five (on either the pretest or posttest) if it indicted that he or she understood that the heart acts as a pump to circulate blood, the arteries and veins transport blood, and the purpose of the circulatory system is to transport oxygen and nutrients would receive a score of five. On the other hand, an essay would receive a score of ten if it included a description of the circulatory loop (heart–body–heart–lungs–heart-continued) in addition to the above information. The pretest and posttest were not significantly related to the participants' GPA ($p > 0.05$).

Fifty-two ($n = 52$) pretest and posttest mental model essays were used from 26 participants to establish inter-rater reliability for the scoring of these essays. There was agreement on 46 out of a total of 52 scored essays, yielding an inter-rater agreement of 0.88. Disagreements on the scoring of these essays were resolved through discussion. While this measure has demonstrated both validity and reliability, it should be noted that writing skills might be a confounding variable. Though writing mechanics are not a component of this coding scheme, participants with limited writing skills may be at a disadvantage when writing the essay for the pretest and posttest. Thus, writing skills may be a confounding variable, particularly for younger developmental groups where the diversity in writing skills may be even more pronounced.

A think-aloud protocol (Ericsson, 2006; Ericsson & Simon, 1994) was used to measure *SRL processes* during learning. Utilizing the think-aloud protocol required four steps. First, each participant was audio recorded during the learning task, which resulted in a total of 2520 min of audio recording ($M_{audio} = 30$ min). Second, the audio recordings were transcribed. Third, the transcriptions were coded with a modified coding scheme originally developed by Azevedo, Cromley, and Seibert (2004). The modified coding scheme includes 16 micro-level SRL processes from the macro categories of *planning, monitoring,* and *strategy use*[1](see Appendix A for SRL coding scheme). This step resulted in a total of 2688 coded micro-level SRL processes ($M_{SRL} = 32$ processes). Lastly, inter-rater agreement was established for the transcripts of 26 participants (31% of total sample). A research assistant who was trained in using the think-aloud protocol with this particular coding scheme blindly coded these transcripts. There was agreement on 702 codes out of a total of 780 codes, resulting in an inter-rater agree mean of 0.90. See Appendix A for the SRL coding scheme and examples of each micro-level code.

Intrinsic motivation and *extrinsic motivation* were measured with the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991). The MSLQ includes four questions that measure intrinsic motivation and four questions that measure extrinsic motivation. All questions are answered on a seven point Likert scale (1 = not at all true of me, 7 = very true of me). A correlation analysis was run on participants' responses to these questions. The results suggest that extrinsic motivation and intrinsic motivation are independent as the correlation was non-significant ($p > 0.05$).

2.3. Learning environment

During the learning task, participants used a commercially-based hypermedia environment, Microsoft Encarta Reference Suite™, on a laptop to learn about the circulatory system. This hypermedia environment contains hundreds of articles, though there are three articles and an animation that are most directly related to the circulatory system. These three articles are comprised of 16,900 words, 35 illustrations, 107 hyperlinks, and 18 sections. Participants could access nodes of information and multimedia through two search engines and hyperlinks embedded in the pages. The Flesch Kincaid Grade Level of the text in these three articles is 12.0. Participants were able to freely search all of Encarta while learning about the circulatory system, but they were not allowed to go on-line. Given the sheer number of articles, multimedia options, and ability to quickly access this information through the search engines and hyperlinks, participants needed to self-regulate their learning in order to use this hypermedia environment effectively. In particular, SRL processes related to monitoring their emerging understanding, relevancy of information in the interlinked nodes and multimedia, and progress towards the learning goal were critical to facilitate learning. Furthermore, the inherent nature of this hypermedia environment also required the use of a variety of learning strategies (e.g., coordinating information sources), as well as planning processes (e.g., creating sub-goals). See Fig. 1 for a screen shot of this hypermedia environment.

2.4. Procedure

The author individually ran each participant in an experimental session that lasted approximately one hour and involved five steps. After completing the consent form and general participant information sheet, participants were given fifteen minutes to complete the mental model essay (pretest). Second, participants were provided directions for the hypermedia learning task. These directions included the instructions and goal for the 30-min learning task, as well as a walkthrough of the hypermedia learning task. The walkthrough of the hypermedia learning task included an overview of the search and navigation features within this environment. Third, participants completed the Extrinsic and Intrinsic Motivation Scale from the MSLQ. It is important to note that this motivation questionnaire was administered after the participants completed the pretest, received a walkthrough of the hypermedia learning environment, and read the directions for the learning task. Thus, it was assumed that the participants had sufficient understanding of the task to make motivational judgments (Winne & Hadwin, 1998). Then, participants were given 30 min to learn about the circulatory system with the hypermedia environment. Lastly, participants were given fifteen minutes to complete the mental model essay (posttest).

3. Results

3.1. Question 1: what groups emerge using cluster analysis on extrinsic and intrinsic motivation for learning with a hypermedia environment?

Data from the MSLQ (intrinsic and extrinsic self-report questions) were used for this research question. Using K-Means cluster analysis (Pollard, 1981), the participants were placed into four groups based on their mean for intrinsic motivation and mean for extrinsic motivation; five iterations occurred. The first cluster had low intrinsic motivation, but high extrinsic motivation, while the second cluster has low

[1] The 16 micro-level SRL variables were grouped into three macro-level categories: *planning, monitoring,* and *strategy use*. The *planning* category consists of goal setting, prior knowledge activation, and recycling goals into working memory. The *monitoring* category consists of monitoring progress towards goals, monitoring use of strategies, monitoring environment, and monitoring understanding. The *strategy use* category consists of coordinating informational sources, drawing, knowledge elaboration, memorizing, reading notes, re-reading, summarizing, using inference, and taking notes.

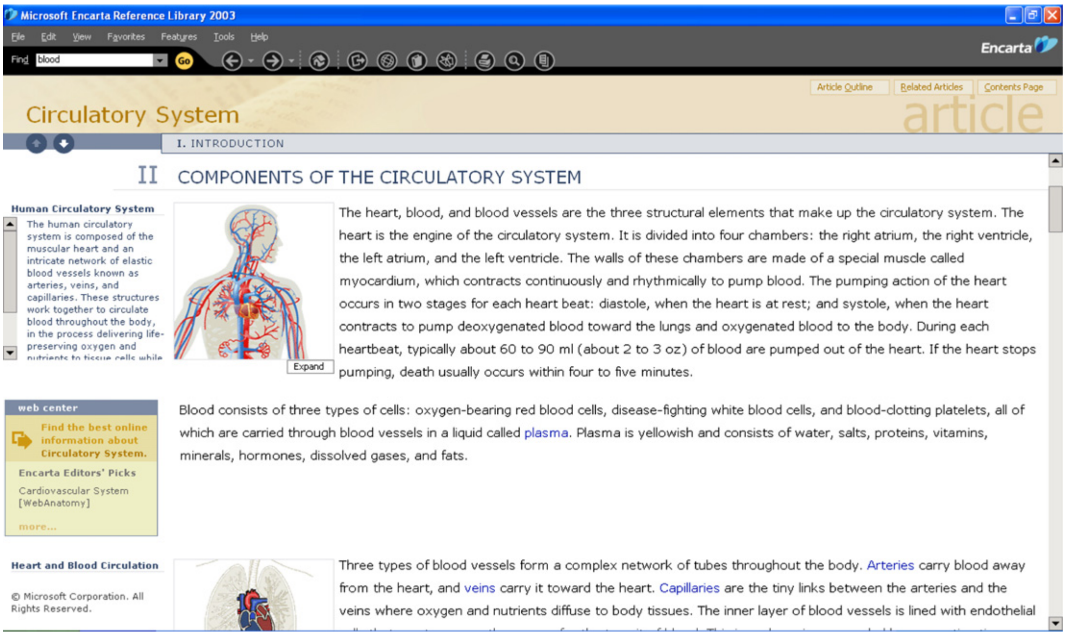

Fig. 1. Screen shot of hypermedia environment.

means for both types of motivation. The third cluster had a high mean for intrinsic motivation, but a low mean for extrinsic motivation. Lastly, cluster four had a high mean for both intrinsic motivation and extrinsic motivation. See Table 1 for cluster centers for each cluster.

3.2. Question 2: to what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to planning?

Data from the think-aloud protocol (use of SRL processes related to planning, monitoring, and learning strategies), MSLQ (intrinsic/extrinsic motivation), and posttest (learning outcomes) were used for the following three research questions. Regression analyses were conducted using conditions put forth by Baron and Kenny (1986). In essence, the following conditions need to be met: (1) The predictor is significantly related to the mediator, (2) the predictor is significantly related to the dependent variable in the absence of the mediator, (3) the mediator has a significant unique relationship with the dependent variable, and (4) the effect of the predictor on the dependent variable becomes smaller upon the addition of the mediator to the model. Four separate regression analyses were run to address research question two, with motivational groups (as established in the first research question) serving as the predictor, use of planning processes as the mediator, and score on the posttest as the dependent variable. In sum, results indicate that the relationship between motivational groups and learning outcomes is significantly mediated by the use of planning processes (see Table 2). Specifically, those with higher intrinsic motivation *and* higher extrinsic motivation tended to use more planning processes, which, in turn, resulted in higher learning outcomes.

3.3. Question 3: to what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to monitoring?

This research question was addressed identically as the previous research question, with the exception that use of monitoring processes served as the mediator in the regression analyses (see Table 2 for results). These results indicate that the relationship between motivational groups and learning outcomes is significantly mediated by the use of monitoring processes. As with the previous question, those with higher intrinsic motivation *and* higher extrinsic motivation tended to use more monitoring processes, which, in turn, resulted in higher learning outcomes.

Table 1
Cluster centers for Each Cluster.

Motivation	Cluster 1[a] $n = 25$	Cluster 2[b] $n = 23$	Cluster 3[c] $n = 23$	Cluster 4[d] $n = 13$
Extrinsic motivation	5.72	4.19	4.30	5.67
Intrinsic motivation	4.21	3.64	5.07	5.90

[a] Cluster 1 = Low intrinsic and High extrinsic motivation.
[b] Cluster 2 = Low intrinsic and Low extrinsic motivation.
[c] Cluster 3 = High intrinsic and Low extrinsic motivation.
[d] Cluster 4 = High intrinsic and High extrinsic motivation.

Table 2
Summary of mediation analyses from Research Questions 2,3, and 4 ($N = 84$).

	B	SE	β	R^2	p
Research Question #2					
Step 1: motivational group predicting planning	1.38	0.38	0.37	0.14	<0.001
Step 2: motivational group predicting learning outcome	0.69	0.32	0.23	0.06	0.032
Step 3: planning predicting learning outcome	0.35	0.08	0.44	0.19	<0.001
Step 4: motivational group predicting learning outcome, controlling for planning	0.24	0.32	0.08	0.01	0.456
Research Question #3					
Step 1: motivational group predicting monitoring	2.47	0.77	0.36	0.11	0.002
Step 2: motivational group predicting learning outcome	0.69	0.32	0.23	0.06	0.032
Step 3: monitoring predicting learning outcome	0.14	0.04	0.34	0.12	0.001
Step 4: motivational group predicting learning outcome, controlling for monitoring	0.39	0.33	0.13	0.02	0.232
Research Question #4					
Step 1: motivational group predicting learning strategies	3.31	1.10	0.32	0.10	0.003
Step 2: motivational group predicting learning outcome	0.69	0.32	0.23	0.06	0.032
Step 3: learning strategies predicting learning outcome	0.07	0.03	0.26	0.07	0.018
Step 4: motivational group predicting learning outcome, controlling for learning strategies	0.49	0.33	0.17	0.03	0.143

3.4. *Question 4: to what extent is the relationship between these motivational groups and learning with hypermedia mediated by the use of SRL processes related to learning strategies?*

Research question four was run using the same approach (Baron & Kenny, 1986), with learning strategies serving as the mediator in analyses. The results were similar with the previous two research questions (see Table 2), as learning strategies significantly mediated the relationship between motivational group and learning outcomes. Furthermore, examining the mean raw frequencies of the SRL processes and the mean posttest scores (see Table 3) reveals that those participants with high intrinsic motivation *and* high extrinsic motivation tended to use more SRL processes during hypermedia learning and outperformed those with lower motivation.

4. Discussion

While previous research has used theoretical approaches to identify *what* SRL processes facilitate learning with hypermedia, the issue of *why* these students use processes has received much less empirical attention. This current study provides theoretically grounded research that supports the consideration of motivation constructs in explaining how students use of cognitive and metacognitive processes during hypermedia learning. Findings from this study indicate that participants with a combination of high extrinsic motivation and high intrinsic motivation tend to use more SRL processes and outperformed those who had low intrinsic and extrinsic motivation. These findings are slightly inconsistent with research that has used traditional approaches to examine the relationship between these two motivation constructs and learning. The following section first briefly highlights research that is inconsistent with findings from this current study. Next, this section identifies distinct perspectives and explanations that account for these inconsistencies. Lastly, potential future directions are provided.

Table 3
Mean use of SRL processes (both micro and macro-level), and mean pretest and posttest scores, by cluster.

SRL processes	Cluster 1[a] $n = 25$	Cluster 2[b] $n = 23$	Cluster 3[c] $n = 23$	Cluster 4[d] $n = 13$
Planning	3.24	1.91	5.30	7.07
Prior domain knowledge activation	1.28	0.69	1.78	3.38
Recycle goal in working memory	1.32	0.91	2.34	2.23
Sub-Goals	0.64	0.30	1.34	1.46
Monitoring	6.40	4.47	9.73	13.69
Monitoring understanding	4.28	2.17	4.78	7.23
Monitoring environment	1.24	1.70	3.69	4.31
Monitoring progress	0.56	0.43	0.65	1.31
Monitoring use of strategies	0.00	0.00	0.25	0.00
Strategy Use	17.24	15.00	22.91	26.23
Coordinating informational sources	0.24	0.09	0.26	0.92
Draw	0.04	0.00	0.43	0.84
Inferences	0.12	0.17	0.61	0.84
Knowledge elaboration	0.48	0.30	0.52	1.69
Memorization	0.04	0.13	0.43	0.00
Read notes	0.40	0.21	1.48	0.69
Re-reading	3.36	2.78	3.17	2.77
Summarization	4.52	3.52	6.73	9.23
Taking notes	7.44	6.30	5.96	7.54
Pretest	5.44	4.70	5.83	7.85
Posttest	8.88	7.30	9.61	10.77

[a] Cluster 1 = Low intrinsic and High extrinsic motivation.
[b] Cluster 2 = Low intrinsic and Low extrinsic motivation.
[c] Cluster 3 = High intrinsic and Low extrinsic motivation.
[d] Cluster 4 = High intrinsic and High extrinsic motivation.

Historically, it has been assumed that intrinsic motivation facilitates learning while extrinsic motivation undermines meaningful learning, an assumption that has been supported through a number of empirical studies. For example, Young (2005) presented findings that found positive relationships between intrinsic motivation and the use of deep cognitive and metacognitive processes during learning in a classroom context. Conversely, this study found that extrinsic motivation was related to the use of superficial learning strategies during learning. Young (2005) concluded that contexts emphasizing learning over grades increase intrinsic motivation, which, in turn promotes the use of deeper SRL processes.

The detrimental effects of extrinsic motivation, as found in studies such as Young's (2005) research, have traditionally been explained by the "overjustificaiton" hypothesis (see Lepper & Greene, 1976). This hypothesis suggests that the presence of extrinsic rewards during a learning task may lead to decreased levels of intrinsic interest. The individual may attribute interest in the learning task due to the presence of an external reward, as opposed to intrinsic motivation. Furthermore, it is also assumed that this relationship is contingent on the extent to which rewards are salient. If a reward (i.e. extrinsic motivator) is presented at the end of a task, and is a surprise to the student, then the reward will not have a negative effect on intrinsic motivation. However, it should be noted that this hypothesis focused, "…on the possible after effects of extrinsic motivation on *intrinsic motivation*" (Lepper & Greene, 1976, p. 28). Other theoretical frameworks have put forth distinct perspectives that attempt to explain the complex effects of intrinsic and extrinsic motivation on *learning*.

Ryan and Deci (2000) conceptualize this relationship distinctly within their Self-Determination theory (SDT). This theory proposes that extrinsic motivation can vary in its relative autonomy (Ryan & Connell, 1989; Vallerand, 1997), a distinct perspective from the traditional approaches that conceptualize extrinsic motivation as non-autonomous. Pragmatically speaking, the underlying reasons for extrinsic motivation can vary from autonomous to non-autonomous. For example, a student may decide to complete homework because it adheres to rules put forth by his or her parents, while another student may decide to complete homework because he or she understands its value for future goals. Both of these examples represent extrinsic motivation. However, the behavior of the first student involves compliance while the behavior of the second student involves personal endorsement (Ryan & Deci, 2000). Research using this conceptualization has found that some forms of extrinsic motivation are positively associated with learning outcomes. In particular, researchers have found a positive relationship between autonomous extrinsic motivation and performance (Miserandino, 1996) and engagement in the learning process (Connell & Wellborn, 1991).

This line of research is not alone in identifying the potential benefits of extrinsic motivation. Some research has also presented empirical evidence that suggest college students' performance is positively related to both intrinsic and extrinsic motivation. For example, Lin, McKeachie, and Kim (2001) hypothesized that there is a curvilinear effect of intrinsic and extrinsic motivation on learning. In order to test this hypothesis, they administered an extrinsic and intrinsic motivation self-report scale to thirteen undergraduate classes from diverse types of campuses (a liberal arts college, a comprehensive university, and a community college). Results indicated that undergraduates who reported high intrinsic motivation and were in the mid-third distribution in motivation for grades (extrinsic motivation) outperformed the other participants.

Findings from this current study are consistent with the conception of extrinsic motivation articulated in these lines of research. While earlier research on extrinsic motivation suggested a negative relationship between this construct and learning, more recent research has identified the potential benefit of extrinsic motivation in some settings. This current study highlights the possibility that extrinsic motivation in combination with intrinsic motivation may be the most optimal combination to facilitate learning, particularly in the context of hypermedia. As noted in the introduction, the design of hypermedia allows the student to control the sequence in which information is accessed. This study used a hypermedia environment that offers considerable autonomy with respect to how the participants' navigational path. The design offered 18 sections, 16,900 words, and 35 illustrations in the three most relevant locations, all of which could be accessed through two different search engines and over 107 hyperlinks. To complicate the learning process, participants could access substantial information over and beyond what was offered in these three locations. Much of this information had limited (or no) relevance to the overall learning goal. Easy accessibility to a wide range of information that is not directly related to the learning goal may actually be somewhat detrimental to a student who has high intrinsic motivation, but low extrinsic motivation.

For example, all participants began the learning task in the "Circulatory System" article. Within this page, there is a section titled "Operation and Function", which outlines the medical contributions of William Harvey and contains a hyperlink to a page with additional information on his biography. Accessing this page reveals a hyperlink to several articles and multimedia that address "The Greatest Medical Discoveries of the Millennium." Information provided in these different pages is only tangentially related to the specifics of the learning goal ("Make sure you learn about the different parts and their purpose, how they work both individually and together, and how they support the human body."). Information about "The Greatest Medical Discoveries of the Millennium" can be accessed very quickly, through three hyperlinks from the originating page. Thus, a student could easily access information that is minimally related to the overall learning goal, such as the section that describes how Antoni van Leeuwenhoek, a part-time janitor, discovered bacteria using a homemade microscope. A student who is intrinsically interested in the circulatory system, but is not motivated to meet the overall learning goal, may decide to learn about Antoni van Leeuwenhoek. A student who has high intrinsic motivation and high extrinsic motivation may also engage in this material due to an inherent interest in information related to the circulatory system. However, unlike those who have lower extrinsic motivation, this participant may limit his/her exposure to this information because it is not as relevant to the overall learning goal. It should be noted that this assertion is a hypothesis and future research would be well served to consider navigation within hypermedia as it relates to extrinsic and intrinsic motivation, an issue addressed in the below section.

4.1. Future directions

While this study presents findings that further explore the relationships between extrinsic motivation, intrinsic motivation and hypermedia learning, it also provides a framework for future research. First, future research should consider the relationship between navigation styles, intrinsic motivation, and extrinsic motivation. While the relationship between navigation styles and learning with hypermedia is an area that has been the focus of considerable research, the role of theoretically-grounded constructs of motivation in this relationship has received much less empirical attention. Considering the interaction between these variables will shed light on how these two motivation constructs affect learning outcomes, as demonstrated in this current study. Second, research from the field of Educational Psychology has given rise to various theoretical approaches to motivation (Eccles, Wigfield, & Schiefele, 1998). Different intellectual traditions (Weiner, 1992) have focused on various motivation theories and, as a consequence, a number of conceptually distinct motivation constructs have been identified. 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 perspectives, which can include focusing on beliefs, values, and goals (Eccles & Wigfield, 2002). Murphy and Alexander (2000) note that extrinsic motivation and intrinsic motivation are conceptually distinct from other predominant perspectives in the motivation literature. Motivation constructs related to Goals (i.e. mastery goal and performance goal), Interest (i.e. individual interest and situational interest), and Self-schema (i.e. attributions and self-efficacy) have also received considerable theoretical and empirical attention in the field. However, most of this research has not been conducted within the context of hypermedia learning (See Moos & Marroquin, 2010 for a recent review). Given the documented individual differences in how students use hypermedia, examining other theoretically grounded constructs of motivation is a worthwhile direction for future research. Explaining individual differences through theoretically-grounded motivation constructs would be well advised to consider several limitations of this study. First, empirical research has demonstrated that prior domain knowledge offers a powerful lens in explaining individual differences with respect to the use of SRL during hypermedia learning (e.g., Moos & Azevedo, 2008b), a factor that this study did not consider. Additionally, the sample of this study was completely comprised of adult learners whose mean age was 21 years old. Pintrich and Zusho (2002) suggest that students' capacity to use SRL is, in part, related to their development. This current study did not account for either the role of development or prior domain. Furthermore, the sample included all education majors, many of whom may be more motivated by the CBL and educational experiment context. Taken together, the potential limitations of this study suggest that research examining motivation in the context of hypermedia learning should account for prior domain knowledge, developmental level, and the sample composition.

Third, this line of research would be furthered by also considering motivation in the context of surface and deep learning. Traditionally, deep learning has been correlated with intrinsic motivation, while surface learning has been related to extrinsic motivation. How might this relationship unfold within the context of self-regulated learning with hypermedia? Previous research would suggest that those learners with high extrinsic motivation would engage in SRL processes associated with surface level learning, such as memorization. In turn, the use of this learning strategy might result in high performance on a posttest, but at a surface level. Conversely, it would be hypothesized that a learner who is intrinsically motivated would engage in SRL processes that are associated with deep learning, such as making inferences and drawing. Future research would be well served to consider a context that includes surface versus deep learning, potentially in the context of transfer of problem solving skills within the context of hypermedia learning.

Fourth, research examining the effect of extrinsic and intrinsic motivation on hypermedia learning should consider Lepper's original work on the overjustificaiton hypothesis (see Lepper & Greene, 1976). This line of research noted that participants should be able to engage the target materials within the most authentic setting possible (i.e. intrusion of research personnel is limited or, if possible, nonexistent). Lepper and Greene (1976) suggested that the most valid method of measuring intrinsic motivation is to eliminate extrinsic contingencies. This approach calls for collecting data in authentic settings (i.e. hypermedia learning in classrooms settings without disruption of normal classroom schedules), and no contact between the research personal and the participants (i.e. observational data collected behind one-way mirrors). The logistics of this approach were not feasible for this current study, but future research should consider using this methodology.

Fifth, a variety of theoretical frameworks have been used to explain how students process information with hypermedia. In addition to SRL theory, research has also used the Cognitive Load Theory. This line of research has identified that the design of hypermedia may lead to extraneous cognitive load (Gerjets & Scheiter, 2003; Kester, Kirschner, & van Merriënboer, 2005). Researchers have suggested that developing conceptual understanding from multiple representations, such as text and diagram, may overload the visual subprocessor in working memory (Mayer & Moreno, 2003; van Merriënboer & Ayres, 2005). Furthermore, research has used the Cognitive Load Theory to explain why animations do not always facilitate learning (Ayres & Pass, 2007). However, there currently is a paucity of research that has used process data to examine the relationship between cognitive load, use of SRL processes, and various theoretically grounded constructs of motivation.

Appendix A. SRL Coding Scheme: Macro-Level SRL processes (in bold), micro-level SRL processes (in italics), and examples (modified version from Azevedo et al., 2005).

Variable	Description[a]	Example from participants
Planning		
Prior knowledge activation	Searching memory for relevant prior knowledge	Reads: "*Their primary function is to carry oxygen from the lungs to every cell in the body.*"Umm, red blood cells are red because the oxygen reacts with iron in the blood and um, which makes it rust, turn red."
Recycle goal in working memory	Restating the goal (e.g., question or parts of a question) in working memory	"…what does blood do when it leaves the left side of the heart?"
Goal setting	Articulating a specific sub-goal that is relevant to the experiment-provided overall goal	"I want to learn more about red blood cells."

(*continued on next page*)

Appendix A (*continued*).

Variable	Description[a]	Example from participants
Monitoring		
Monitoring environment	Stating that text, diagram, or video is relevant and/or irrelevant	[Learner reads about the function of the lungs] "That section was really helpful…just what I needed."*Or*" I'm looking at this section, but it is just not helping me…"
Monitoring Understanding	Indicating a level of familiarity with content in the environment. Also, includes indications of the extent to which there is an understanding of what was just read/seen in the environment.	"Oh, I already read that. "*OR*"Wait, I have not looked at this before…""Okay, I am getting this…this makes sense."*Or*"Wait, I don't understand what this is saying…"
Monitor progress toward goals	Assessing whether previously-set goal has been met	"Yeah, I think I met all the goals for this task."
Monitor use of strategies	Commenting on usefulness of strategy	"I am going to take notes now, 'cause that really helps me with stuff I don't know."
Strategy use		
Coordinating informational sources	Coordinating multiple representations (e.g., drawing and notes)	"I'm using the text with this picture of the heart."
Drawing	Making a drawing or diagram to assist in learning	"…I'm going to draw the path of blood through the heart."
Inferences	Drawing a conclusion based on two or more pieces of information that were read within the same paragraph in the hypermedia environment.	Reads: "*Hypertension is elevated blood pressure, develops when the* blood- *body's blood vessels narrow, causing the heart to pump harder*… "Which I'm guessing could cause a heart attack."
Knowledge elaboration	Elaborating on what was just read, seen, or heard with prior knowledge	Reads: "*Heat dissipates through the skin, effectively lowering the temperature.*"Like a car radiator."
Memorization	Memorizing text, diagram, etc.	"Arteries, away, arteries, away…trying to memorize this…"
Re-reading	Re-reading or revisiting a section	"I'm reading this again."
Reading notes	Reviewing notes	"Going look over my notes now…"
Summarizing	Verbally restating what was just read, inspected, or heard in the hypermedia environment	"This says that white blood cells are attack foreign bodies."
Taking notes	Writing down information	"I'm going to take notes on this stuff…"

[a] All codes refer to what was recorded with the think-aloud protocol.

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