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Domain-specificity of self-regulated learning processing in science and history

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ABSTRACT

As computer-based learning environments grow in prominence, so do the demands placed upon students to learn with these tools. Empirical research has shown that students who are effective at self-regulating their learning are more likely to acquire deep conceptual understanding while using these environments. However, there is a noticeable lack of research into the degree to which self-regulated learning (SRL) is domain-specific. Investigating this theoretical question about domain-specificity results in related questions about how to best capture and model SRL. To address these concerns, we randomly assigned college students to either a science or history digital library, and used think-aloud protocol (TAP) data to examine the degree to which SRL processing predicted knowledge gains, above and beyond the effects of prior knowledge. We examined multiple methods of aggregating SRL TAP data into analysis variables, to determine which would be the most predictive of learning gains, and then tested these findings using a sample from a second study. In addition, we tested whether the frequency of SRL processing differed by academic domain. We found that data-driven aggregation methods were the most effective at predicting learning gains, and that there were both intriguing similarities in SRL processing across domains (e.g., the importance of corroborating sources) as well as differences (e.g., the predictive validity of self-questioning). Our findings have implications for how to capture and model SRL processing, as well as how to foster SRL among those students who do not yet enact it effectively on their own.

1. Introduction

The idea that today's students are "digital natives" (Palfrey & Gasser, 2008; Prensky, 2001) who are naturally adept at using computers to learn is, frankly, false (Bennett, Maton, & Kervin, 2008; Kirschner & van Merriënboer, 2013; Selwyn, 2009). Unfortunately, while these students are often skilled at online browsing, gaming, and socializing, they struggle when using computer-based learning environments (CBLEs) to accomplish academic tasks (Borgman et al., 2000; Mervis, 2009; Nasah, DaCosta, Kinsell, & Seok, 2010). This disparity between society's expectations of these "digital natives" and the reality of their struggles is particularly concerning given the rapid proliferation of computers into primary, secondary, and post-secondary classrooms (Collins & Halverson, 2009). Within the scholarly literature, there is ample evidence that students' ability to enact self-regulated learning (SRL; Winne & Hadwin, 2008; Zimmerman, 2000) knowledge and skills is a key predictor of their success when learning with CBLEs (Azevedo, 2005; Greene, Bolick, & Robertson, 2010; Greene, Hutchison, Costa, & Crompton, 2012; Lajoie & Azevedo, 2006). SRL involves the active, thoughtful monitoring and control of a person's cognition, metacognition, motivation, and behavior. Numerous studies have identified SRL processes that are advantageous when learning with CBLEs, including judgments of learning and creating subgoals. However, the literature lacks empirical investigations of the degree to which SRL knowledge, skills, and behaviors are domain-specific (i.e., whether the predictive validity and utility of particular SRL processes vary across subjects, such as science, history, or literature). The existence of this gap, and the need to fill it, were stated clearly by Alexander, Dinsmore, Parkinson, and Winters (2011):

> Empirical research on SRL has not systematically or seriously regarded the potential effects of domains or domain-specific tasks on individuals' regulation of their cognition, motivation, or emotions…we hold that this lack of domain-specific attention within the SRL empirical research demands immediate and considerable attention if educational researchers are going to achieve a deeper understanding of the very nature of self-regulation and its role in human learning and development (p. 403).

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Increasingly, researchers have been calling for investigations of the domain-specificity, or contextuality, of learning processes such as SRL, motivation (King & McInerney, 2014) and epistemic cognition (Greene & Yu, 2014; Sandoval, 2012). We share these scholars' sense of urgency, but caution that such investigations must be conducted in ways that accurately capture the phenomena in question.

Although there have been a few investigations of the domain-specificity of SRL (e.g., Rotgans & Schmidt, 2009), these studies have relied upon retrospective, self-report SRL instruments. The numerous concerns about the accuracy (Winne & Jamieson-Noel, 2002) and utility (Veenman, 2005; Winne & Perry, 2000) of participants' self-report data call into question any findings based upon them. As an alternative, Greene, Dellinger, Tüysüzoğlu, and Costa (2013) contended that researchers should utilize concurrent measures (Winne & Perry, 2000), such as think-aloud protocols (TAPs; Ericsson & Simon, 1993), to study SRL, and in particular to investigate the degree to which SRL depends upon the domain, task, and environment. However, concurrent measures such as TAPs pose two challenges. First, they are resource-intense in terms of data collection and preparation (Greene, Robertson, & Costa, 2011). Second, TAPs produce large amounts of data that can be challenging to analyze and understand. Therefore, the theoretical research question regarding how SRL varies, or not, by domain is matched by an equally important methodological question regarding how to conduct this work in a way that is both feasible and accurate.

We responded to the theoretical question about the domain-specificity of SRL posed by Alexander et al. (2011) by randomly assigning college students to either a science or history digital library. Given the paucity of research on domain-specificity in SRL, multiple studies, using both between- and within-subjects designs, are needed. In this work, we utilized a between-subjects design where each participant engaged in a single, relatively long learning task (i.e., 30 minutes), to increase the likelihood that participants would have sufficient time to go through the various phases of SRL (e.g., task definition, goal setting, studying, adaptation; Winne & Hadwin, 2008). To study the relationship between SRL and learning within each domain, and to compare participants' SRL across domains, we chose comparable learning tasks and assessments that required the acquisition of both declarative and conceptual knowledge of the content.

Our research also required the development and investigation of new methodologies for preparing and analyzing large amounts of SRL TAP data. We compared Greene and Azevedo's (2009) SRL TAP data preparation and analysis methodology to Greene et al.'s (2013) methodology to determine which best predicted learning in each of our academic domains. Then, we conducted a partial replication of these methodologies with a different sample, to further investigate their predictive validity. Our methodological findings, as well as our findings regarding the domain-specificity of SRL that emerged from those methods, have implications for theory and future research. Our findings also have implications for the design of SRL interventions within and across academic disciplines (Bembenutty, Cleary, & Kitsantas, 2013).

2. Literature review

2.1. Managing learning in computer-based learning environments

CBLEs have a number of important affordances, including the ability to present vast amounts of sometimes abstract information in multiple, non-linear ways that users can control themselves (Azevedo, 2005; Jacobson & Archodidou, 2000; Mayer, 2005). For example, one of the CBLEs utilized in this study, the National Science Digital Library (NSDL), provides a comprehensive, curated network of text, image, interactive, simulation, and video based resources related to a variety of science topics. Digital libraries share the affordances of CBLEs, while also benefitting from curators who verify the accuracy and utility of the resources. By integrating the myriad of resources typically available via CBLEs, students can develop deep understandings of content in science, history and other academic domains (Azevedo, Johnson, Chauncey, & Burkett, 2010; Greene, Costa, Robertson, Pan, & Deekens, 2010; Koedinger, Aleven, Roll, & Baker, 2009).

However, researchers have also shown that students struggle to learn with CBLEs, because they have difficulty coordinating multiple representations of information into coherent understanding, as well as trouble differentiating the relevant from the salient but irrelevant information (Ainsworth, 2006; Liu & Hmelo-Silver, 2009). These tasks can overwhelm working memory capacity and lead to cognitive overload, specifically high mental load (Baddeley, 2001; Gerjets, Scheiter, & Schuh, 2008; Moos, 2013; van Merriënboer & Sweller, 2005).

2.2. Self-regulated learning

Researchers have shown that students who enact effective SRL processes are far more likely to overcome mental load and acquire deep conceptual understanding from CBLEs than those who do not (Azevedo, 2005; Azevedo, Guthrie, & Seibert, 2004; Azevedo, Johnson et al., 2010; Azevedo, Moos, Johnson, & Chauncey, 2010; Greene, Costa et al., 2010; Greene et al., 2012; Greene, Moos, & Azevedo, 2011; Jacobson & Archodidou, 2000; Koedinger et al., 2009; Lajoie & Azevedo, 2006). Although multiple frameworks exist, there is general consensus that SRL is a process where learners actively set goals for learning, and then monitor and control their behavior toward achieving those identified learning goals (Pintrich, 2000; Winne & Hadwin, 2008; Zimmerman, 2000). Winne and Hadwin's (2008) model of SRL has four phases: task definition, planning and goal setting, studying tactics, and adaptation. During task definition, learners develop an understanding of what the learning task will require of them. Learners then create benchmarks or goals to guide and monitor their learning progress during planning and goal setting. Learners engage the use of various tactics (e.g., taking notes, summarizing, or corroborating sources) in order to achieve their desired learning goals during the third phase. Finally, in the adaptation phase learners reflect on their learning decisions, progress, and success to make critical decisions about what actions to take next. Additionally, self-regulating learners will assess the effectiveness of the various strategies and behaviors that they enacted, to inform their own knowledge about how to be a more adaptive learner.

Winne and Hadwin (2008) asserted that as learners move through these phases, they utilize metacognitive monitoring and control to make learning decisions. The metacognitive monitoring process occurs when learners compare learning products or outcomes to their goals. Depending on the progress indicated by this comparison, learners may make adaptations, such as creating new goals, changing strategies, or even adjusting their knowledge about the effectiveness of strategies they have used.

2.3. Domain specificity in self-regulated learning

Despite the large body of SRL scholarship, researchers have conducted few empirical investigations into how SRL processing might vary across learning domains, contexts or environments (e.g., how planning, strategy use and monitoring may, or may not, differ across science and history CBLEs; Alexander et al., 2011). This leaves a particularly interesting gap in the literature, as a number of SRL researchers (Alexander, 1995; Boekaerts, 1999; Greene et al., 2013; Poitras & Lajoie, 2013) have asserted that SRL processing likely has significant domain-specific aspects. For example, Poitras and Lajoie (2013) have presented a conceptual argument that incorporates