Using Technology-Rich Environments to Foster Self-Regulated Learning in Social Studies

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Abstract

In this chapter, we discuss contemporary research on domain- and task-specific self-regulatory processes in the context of the social studies. Considering the dynamic nature of historical thinking, and how learning unfolds throughout the course of studying multiple and often conflicting or unreliable sources of information, the importance of regulatory processes becomes apparent. We begin by conceptualizing how students monitor and control their own learning. Given the inherent challenges faced by learners in the context of historical reasoning, we detail the design of scaffolds embedded in technology-rich learning environments, including adaptive hypermedia and tutoring systems that can assist learners in this domain.

Keywords: social studies, technology-rich learning environment, domain-specific, task-specific.

Using Technology-Rich Environments to Foster Self-Regulated Learning in the Social Studies

The self-regulation of learning in history is an emerging area of research in the field of social studies education. The goal of self-regulated learning (SRL) research is to identify the cognitive, metacognitive, affective, and motivational processes that underlie learners' efforts to reconstruct the past along with the instructional strategies that can be used to enhance learning and task performance. The challenge facing educators and students in history classrooms is to engage in analytical skills to reason and gain better understanding of the past, drawing inferences on the basis of available and reliable evidence as opposed to memorizing lists of facts and dates (Donovan, Bransford, & Pellegrino, 1999). The seminal works by Wineburg (1991, 1994) highlight the nature of novice-expert differences in historical reasoning and document the complex interplay of cognitive skills involved in evaluating the credibility of historical sources, corroborating information from multiple accounts, and making inferences based on the available evidence and one's own prior knowledge. Considering the dynamic nature of historical thinking, and how learning unfolds throughout the course of studying multiple and often conflicting or unreliable sources of information, the importance of regulatory processes becomes apparent. From an educational perspective, we consider it essential to situate SRL development and instruction in the context of these disciplinary-based practices.

In a review of the terms metacognition, self-regulation, and SRL within contemporary research, Dinsmore, Alexander, and Loughlin (2008) allude to theoretical frameworks that inform the study of these constructs. Although the definition and measurement of each construct is often inconsistent across studies, researchers typically distinguish between information-processing models (Winne, 2001; Winne & Hadwin, 1998, Winne & Perry, 2000) and social-

cognitive models (Pintrich, 2004; Schunk, 2005; Zimmerman, 2001) of self-regulation in academic studying and other forms of learning. SRL emphasizes the dynamic nature of skills, attitudes, motivations, and contextual factors involved in these settings, and attempts to explain individual differences in learning outcomes as well as how to improve learning and performance. For a more detailed discussion of these theoretical frameworks, we refer the reader to Winne as well as Usher and Schunk (Chapters 2 and 3, this volume). This chapter compares the different ways in which SRL has been defined by educational researchers in the area of social studies. In particular, the relationship between self-regulatory processes and historical reasoning is examined under the information-processing view of SRL. To date, there are few studies that have investigated the domain-specificity of SRL (Alexander, Dinsmore, Parkinson, & Winters, 2011). While some research has been carried out on students' ability to regulate their learning as well as the role of technology in facilitating SRL in the social studies, there is still very little scientific understanding of how these factors mediate their understanding of the past.

In this chapter, we discuss technology-rich learning environments (TREs) designed to support or scaffold students to gain a deeper understanding of the past that would otherwise be beyond their reach. We critically examine recent empirical evidence on the design of scaffolds in TREs such as hypermedia-based environments and intelligent tutoring systems to promote SRL. In doing so, scaffolds embedded in TREs are progressively faded as students become more competent in regulating certain aspects of their own learning (Lajoie, 2005; Lajoie & Azevedo, 2006). The past two decades has seen rapid developments in scaffolds embedded in TREs designed as metacognitive tools to promote SRL (Azevedo & Aleven, 2013; Quintana, Zhang, Krajcik, 2005; Moreno & Mayer, 2007), and reviews such as that conducted by Reiser (2004) differentiate between structuring and problematizing certain aspects of learning and task

performance. On the one hand, learning tasks can be structured to help students by reducing or sequencing the amount of choices to make, providing guidance and cues, and facilitating performance through external representations. On the other hand, tasks can also be made more problematic to challenge students to construct their knowledge by addressing issues or gaps, thereby providing them with opportunities for meaningful learning to occur. The theoretical assumptions that guide the design of metacognitive tools are described in the next section.

Relevant Theoretical Ideas Underlying Their Topic

Alexander and colleagues (2011) reviewed the SRL literature to identify the domains under investigation and whether the choice of domain or task was purposefully defined or manipulated to address a particular research question. Very little research addressed the question of whether SRL may be affected by task or domain differences. The majority of the 77 empirical studies included in the review did not identify any particular academic domain or task and its relevance to specific SRL processes. The most popular disciplines reported in empirical studies on SRL included the areas of science, psychology, as well as teaching and instruction. An implication of this finding is the possibility that the nature of the task performed in a specific domain such as the social studies, along with the learners' prior knowledge of disciplinary-based practices is often overlooked in the research literature.

Only in the past five years have studies of SRL directly addressed how disciplinary-based practices in the social studies affect learners' ability to regulate certain aspects of their own learning. The first systematic study of SRL in the social studies was conducted by Greene, Bolick, and Robertson (2010). Learners' use of SRL processes were assessed in addition to the resulting knowledge of study tactics or strategies used in history as well as gains in declarative knowledge (Greene, Bolick, & Robertson, 2010). Historical thinking skills were assessed as the

students' ability to evaluate multiple sources, arrange events in the order of their occurrence, and come to an understanding of how a historical narrative might include multiple perspectives of the same event. The deployment of historical thinking skills was later examined throughout learning and task performance as a form of cognitive operation defined in accordance to information-processing models of SRL (Greene, Bolick, Jackson, Caprino, Oswald, & McVea, 2015; Poitras & Lajoie, 2013). From this perspective, historical thinking itself can become a topic of cognition, enabling students to allocate cognitive resources towards monitoring and controlling its products and appraising the amount of efforts required to achieve certain standards. For instance, students might investigate the causes of an historical event by asking appropriate questions, formulating an explanation, and evaluating the trustworthiness of sources while gathering, corroborating, and making sense of conflicting accounts. Another significant aspect of these domain-specific strategies is their interrelationships with students' understanding of the task and their efforts to set goals, monitor their progress, and adapt their approach in response to changing task conditions. In the following section, we describe the phases of SRL as outlined in the three-phase model of cognitive and metacognitive activities in historical inquiry (CMHI), a model that characterizes disciplinary-based practices in history.

Defining the Task. Learners consider a learning task based on the resources that are available to them and any relevant constraints that will impact their performance. These considerations may be internal or external to the learner. Internal considerations refer to learner's knowledge of the historical time period or historiographical practices, as well as their motivation to pursue learning in this area. External factors may refer to the amount of time available to pursue the task, access to more knowledgeable peers or other sources of information, the nature and content of each informational source and whether or not learners were in control of their

learning goals. Historical evidence is often incomplete, unclear, or even contradictory, and the practice of history necessitates learners to continually re-define these task conditions as new evidence emerges, which leads them to re-evaluate their understanding of an event (VanSledright & Límon, 2006).

A student learning about the sinking of the RMS Titanic, for instance, might begin by reading a firsthand account of the circumstances surrounding the events of the night of April the 14th, 1912. Although an iceberg reportedly sank the Titanic, the historical account raises several questions, amongst which is the reasons why the tragedy occurred. An inquiry into the causes of the event and one's own emerging understanding is constrained by the factors mentioned above, and most importantly access to primary and secondary sources to support or refute plausible explanations. These explanations may include, but are not limited to the high concentration of icebergs due to climate, thermal inversion refracting light and camouflaging the iceberg, the ship's high travel speed, failure to deliver an ice warning message to the bridge, the use of wrought iron rivets instead of steel rivets. The writing of an historical narrative is often the end result of the inquiry process, although narratives themselves vary substantially in terms of their audience, structure, and criteria for assessing quality (Voss & Wiley, 2006).

Planning. Learners begin to write an historical narrative by stating and refining goals into sub-goals. During the course of learning, learners may revisit or change their goals when they realize there is insufficient time to meet them or that they need more support to attain their goals. Planning is a complex process where learners progressively define the desired end result of the task, determine what level of achievement is suitable, identify the relevant knowledge that must be gained, and reflect on what steps must be taken to solve a problem.

As an example, learners may encounter an important event that occurred in an historical account. However, the account fails to mention any information pertaining to the causes of that event. Learners would likely begin their inquiry into the causes of an event by formulating a tentative explanation, which consists of an argument in favor of a specific cause (e.g., Frederick Fleet, a crewman and lookout, failed to spot the iceberg that sunk the Titanic since he forgot his binoculars). As the learners make progress and use strategies to analyze historical documents, their understanding of the event becomes progressively more coherent. They might consider the role of multiple causes and weigh alternative factors in their explanation of an event (e.g., Frederick Fleet, a crewman and lookout, failed to spot the iceberg due to an optical illusion caused by light refraction) or respond to counter-arguments (e.g., binoculars are not effective in the dark) by refuting or acknowledging such factors on the basis of evidence gathered from historical accounts. These different goal-setting activities (i.e., formulating an explanation, weighing alternative causes, and anticipating counter-arguments) are distinguishable in patterns of strategy use and the resulting products or changes made to a narrative.

Using Learning Strategies. Learners engage in task performance utilizing cognitive operations to make sense of information and transform it in a way that is conducive to their stated objectives. For instance, the information-processing model of SRL assumes several "primitive" operations that include searching, monitoring, assembling, rehearsing, and translating, fittingly labeled as SMART operations (Winne, 2001). These primitive operations underlie more complex strategies involved in the transformation of information in a manner conducive to enhancing learning, such as generating inferences or elaborating information based on prior knowledge (Azevedo, Moos, Greene, Winters, & Cromley, 2008; Greene & Azevedo, 2009). In the CMHI model of SRL, learners rely on a range of domain-specific strategies

deployed in a cyclical manner during learning while performing inquiries into the causes of historical events.

For instance, an argument in favor of a particular cause necessitates that learners gather evidence such as a direct quote taken from a document. In the case of the Titanic sinking, historical records may not be easily obtainable or complete, for instance weather records of that time period, survivors' testimonies, as well as ships' logs may not be readily available to learners. Consider the following firsthand account provided by Dr. Washington Dodge, an eyewitness of the sinking of the Titanic on April 15th, 1912.

> *"[…] The ocean as calm as the waters of a smooth flowing river we rowed off to overtake a boat having a lantern aboard, we being unable to find one in our boat - Having rowed about ¼ mile we found ourselves in close proximity to five boats - We observed the closing incidents the gradual submergence of the ship forward – […] From this time until shortly after 4 in a sea gradually growing rougher a temperature extremely cold we rowed about – Observing in the darkness what first appeared to be a ship full rigged, but to our disappointment proved to be an ice berg about ½ mile distant […]"*

Learners may evaluate a document such as this firsthand account as being a credible source of information by taking into consideration the author's reasons, perspectives, and opportunity for writing the account. The carelessness of Dr. Dodge's own handwriting for instance may be suggestive of his state of mind, writing a firsthand account of the sinking within days after the disaster. The evidence itself may be corroborated by other accounts, which requires the learners to coordinate multiple sources of information. A critical factor in reconciling these different historical accounts is the learners' ability to situate the documents in the time and place of their creation and imagine themselves in the context of the event as it unfolds to understand the values

and perspectives of historical figures. This set of historical thinking skills enable learners without any prior knowledge of an event to carefully re-construct its circumstances and build arguments as to the plausible causes that led to its occurrence.

Making Adaptations. Adaptations to historical understanding occur when learners evaluate their progress and determine that changes are needed to improve upon certain aspects of learning or task performance. These evaluations are complex and may be the result of (1) judgements about the adequacy of the sources they read in trying to meet their goals, (2) the effectiveness of specific strategies, (3) their emotional responses to certain aspects of the task, (4) their awareness of relevant prior knowledge and (5) emerging understanding of the topic. These learning experiences leads to re-organizing the retrieval and retention processes that characterize learners' procedural knowledge, thereby modifying future efforts to perform similar tasks. In particular, adaptations include experiences where learners' explanations are evaluated against standards of causality. In these evaluations, causality serves as a standard by evaluating whether antecedent events are logically followed by their consequents. In doing so, causal standards constrain learning through the need to organize and interpret information obtained from historical sources as a coherent chain of causes and effects.

For instance, learners' understanding of the causes of the Titanic sinking may settle on a primary factor (i.e., the lookout's failure to quickly spot the iceburg), while learners are unaware of the relevant conditions that enabled this event to take place (i.e., atmospheric conditions, high concentration of icebergs) or instead believe in the importance of irrelevant details (i.e., the lack of binoculars). Furthermore, the order of causation is another factor to consider while reflecting on one's own understanding. For example, is the time delay in reporting the iceberg a necessary condition for the sinking of the Titanic? What if First Officer Murdoch had not ordered a port-

around maneuver, would the Titanic still have collided with the iceberg with the bow veering port? What if steel rather than iron rivets were used? Would the hull have been capable of sustaining the damage? The time delay to report the iceberg may be a necessary condition for the event to occur, but there are also a number of sufficient conditions which are closest to, or immediately responsible for the outcome.

An interesting facet of adaptation is that as an explanation increases in its level of coherence, the nature of the argument shifts from the achievement of lower-order (i.e., confirm the most likely cause of an event) to higher-order goals (i.e., weigh alternatives or anticipate counter-arguments). The learners' inquiries into the causes of the event are performed until coherence in understanding the event is reinstated to a sufficient degree given learners' motivations, task constraints, and available resources. As such, the CMHI model of SRL characterizes the phases and cyclical nature of learners' ability to regulate certain aspects of their own learning while making inquiries into the causes of events in accordance with disciplinary-based practices in social studies. Having defined what is meant by the domain-specificity of SRL, we now move on to discuss recent empirical findings bearing on these notions and the role of TREs in facilitating SRL.

Research Evidence Bearing on These Ideas

TREs designed as metacognitive tools aim to model, track, and support learners' self-regulatory processes. In doing so, TREs may scaffold cognitive (e.g., goal-setting, learning strategies), metacognitive (e.g., feeling of knowing, judgement of learning, evaluation of understanding), motivational/affective (e.g., interest, confusion), and behavioral activities (e.g., defining task demands, engage in help-seeking behaviors) that mediate learning and task performance (Azevedo, 2005, 2008). There are several reasons why learners may fail to regulate

certain aspects of their own learning, i.e. when the learning environment lacks structure (Mayer, 2004), or learners lack the pre-requisite metacognitive knowledge (Veenman, Van Hout-Wolters, & Afflerbach, 2006), or that learners do not understand how to deploy self-regulatory processes during learning (Azevedo & Feyzi-Behnagh, 2011). Over the past decade, there has been an increasing amount of literature on the adaptive capabilities of TREs designed as metacognitive tools. Adaptive TREs provide scaffolds on the basis of the changing needs of each learner, fading assistance as individuals become proficient (Azevedo & Aleven, 2013). The following sections review recent empirical evidence on the role of TREs designed as metacognitive tools to foster SRL in the area of social studies, including hypermedia-based environments and intelligent tutoring systems.

Self-Regulated Learning in Hypermedia-Based Environments. Hypermedia learning environments enable learners to navigate through multiple sources of instructional content (i.e., text, animations, videos, sounds, and images) in a non-linear manner. The content is made accessible through hyperlinks that are embedded within each document, facilitating learners' efforts to access and manipulate relevant information (Jonassen, 1996). The most obvious finding to emerge from research on hypermedia is that multiple representations of complex topics may be helpful for learners, allowing them to access, transform, store, and revisit information in a convenient manner (Jacobson & Archodidou, 2000). However, the manner in which these representations are designed and delivered to learners is often problematic. Learners have limited attentional resources that can be allocated to assimilating and retaining information, and poorly designed representations often induce cognitive load (Baddeley, 2001; Mayer & Moreno, 2003). Furthermore, learners' prior knowledge of the topic or task may not be sufficient to allow them to effectively navigate through the content, resulting in cognitive disorientation

due to the large amounts of potentially irrelevant or tangential subject matter (Azevedo & Feyzi-Behnagh, 2011; Lajoie, 2014; Niederhauser, Reynolds, Salmen, & Skolmoski, 2000).

In a seminal study on SRL in history, Greene and colleagues (2010) asked high-school students to perform a think-aloud protocol while learning from primary and secondary sources (i.e., 5 text documents and 4 images) obtained from a larger collection about the Regulator Movement. The event in question occurred in the 1760s, and involved an uprising of residents in present day North Carolina who claimed that British colonial officials were engaging in corrupt and oppressive practices. Multiple-choice/true-false task and open-ended essays were used to assess prior and gained knowledge of the Regulator Movement that could be attributed to self-regulatory processes. The results obtained from the non-parametric analyses confirmed that students demonstrated modest gains in both declarative knowledge and the use of historical thinking skills while writing an essay about the Regulator Movement.

The most striking result to emerge from the data is that students often failed to engage in planning activities, preferring instead to rely on learning strategies and then monitoring their progress. However, a statistically significant relationship was found between planning activities and learning outcomes. Students who planned their efforts by setting goals and refining them into sub-goals obtained higher scores in declarative knowledge about the historical topic at the end of the learning session. In other words, these students were better able to recall correctly factual information regarding the event under examination because they set goals during learning. A small but non-significant effect was also observed with regards to learners' conceptual understanding and use of historical thinking skills while writing an essay.

Extensive research has shown that the ability to make inferences and elaborate on information by activating prior knowledge is necessary to improve learning about science topics

(see Greene & Azevedo, 2007). However, students were observed to rely most often on ineffective strategies while learning about history (i.e., taking notes, as well as searching and summarizing information or selecting new informational sources). They often mentioned experiencing difficulties while performing the task (i.e., self-questioning as well as negative judgements of learning and evaluation of the usefulness of content).

The present results are significant in at least two major respects. It may be the case that students would benefit from scaffolds that target goal-setting activities, supporting them to state and reinstate goals on a frequent basis during learning and task performance. Furthermore, students require extensive training on the use of learning strategies, in particular, elaborative processes that enable students to control their own learning. The study conducted by Greene and colleagues (2010) makes no attempt however to substantiate claims in regards to the impact of domain-related differences in SRL processes towards learning outcomes and whether the benefits of elaborative processing may be restricted to science-related topics. The evidence reviewed here seems to suggest an approach to SRL training that may be transferable to multiple domains, including both history and science topics.

The question of whether certain self-regulatory processes lead to gains in understanding key concepts and relationships across subject matter areas was further examined. Greene and colleagues (2015) conducted a subsequent study where college rather than high school students were randomly assigned to learn either about the Blue Ridge Parkway (i.e., history topic) or the phase change process as substances move from solids, liquids, and then gaseous states (i.e., science topic). The think-aloud protocol data was examined for the use of fine-grained SRL processes that were found to be predictive of learning gains in each discipline (Greene, Dellinger, Tüysüzoğlu, & Costa, 2013). The method involved the aggregation of effective and

ineffective SRL processes in coarse-grained descriptions that characterize the broad phases of SRL – planning, using strategies, and monitoring – to more accurately model their outcomes towards learning.

In doing so, college students were observed to engage often in strategy use rather than making efforts to monitor and plan certain aspects of their own learning, in a similar manner to the high-school students who learned about the Regulator Movement (Greene et al., 2010; Greene et al., 2015). College students did however plan their efforts and set sub-goals more often than high-school students while learning history, which may have contributed to the increase observed in declarative knowledge gains about the Blue Ridge Parkway. These results confirm our previous conclusion that students should be supported in their planning skills while learning from hypermedia.

The comparison of effective SRL processes observed while students learn either the history or science topics provides important insights into the design of adaptive hypermedia learning environments. Regardless of the domain of study, students who are able to search their memory for relevant knowledge, reinstate information from memory, elaborate on what was read with prior knowledge, memorize text, as well as monitor the time left to task completion were found to gain more declarative knowledge about the topic. In learning about history rather than the science topic, the ability to guess the content available in a source, monitor the effectiveness of strategies, and engage in self-questioning were positive predictors of scores obtained on posttest declarative knowledge measures. Finally, learning strategies that are exclusive to the history domain, referred to as historical thinking skills, are amongst the most underutilized strategies reported by students, but are nonetheless predictive of gains in declarative knowledge

(i.e., comparing sources to determine the accuracy of their content and inferring historical figure's perspective, thinking, and emotions).

Taken together, these studies support the notion that adaptive hypermedia-based environments should scaffold SRL processes in accordance with disciplinary-based practices. Researchers have noted the importance of demographic characteristics (i.e., high-school vs. college level) as well as the domain (i.e., history vs. science) towards students' self-regulatory processes. In particular, less-experienced students in history require scaffolds that support them in setting goals and using effective strategies to make sense of information while navigating through hypermedia. The design of scaffolds should also be sensitive to the domain under examination. Learning strategies that are specific to an area may be underutilized by less experienced students due to their lack of domain knowledge. While many SRL processes are transferable across domains, the effectiveness of specific learning strategies may also vary depending on whether students are learning about history or science topics. The problem of fostering SRL processes in accordance with disciplinary-based practices in students with low prior domain knowledge is examined further in the context of intelligent tutoring environments.

Self-Regulated Learning with Intelligent Tutoring Systems. Intelligent tutoring systems may be defined as any type of technology that adapts itself to the specific needs of different learners (Anderson, Boyle, Corbett, & Lewis, 1990; Greer & McCalla, 1994; Self, 1999). The adaptive capabilities of such systems are predicated upon comprehensive models and assessments of skills, emotions, and other factors that mediate learning and performance (Desmarais & Baker, 2012; Pavlik, Brawner, Olney, & Mitrovic, 2013). Shute and Zapata-Rivera (2012) list the main features of intelligent tutoring systems as follows: (1) the capability to capture information about learners using multiple sources of data; (2) the real-time analysis of

the data to make inferences about learners' progress; (3) the selection of the most suitable instructional content or strategy to support learners; (4) the delivery of instruction through the system interface. In doing so, the tutoring system may choose to sequence the order of tasks to be performed by learners or might intervene during task performance through hints, prompts, and feedback (VanLehn, 2006).

The MetaHistoReasoning tool was designed to support students in monitoring and controlling their own learning while performing inquiries into the causes of historical events (Poitras, 2015). Students learn about the circumstances in which a particular event occurred, such as the council meeting where the order to deport the Acadians was given by Governor Charles Lawrence at Halifax, in July 1755. However, the narrative excludes any information pertaining to the potential causes or contributing factors that led to the Governor to make his decision. Learners with low prior knowledge of the domain often fail to notice that gap in their understanding of the event and formulate tentative explanations (see Poitras, Lajoie, & Hong, 2012). The ensuing investigation into the causes of the event requires students to set goals, monitor their progress, and use disciplinary-based strategies to formulate their own explanations based on information obtained from primary and secondary sources. The MetaHistoReasoning tool was conceived as a modular system, wherein the first module completed by the students is designed to support skill acquisition (i.e., Training Module), while the subsequent one enables them to practice and refine these skills (i.e., Inquiry Module).

Poitras and Lajoie (2014) asked undergraduate students to learn with the MetaHistoReasoning tool and examined trace logs of user interactions as well as pre-test measures of domain knowledge and post-test measures of topic knowledge and historical thinking skills. In regards to the pre-test survey, students were unfamiliar with historical

practices in general, and did not know a lot about the topic under investigation (i.e., the Acadian Deportation). The examination of the topic knowledge assessments shows that students were moderately capable of recognizing statements and inferences drawn from the source documents. The analysis of the least and most elaborate essays written by the students also suggests a broad range of abilities in applying historical thinking skills. On the one hand, the written essays both argued in favor of the claim that the deportation was caused by the refusal of the Acadians to swear to the oath of allegiance on the basis of evidence gathered from the historical documents. On the other hand, the most elaborate essay also challenged the neutrality of the Acadians in the conflict with the British government, referring to specific quotations taken from primary sources and questioning the reliability of Governor Charles Lawrence as a witness due to his need to obtain the approval of the board members tasked with the administration of the colony. These findings suggest that students were able to apply historical thinking skills such as sourcing and gathering evidence to support either single or multiple causes while formulating an explanation.

The examination of the trace log data of user interactions with the Training Module identified student behaviors that predict the acquisition of skills deployed while regulating certain aspects of their inquiries into the causes of the event. In the Training Module, students recognized skills shown in examples by choosing amongst eight multiple-choice options. A logistic regression model of the correctness of their responses achieved 76.2% accuracy using a ten-fold stratified cross-validation procedure. The model suggests that historical thinking skills such as gathering, corroborating, and contextualizing evidence as well as using substantive concepts were the most difficult for students to correctly recognize from the examples. Students that spent more time to study and made more attempts to categorize an example were more likely

to incorrectly recognize the relevant skills. Furthermore, the amount of prior exposure to examples of a particular skill was found to predict the correctness of example categorizations.

In the Inquiry Module, students were expected to practice and refine these historical thinking skills while regulating their own learning about the causes of the Acadian Deportation. A series of decision rules were applied to the trace log data of learner behaviors to detect students' goal-setting activities and strategy use while performing inquiries into the causes of historical events. The results show that students performed on average only two lines of inquiries, where an explanation is formulated and revised based on information found by students while analyzing historical sources. The examination of the goals set by students while performing their inquiries suggest that they most often confirmed the most probable cause for the event under investigation, rather than weighing alternative causes or refuting counter-arguments. Furthermore, the strategies used by students to build their arguments also indicates several areas of improvement, most notably the need to elaborate or describe in full details the information used as evidence or explain their reasoning or the warrant that links the evidence to their claim. Furthermore, students should make more efforts to build their evidentiary base, which often included repeated mentions of the same factual statement, or facts that were noted as being contradicted by other accounts.

These findings suggest that intelligent tutoring systems that adaptively scaffold SRL processes should consider student motivation as well as task conditions when assisting students to use learning strategies in the pursuit of goals. Students pursued only a limited amount of inquiries into the topic and preferred to settle on the most likely explanation for the event under investigation, whether due to lack of time, the amount of evidence available, or low interest in the topic. This is especially important for enabling students to build a solid evidentiary base,

while prompts may be designed to support students in describing further the pieces of evidence and warrants of their arguments. The challenge is to design scaffolds that can efficiently support students in acquiring, practicing, and refining the use of these learning strategies, while at the same time allowing them to set meaningful goals for them to learn about different topics of interest. The following sections of this chapter elaborate further on these notions by suggesting educational implications while also making recommendations for future research.

Future Research Directions

These findings have significant implications for understanding and supporting SRL processes with TREs in social studies education. The scope of this chapter was limited to empirical research that relied on process measures to capture the deployment of SRL processes during learning and task performance. In particular, think-aloud protocols were used to assess learners' verbalizations of their own thought processes, which provides the basis for researchers to infer the onset of cognitive, metacognitive, behavioral, and affective states that characterize SRL (Greene, Deekens, Copeland, & Yu, this volume). Trace log data of learner behaviors were also used as observable indicators of SRL processes that may be informative of how they unfold during the course of learning (Bernacki, this volume). A more systematic approach would identify how events detected through each of these methods are similar or different, and whether the data provides common grounds for supporting theoretical claims. The issue of how think-aloud protocol data obtained by Greene and colleagues (2010, 2015) translates to observable indicators that can be analyzed by computers, and whether these same indicators are validated through alternative approaches is important to establish the validity, reliability, and practicality of assessment methods. These issues notwithstanding, additional research using controlled hypermedia manipulations (i.e., history and science subject matter) as well as analysis of finer-

grained constructs using process measures is needed to better understand the role of disciplinary-based practices within SRL frameworks.

One of the most important assumptions underlying the design of scaffolds in TREs is whether SRL processes can be externally supported by human or artificial tutors as well as tools and representations. We use the term scalable to refer to any scaffolds embedded in TREs that support SRL processes while taking into account topic, domain, and/or environmental considerations and are faded once the learners become more competent. Learners are hypothesized to progressively internalize SRL processes, leading them to become more autonomous and proficient in their own future learning. Scalable scaffolding solutions enable TREs to adapt the delivery of instructional content, prompts, and materials depending on the topics studied by learners, the domain under investigation, or other scaffolds made available in the learning environment. As researchers differentiate between SRL processes that are generalizable across domains and others who are situated in specific disciplines such as the social studies, we call on the broader community to establish common standards for scaffold design guidelines that take into consideration the role of these mediating factors.

Research into the domain-specificity of SRL is still in its infancy, but it raises important questions about the feasibility of designing scalable scaffolding solutions in TREs, and the challenges involved in replicating research to evaluate their effectiveness in fostering SRL. For example, a textbox designed to support learners in making inferences may be made available under specific experimental conditions (i.e., pre-defined groups of students with access to different hypermedia pages), while logging the written content for further analysis. A research and training platform that facilitates access to these datasets, interface plug-ins, databases of hypermedia content, and standardized log records stands to increase the feasibility of group-

randomized experiments of domain-related differences in SRL (Greene et al., 2015) as well as the scalability of models and scaffolds embedded in the system interface (Poitras & Lajoie, 2014). The issue relates to the broader impacts of how these findings translate to improved tool designs that foster the most effective SRL processes in specific tasks and domains, and how to make them widely available to the academic and educational community in a timely manner given the current state of the research literature.

Implications for Educational Practice

The findings obtained in recent empirical studies on SRL have several practical considerations for social studies education. Students have opportunities to practice how to regulate certain aspects of their own learning when it is necessary to perform a task such as solving a problem or answering a question. Teachers may ask groups of students to investigate questions and report their findings to the rest of the class. The open-ended nature of the task demands that students cooperate in terms of setting common goals, using strategies, and monitoring their progress while making sense of information obtained from an online collection of documents on the relevant topic. By problematizing the subject matter and challenging students, they have the opportunity to engage in meaningful problem-solving that results in SRL development.

As noted by Greene and colleagues (2015), an emphasis must be placed on supporting students to set goals and monitor their progress through external representations of such activities. This also provides opportunities for students to engage in disciplinary-based practices while regulating their own learning. In order to support students in acquiring such skills, teachers can explicitly model or verbalize these thought processes by explaining how proficient learners approach a similar task, and the strategies that are helpful in making sense of the past. The

teacher can also monitor the performance of each group by offering hints, answering questions, and making recommendations while students are searching for relevant information.

As was made evident in the empirical literature, software tools may serve as metacognitive tools by creating external representations that structure thought processes in a manner that promotes learning and task performance (Poitras & Lajoie, 2014). The same line of reasoning applies to the classroom environment, and ensuring that students have access to a variety of means to express and record their thinking as it evolves throughout the course of task performance is crucial to promote self-assessment and reflective practices. For instance, one of the students in each group may rely on a note-taking software or use sticky notes to evaluate what is known about the topic and what is unknown. Another student may keep track of the remaining time and list all the web pages that were visited by the group in order to set the search priorities and persist in finding relevant information. Periodically, teachers may inform each group to review the progress they have made so far, in order for students to re-adjust their efforts and correct mistakes. In this view, students encounter situations that are authentic and meaningful, enabling them express their own understanding and interests while monitoring their progress using external visualizations. The assumption is that with repeated exposure to such tasks, students internalize effective strategies that are articulated by the teacher, allowing them to be successful and autonomous learners in similar circumstances.

In conclusion, researchers can rely on TREs to serve as both research and training platforms to model and foster SRL in accordance with disciplinary-based practices. In the social studies, learners monitor and control their emerging understanding of historical events while reading firsthand and secondhand accounts (Poitras & Lajoie, 2013). Furthermore, the evidence suggests that the SRL processes that mediate successful learning may differ across disciplines,

such as social studies and sciences. These findings raise intriguing questions regarding the nature of SRL skills and the extent of their transferability across domains, tasks, and the role of prior knowledge regarding disciplinary-based practices. Research infrastructures can facilitate work in this area, raising the possibility of personalized learning solutions that implement scalable models and scaffolds to foster SRL within and across academic disciplines.

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