PERLS of Wisdom: Designing a Mobile Application to Support Self-Regulated Learning

Katlin Anglin
CACI
Alexandria, VA
katlin.anglin@caci.com

Jacquelyn Schreck
Quantum Improvements Consulting
Orlando, FL
jschreck@quantumimprovements.net

Eric Sikorski
Quantum Improvements Consulting
Orlando, FL
esikorski@quantumimprovements.net

Evan Scronce
Float
Morton, IL
escronce@gowithfloat.com

ABSTRACT

Teaching and learning can occur anytime and anywhere due to advancements in technology, such as the creation and proliferation of mobile devices. While convenient, online environments and mobile learning platforms must be designed to promote self-regulated learning (SRL) to ensure students get the most out of their experience. This paper provides an overview of SRL models and practical-design feature recommendations in pursuit of informing the design of mobile learning platforms that promote SRL. Design recommendations are presented within the *preparatory*, *performance*, and *appraisal* framework based on established research and experience developing the PERvasive Learning System (PERLS). Select examples from the PERLS platform are provided.

ABOUT THE AUTHORS

Dr. Katlin Anglin is a Human Factors Engineer at CACI. Katlin has experience in developing predictive models of human performance, data analytics, designing wireframes and mockups, and user research and testing in military contexts. She has supported projects for NASA's Extreme Environment Mission Operation, U.S. Army Research Laboratory, Combating Terrorism Technical Support Office, Advanced Distributed Learning, and Naval Air Warfare Center Training Systems Division. Katlin holds a Ph.D. and M.S. in Human Factors Psychology from Embry-Riddle Aeronautical University and a B.Sc. in Psychology from University of Central Florida.

Ms. Jacquelyn Schreck is a Human Factors Engineer Intern at Quantum Improvements Consulting. She has 4 years of lab and research experience in topics such as cognitive psychology, social psychology, and human factors psychology. Jacquelyn is pursuing an M.S. in Modeling and Simulation from the University of Central Florida and has a B.Sc. in Psychology.

Dr. Eric Sikorski is Director of Programs and Research at Quantum Improvements Consulting where he leads a team of Research Psychologists and Human Factors Engineers. He has managed a diverse portfolio comprising human performance and training technology development initiatives for military and interagency end users throughout the United States and internationally. Eric holds a Ph.D. and M.S. in Instructional Systems from Florida State University, an M.A. in Human Factors and Applied Cognition from George Mason University, and a B.A. in Psychology from Brock University.

Mr. Evan Scronce is director of experience design at Float. He designs enterprise web and mobile products, collaborates with industry-leading Fortune 500 companies and government agencies to concept, design, and develop award-winning experiences. Evan is recognized as an expert in user experience and enterprise product design.

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INTRODUCTION

Historically the domain of formal institutions, teaching and learning can now occur anytime and anywhere due to advancements in technology, such as high-speed internet and mobile devices. Using current technology, learners can access content and schedule learning at their convenience instead of attending regular classes on strict schedules. Key aspects of learning, such as retrieving information and interacting with faculty and peers, now reside at one's fingertips rather than solely within a brick and mortar classroom. While this technology offers a viable alternative to traditional models of instruction, it also requires greater discipline from the learner to self-regulate and become effective stewards of their own learning. Therefore, online and mobile platforms must be designed to promote self-regulated learning to ensure students get the most out of their experience and not fall behind.

Self-regulated learning (SRL) is broadly defined as directing one's own efforts to develop knowledge and skills rather than relying on others (e.g., teachers, parents, instructors) (Zimmerman, 1989). SRL consists of cognitive, motivational, and affective characteristics that play a role in how learners initiate, adjust, and sustain their learning habits in specific contexts (Zimmerman, 1986). SRL involves analyzing context and settings, managing goals and strategies, and knowing when to use those strategies. Additionally, metacognitive aspects need to be taken into account, such as the ability to monitor and accurately judge understanding of one's plans, goals, strategies, and context, while also monitoring and modifying personal motivation and affective states. Some contexts may require modification of cognition, metacognition, motivation, and affect. Extant literature has described several different SRL models in an effort to gain a better understanding of the strategies that successful students use to maintain motivation and direction while learning (Boekaerts, 1996, 2011; Efklides, 2011; Pintrich, 2004; Winne & Hadwin, 1998; Zimmerman, 1986, 1989).

Online learning environments have been created to support self-regulated learning. One, for instance, is MetaTutor, a system that incorporates learning strategies such as prior knowledge activation, goal setting, evaluation of learning strategies, integration of information across representations, content evaluation, summarization, note taking, and drawing. It also incorporates aspects related to metacognition like judgment of learning and goal monitoring(Azevedo et al., 2009). Similarly, Betty's Brain helps students with science by creating concept maps to be followed regarding goals, responsibility, and metacognitive processes (Vanderbilt School of Engineering, 2020). Crystal Island uses story-centric virtual spaces for knowledge and problem-solving skill acquisition, specifically for science and literary skills. The story-centric environment tests students' abilities in learning, engagement, and self-regulation (Azevedo, Taub, & Mudrich, 2015). This paper, however, leverages the research team's experience developing and testing the PERvasive Learning System (PERLS). PERLS is an open mobile platform that guides and mentors the learner by recommending content-on-demand. These recommendations are based on several factors including the learner's goals and expressed interests, expertise, schedule, media preferences, and behaviors, such as daily routines (Advanced Distributed Learning Initiative, 2020). The purpose of this paper is to recommend design features to promote SRL in mobile learning environments based on established research and PERLS project experience.

SRL Design Recommendations

Several theoretical models exist that describe the SRL processes and subprocesses that can inform technology-enabled learning application design. A pioneer of SRL, Barry Zimmerman, has provided multiple SRL models throughout the decades. The first SRL model provided a triadic, social-cognitive perspective (Zimmerman, 1986). Within the triadic

model, three factors affect a learner's self-regulation: behavior, environment, and self (i.e., the learner). *Behavior* regulates learning through self-observation, self-judgements, and self-reactions as the learner observes their performance and strategically adapts their learning process. *Environment* encompasses the learner choosing, creating, and modifying the setting for learning (e.g., eliminating noise, providing adequate lighting). The *self* consists of the individual's goal setting, aims, and objectives related to learning tasks. Metacognitive processes allow the learner to observe their learning and adapt their affective thoughts and feelings. Other models such as those from Boekaerts (1996, 2011), Pintrich (2004), Winne and Hadwin (1998), and Efklides (2011) have also significantly contributed to the current understanding of SRL. While the list of contributors to the SRL literature is by no means exhaustive, these models are the most relevant and widely utilized. As indicated by Panadero (2017), most SRL models have phases that can be subsumed under Puustinen and Pulkkinen's (2001) *preparatory*, *performance*, and *appraisal* SRL phases. The following section provides mobile learning application design recommendations to promote SRL according to the three phases and based on lessons learned during PERLS design, development, and testing.

Preparatory Phase

The preparatory phase of SRL involves getting ready for the learning experience through activities such as task analysis, planning, goal-activation, and goal setting (Panadero, 2017). Below are two preparatory phase strategies for promoting SRL based on PERLS research and development.

SRL recommendation: Incorporate a **goal setting** capability that breaks down bigger goals and allows learners to set attainable goals based on their skill level.

The beginning stage of SRL in every model includes the learner setting goals. Goal setting involves the process of deciding what the learner wants to accomplish, such as reading 10 pages a day or being able to read 150 words per minute. Features that allow users to set and visualize goals and priorities support the learner in establishing methods that are appropriate for the task and environmental setting. If the goals are overwhelming (e.g., higher-level goals not broken down in smaller chunks), the learner's self-efficacy will decrease, deterring the learner from continuing the learning process (Schunk, 1990; Zimmerman & Moylan, 2009). The PERLS platform allows learners to set goals and track their progress relative to those goals (see Figure 1).

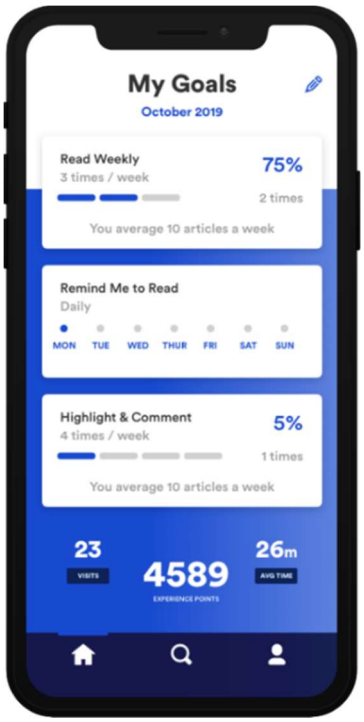

Figure 1. PERLS goal setting, tracking, and reminder schedule

SRL recommendation: Support the user in establishing **learning paths** by providing the learning objectives or goals, categorizing the content in a sequential order (e.g., from easier to more difficult), and/or providing information about the level of difficulty for each piece of content.

During the preparatory phase of the SRL, the learner performs a task analysis. The task analysis consists of the learner generating an understanding of the task by breaking the task down into smaller components. The goal of the task analysis is for the learner to establish meaning to the learning tasks, which will influence their goals and how they attempt to achieve them (e.g., Boekaerts, 2011). The learner's task analysis influences the learner's activities and strategy to accomplish a task. If the task analysis does not break the task down into manageable and accomplishable components, the learner will be unlikely to attempt learning the particular topic (Usher & Schunk, 2017). PERLS presents content as sequential, manageable components. Learning paths guide the learner through stages of content and milestones.

Performance Phase

The performance phase of SRL involves engaging in learning while monitoring and controlling performance progress (Panadero, 2017). Below are six performance phase strategies for promoting SRL based on PERLS research and development.

SRL recommendation: Include a **schedule notification** feature that prompts the learner to use the application and continue learning.

Time management encompasses the strategies to complete a task on schedule. Time management is considered a component of SRL because the learner must activate self-monitoring and self-control in order to achieve their learning goals (Pintrich, 2004). Time management includes setting specific task goals, estimating time requirements for those tasks, and monitoring progress in attaining those goals. For example, a learner must allocate extra studying time for topics that are more time-consuming and try to schedule studying time evenly across days (Barnard-Brak, L., Paton, & Lan, 2010). Features that allow the learner to set a time to study and provide reminders will support their ability to manage time. PERLS allows the user to set reminders, such as when to read (see Figure 1).

SRL recommendation: Allow learners to determine the **learning strategies** needed to achieve their goals.

Learning strategies may include taking notes, highlighting content, drawing tables or diagrams, re-reading, and/or summarizing content (Zimmerman & Moylan, 2009). Winne et al. (2006), for instance, developed SRL software that consists of a note-taking function that extracts key information. If specific text is unclear for the learner, the software has a function in which the learner can search for relevant information in the other content or web-based sources to increase understanding (Winne et al., 2006). These features provide learners with the ability to draw attention to the important information in the content and allows them to review the most meaningful information later. PERLS features note taking, highlighting, and tagging of information (see Figure 2).

SRL recommendation: Provide learners access to a **course repository** with topics and relevance of the information, allowing learners to choose their learning topics.

In order to engage in SRL, learners must self-initiate learning (Zimmerman, 1989). McCombs and Marzano (1990) suggest offering opportunities for learners to choose and actively participate in decision making, as well as providing materials and activities that stimulate curiosity through self-relevance, novelty, and challenge. A repository can promote the exploration and discovery of topics related to the learner's interests. It can also provide the learner with purposeful content and topics that support self-initiation of learning, especially for those that have difficulty identifying important topics. PERLS features a repository that allows users to discover new learning material and offers content based on the learner's interests as well as content that is new and/or trending (see Figure 3).

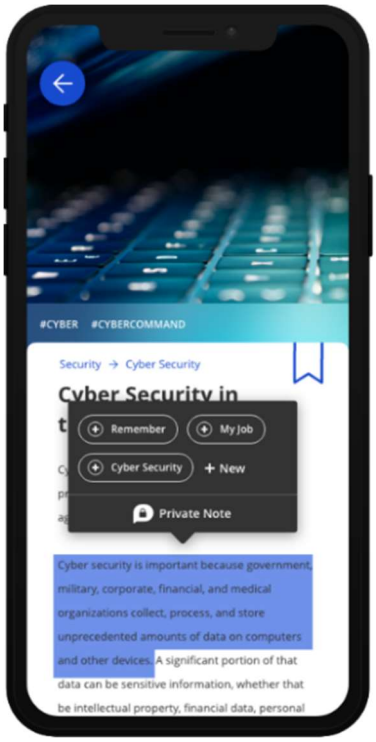

Figure 2. PERLS note taking, highlighting, and tagging

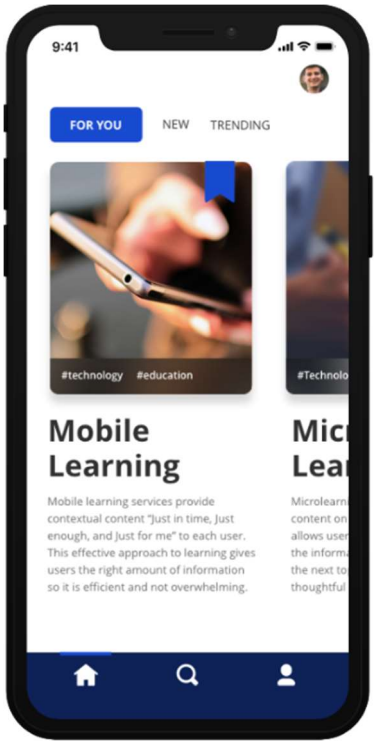

Figure 3. PERLS customized content

SRL recommendation: Include **social elements** to create a supportive social environment and allow the user to seek help.

Learners monitor their performance and understanding of information during SRL. If a self-regulated learner is having difficulty when learning, they seek help. Rather than having teachers and instructors identifying when a learner is struggling, the learner must: 1) determine if they need to seek help; 2) identify the type of help and who to ask for help; and 3) solicit, acquire, and decide whether or not the help provided resolved their problem (Karabenick & Dembo, 2011). Social elements allow the learner to engage in reflection with others, which in turn influences learning processes and beliefs for future efforts to learn. A supportive social environment may allow leaners to seek help, knowing that a strategy can lead to success (Kitsantas, Kavussanu, Corbatto, & Van De Pol, 2018). Features such as guided chats with a tutor or student, allowing for constructive critique and insight sharing, can be beneficial. The ability to follow other learners' progress, join communities, discuss projects and learning, post a question, have access to newsfeed and team competitions, and recommend content may also enable better sharing and social collaboration to support help-seeking behaviors.

SRL recommendation: Use **gamification** features, such as rewards, to encourage learner participation and achievement.

Kornell and Finn (2016) suggest that game elements promote SRL by creating high levels of motivation and engagement through curiosity, interest, competition, feedback, and challenge. Game elements promote situational interest that may morph into sustained personal interest (Nietfeld, 2011). For example, a learner may initially be motivated to complete learning modules in order gain points, then, over time, become more interested in the topic as they learn more, which can help sustain their engagement. Through gamification, learners are also able to self-monitor and reflect on their learning during SRL by comparing their performance against others. These elements include points, leaderboards, achievements/badges, levels, clear goals, feedback, rewards, progress, and challenge.

SRL recommendation: Provide opportunities for **self-assessment**, such as quizzes, that allow learners to check their learning progress.

Formative assessments are evaluations of learning or performance that occur during the learning process. Learners use these assessments to monitor their learning progress and compare it against a desired outcome (Clark, 2012). When students engage in formative assessments, they are gauging their own learning progression through self-monitoring and self-regulating their learning processes (Clark, 2012; Pintrich, 2004). These assessments should also provide reasoning for the correct/incorrect answer, which promotes learning opportunities and a better understanding of the content. PERLS offers quiz cards that allow the user to assess their own learning progress (see Figure 4). The quiz cards also provide reasoning for the correct/incorrect answer, which promotes learning opportunities and a better understanding of the content.

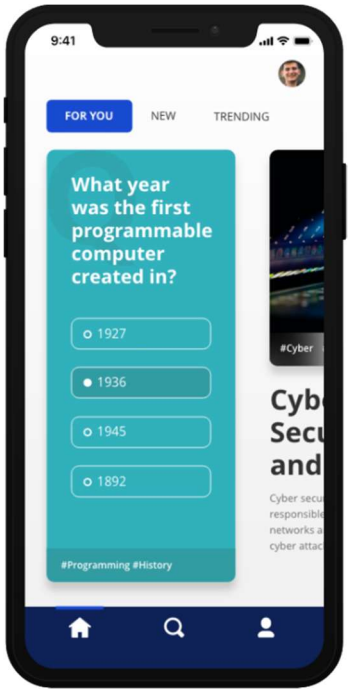

Figure 4. Quiz feature in PERLS

Appraisal Phase

The appraisal phase of SRL consists of self-reflection, self-regulation, and adaptation for future performances (Panadero, 2017). Below are two appraisal phase strategies for promoting SRL based on PERLS research and development.

SRL recommendation: Implement **performance analyses** and **visualizations** in the application to allow the learner to reflect on their learning efforts.

It is important that learners assess their performance and infer reasons for their success and/or failure (Zimmerman & Moylan, 2009). Learning applications should unobtrusively record students' methods of learning, such as the frequency and pattern of highlighting text, number of notes, and amount of social interactions. Capturing and reporting data such as assessment scores, the total number of times the course was accessed, when training was completed, activity participation, and time spent within a course is also beneficial. These records of learning can be mapped to their learning outcomes and help learners see which strategies work best for them.

SRL recommendation: Provide opportunities for **self-reflection**.

Self-reflection during SRL creates reactions that can influence how the learner approaches the task in later learning (Pintrich, 2004; Zimmerman & Moylan, 2009). Structured self-reflection can occur by identifying the strengths and weaknesses in their work when comparing it to relevant criteria or standards. Reflection can occur, for instance, before a task on milestones, on overall achievements and progress, and on the next stage of action. A metacognitive log, such as a diary or prompts, affords the learner the ability to monitor self-beliefs about competencies and progress, as well as reflect on their learning strategies and inner dialogue. PERLS allows learners to indicate whether they understood the content, which can be tracked by the system and reflected upon by the learner (see Figure 5).

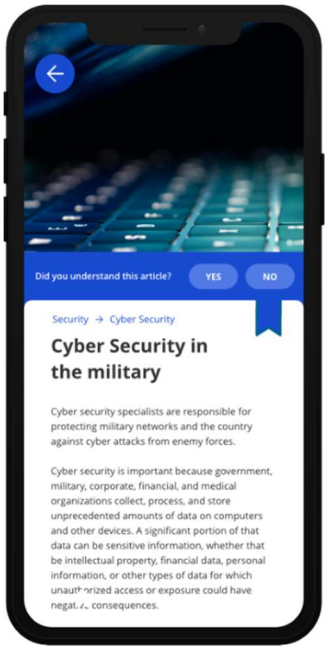

Figure 5. Self-reflection in PERLS

CONCLUSION

This paper provided practical design recommendations for designing online environments and mobile applications to support SRL. The recommendations are derived from extant literature and experience developing the PERLS application. While there are various SRL models in the literature, Puustinen and Pulkkinen's (2001) three phases of *preparatory*, *performance*, and *appraisal* provide a reasonable framework for organizing SRL theory into practical design recommendations. When it comes to the design of instruction, it is important to understand the learner and their proficiency level. For instance, taking into account how familiar the learner is with the tasks they need to complete, what their prior knowledge on the topic is, their ability to access the necessities of learning, and constructive responses and learning encouragement from the environment (Azevedo, Taub, & Mudrich, 2015). However, understanding the learner and tailoring content to address individual learning needs can be a significant challenge when a learning environment or application is being accessed independently by thousands of unique learners. Unable to receive individual attention, learners can quickly become lost in the content, fall behind on their progress, become frustrated, and eventually give-up. Designing learning environments and mobile learning applications based on the SRL recommendations above may be a way to ensure learners are getting the most out of their experience.

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