PERLS: An Approach to Pervasive Personal Assistance in Adult Learning

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ABSTRACT

Adult learners in both military and civilian settings increasingly use mobile devices for "Pervasive Learning" (Banavar et al., 2000; Thomas, 2007), which occurs without classrooms, instructors, and training facilities. By expanding options for what, when, and how we learn, Pervasive Learning has the potential to remedy stubborn deficiencies of traditional instruction. The central feature of PERLS is a virtual personal assistant that supports self-learning by sorting resources, supporting navigation through resources, and recommending specific learning episodes based on learners' interests, available time, and location. PERLS is intended to guide learners to resources located in both formal (closed corpus) and informal (open corpus) repositories. In this paper, we present the pedagogical design, user interface, system architecture, initial concept validation results, and field test for PERLS, a prototype PERvasive Learning System. The concept validation and field-testing take place in one civilian corporate context. The concept validation indicated that adult learners in the corporate setting favored limited use of "push" reminders to engage in learning and broader use of adaptive lists of content that have been intelligently informed by contextual data about their interests and available time for learning. Planned field tests will examine system functionality, usability, and impacts on self-learning habits around corporate onboarding content for new hires.

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PERLS: A Concept and Formative Evaluation of the Architecture for Pervasive Personal Assistance in Adult Learning

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A PERSONAL ASSISTANT FOR LEARNING

As public and corporate budgets decline for formal educational approaches to adult learning, research focuses on using technology to improve the efficacy of self-directed learning, or "self-learning," (Collins & Halverson, 2010; Kay & Kummerfled, 2010; Redecker et al., 2011). Without a human guide, it can be daunting to know which formal and informal resources and experiences will best address personal knowledge gaps or build confidence in a new learning domain. In practice, good mentorship that provides such guidance is the exception. Adult learners are generally on their own.

We are designing and testing an architecture that addresses this "missing mentor" problem by building on advances in intelligent virtual assistant technology and the widespread adoption of mobile, context-aware devices. The system offers the possibility of providing self-learning assistance that is always available and scales to large learner populations. Our system is delivered on a mobile phone through an interface that provides adaptive navigation of a corpus of learning resources (Brusilovsky & Nejdl, 2005) and a persuasive recommendation framework that fosters the self-learning skills of planning, reflection, and social learning.

Called PERLS (PERvasive Learning System), our system is a prototype learning platform developed under the Advanced Distributed Learning (ADL) Personal Assistant for Learning (PAL) program. PAL aims to offer the highest quality learning and performance support that can be tailored to individual needs, and delivered cost effectively at the right time and at the right place. It seeks to develop an architecture that brings together diverse learning resources and tracks the learner experience intelligently to recommend personalized learning pathways.

PERLS combines anytime/anywhere content delivery with a context-aware personal assistant. The personal assistant is intended to help typical learners make choices and take actions that strong self-learners use to improve learning outcomes. In its prototype phase, PERLS is intended to support lifelong (or at least employment-long) learning for members of large organizations where the need to support learning is high, some capacity to invest in it exists, and there is concentration of personnel to support social learning and aggregate data analysis. Users would ideally be given access to PERLS at the inception of their employment when learning need is especially high.

PERLS differs in important ways from content-focused technologies such as cognitive tutors. Cognitive tutors use technology to automate and personalize formal instruction in academic domains. By contrast, PERLS might recommend content offered through a cognitive tutoring application. PERLS aims to automate and personalize the kind of mentorship that supports self-learners' decision-making about what to study and when in multiple domains. It is our view that, no matter what the content area, adult learners can benefit from approaching learning in a disciplined way that is informed by improved awareness about the resources and time they have available.

The focus of this paper will be on identifying the requirements and design of a PERLS virtual personal assistant that facilitates self-learning. In this paper, we summarize the literature on self-learning, the PERLS concept, the results of a concept validation study, and plans for field-testing. The concept validation has informed the PERLS user experience design around two key learner behaviors: The decision to engage in learning, and the selection of appropriate and compelling content. The field-testing will inform the PERLS user experience design and engineering, while testing the impacts on self-learning awareness and engagement. The PERLS assistant contains three sets of software services: context awareness, persuasive recommendation, and presentation logic.

SUPPORTING ADULT SELF-LEARNING

Challenges to Self-learning

To enhance adult self-learning, we focus on addressing the most important challenges faced in improving self-learning goals: finding time and knowing how to assess one's progress so as to inform next steps in learning.

The time limitations surrounding adult learning are clear in the literature. Adults engage in learning in a range of contexts—work, community, and classrooms. It involves a mix of both self-directed and expert-directed experiences, and it occurs relatively regularly, on average about 2 hours a day (Livingstone, 1999; Tough, 1971). Research indicates that most adult learning is self-directed and occurs in urgent, time-pressed conditions in informal and incidental ways rather than in extended, mentored conditions similar to school-based learning. Little empirical research indicates how effective much of this hurried adult learning is. For assessment, adults may seek out and rely on external authority figures to judge the quality of their self-directed learning or they may cultivate habits of reflecting on their performance and generating new learning goals (Graves, Rauchfuss, & Wisecarver, 2012; Marsick & Watkins, 2001). This review indicates that the context of adult learning poses problems of time constraints and urgency around short-term learning goals, and finding available time to study and reflect to inform longer-term learning.

In addition to these high-level challenges of adult learning, past research identifies a raft of social and motivational threats to self-learning. Studies of self-regulation in classroom and workplace settings note that surrounding social influences strongly impact learners' decisions to abandon learning (Kuhl, 2000; Marsick & Watkins, 2001).

Finally, studies of schoolchildren indicate that self-learning skill is not a trait that presents itself consistently; rather, learners may be attentive and focused in one environment or in one subject area, and distracted and disinterested in others. In sum, it is a malleable skill that may be influenced positively.

Positive Supports for Self-Learning

Meta-analyses of programs that teach schoolchildren how to regulate self-learning indicate they are effective to the extent that they make learners aware of strategies relevant to specific learning situations (Hattie, Biggs, & Purdie, 1996; Rosenshine, Meister, & Chapman, 1996) and help them apply these strategies as a matter of habit. Research on self-learning identifies several activities of special importance in achieving good learning outcomes: [1] use of *metacognitive strategies* that include orienting oneself before starting on a new task, collecting relevant resources, self-monitoring comprehension, and self-assessing progress; [2] use of *motivation strategies* that include setting the scene for learning, assigning value to a learning activity, getting started, and sustaining effort until task completion; and, [3] use of *volitional strategies* that include negotiating local social settings and changes in surrounding learning context that affect the learning process (for review, see Boekaerts & Cascallar, 2006 and Graves, Rauchfuss, & Wisecarver, 2012).To address the threats to self-regulation, it is key to develop *coping strategies* to reduce transient arousal to support the use of volitional strategies to re-focus on the task. Self-learning involves using both "top down" and "bottom up" self-regulatory systems (Boekaerts & Niemivirta, 2000; Boekaerts & Corno, 2005). There is a top-down "goal pathway" that serves as a motivating structure and a bottom-up approach for managing one's well-being while learning and minimizes distractions that detract from achieving learning goals. This theoretical framework suggests the complexity of the self-learning process. It is likely to be one that can break down for multiple reasons and the reasons may vary by learning context and topic.

Studies of learning motivation of schoolchildren indicates that those who have personally meaningful learning goals are in a better position to learn to self-regulate their own learning (Elliot & Sheldon, 1997). By contrast, for most adults, learning goals will include those that are externally imposed and those that are intrinsically motivating and personally meaningful. Externally imposed goals are more likely to be pursued in a short-term, episodic fashion, while personally meaningful learning goals are more likely to be pursued in the longer term (Ryan & Connell, 1989; Ryan & Deci, 2000; Sheldon & Elliot, 1998). Support for adult self-learning needs, therefore, to focus on supporting both types of learning goals.

Technology's Role: Persuasive Recommendation and Self-Learning

Based on this review, pervasive technologies for personal assistance can help self-learners apply a set of metacognitive strategies, motivational strategies, and volitional strategies. Technology can help by:

- encouraging these activities at contextually appropriate times,
- recommending or automatically performing them for the user in contextually appropriate ways, and
- helping to train the learner to perform them by habit.

Underlying each of these forms of assistance is the need for technology to be able to figure out what actions are likely to be both valuable and compelling to the learner in a given situation—i.e. to be able to make persuasive recommendations in context.

Research on persuasive technologies (Fogg, 2003) indicates some effective ways of fostering uptake of recommendations. All use current and historical context data about the learner to influence behavior around learning resources (Consolvo, Everitt, Smith, & Landay, 2006; Gasser, Brodbeck, Degen, Luthiger, Wyss, & Reichlin, 2006). Learner data is most persuasive if it is the following (Consolvo, McDonald, & Landay, 2009): 1) goal-oriented to support reflection on progress, 2) unobtrusive in presentation to avoid annoyance, 3) public to activate self-consciousness, 4) aesthetic, meaning that the technology must be attractive, 5) positive in tone, 6) controllable by the user, 7) historical, showing the users' past behavior, and 8) comprehensive, meaning it permits inspection of all behaviors at different levels of granularity. Such technology effectively can create a model of adult learners' interests and availability for engaging with learning resources, and then make recommendations customized to that individual schedule and set of interests. Further, a mobile, recommender-based technology can reinforce adult learners' awareness of particular long-term goals by creating a user interface that represents desired learning goals and progress toward attaining them in a motivating, aesthetically pleasing manner.

PERLS

PERLS (PERvasive Learning System) is a personal assistant learning application designed to support adult self-learners. It provides an extensible platform for diverse instructional technologies, especially including those developed under the ADL PAL program. The platform mediates anytime/anywhere (pervasive) access to instructional content, allowing users to learn at times and places that suit their preferences, regulate the pace of learning to suit their schedule, and situate learning to take advantage of environmental affordances. Personal assistance capabilities in PERLS help users realize potential benefits from increased access. Instead of relying solely on the learner's organizational skills, observational skills, and drive, the assistant encourages and facilitates strategies associated with good self-learning outcomes.

For illustration, consider a new employee given PERLS for the purpose of "enhanced onboarding." The employee might start learning compliance content such as how to fill out a timecard or follow safety procedures. But as the built-in, context-aware assistant learns and adapts to user patterns and preferences, the employee begins to see more interesting and intrinsically motivating content that helps him/her to operate more effectively in the job role, develop insider awareness, and make connections. PERLS gently helps the learner establish learning goals, find time and resources to pursue those goals, clarify and reinforce motivations, and make steady progress. Eventually the learner may become accustomed to this sort personal assistance and use it to support learning for professional development throughout their period of employment.

PERLS provides user guidance through Smart Lists and Smart Alerts. With Smart Lists, the user can swipe through an ordered set of "cards," quickly deciding whether to select the content or action suggested on the card or to keep browsing. PERLS uses context-aware recommendation engines (Lonsdale, Baber, Sharples, & Arvanitiss, 2004; Verbert et al., 2012), to order cards based on context-dependent estimates of the learner's goals, readiness, willingness to spend time learning each item and other factors. Each **content card** (see Figure 1a) displays contextual "sell points" explaining why PERLS made the recommendation. For example, a sell point might highlight that the user is near some fleeting learning opportunity, that peers have found the content valuable, or simply that the user is likely to enjoy the material. **Action cards** encourage learners to engage in reflection, goal-setting, planning and other metacognitive, motivational, and volitional self-learning strategies. Figure 1b shows an example action card in which the learner is encouraged to set a learning goal for a topic in which she/he has shown a pattern of

interest. Accepting the recommendation brings the user to the view shown in Figure 1c for specifying topic learning goals. For example, if the user selects "Explore," PERLS will tend to recommend additional content on the topic, preferring items that are interesting but not very challenging. If instead, "Study" is selected, PERLS will recommend content representing a logical progression of content, and will track progress.

Sell points are based on context information drawn from diverse sources including mobile devices sensors, remote data services, recent user interactions, analysis of past user behaviors, and analysis of related user populations. However, not all important context factors can be sensed or inferred. In particular, it is difficult to infer immediate learning motivation—i.e. why the user is choosing to interact with PERLS *right now* and *what type of learning experience the user seeks*. To compensate, PERLS provides several different types of Smart Lists for a user to choose among, each corresponding to different kind of interaction motive, and each backed by a separate, specialized recommendation engine. Different Smart Lists focus on: limited time a user has available for learning (Quick Pick), a user's desire for novelty (Surprise Me), a user's drive to make progress on longer-term goals (To Do), and a user's interest in nearby or near term learning opportunities (Here and Now). The system will learn over time what types of transient learning orientations appeal to the learner.

Smart Alerts address the case where the learner faces challenges related to timing, such as recognizing that a window of availability for learning has arisen, detecting a specific, transient learning opportunity, or remembering a prior intention to learn at some time or in some circumstance. PERLS uses the same context awareness and persuasive recommendation technologies for Smart Alerts as for Smart Lists. However, since mobile device users are often averse to app alerts, PERLS, filters alert candidates aggressively based on user preference information.

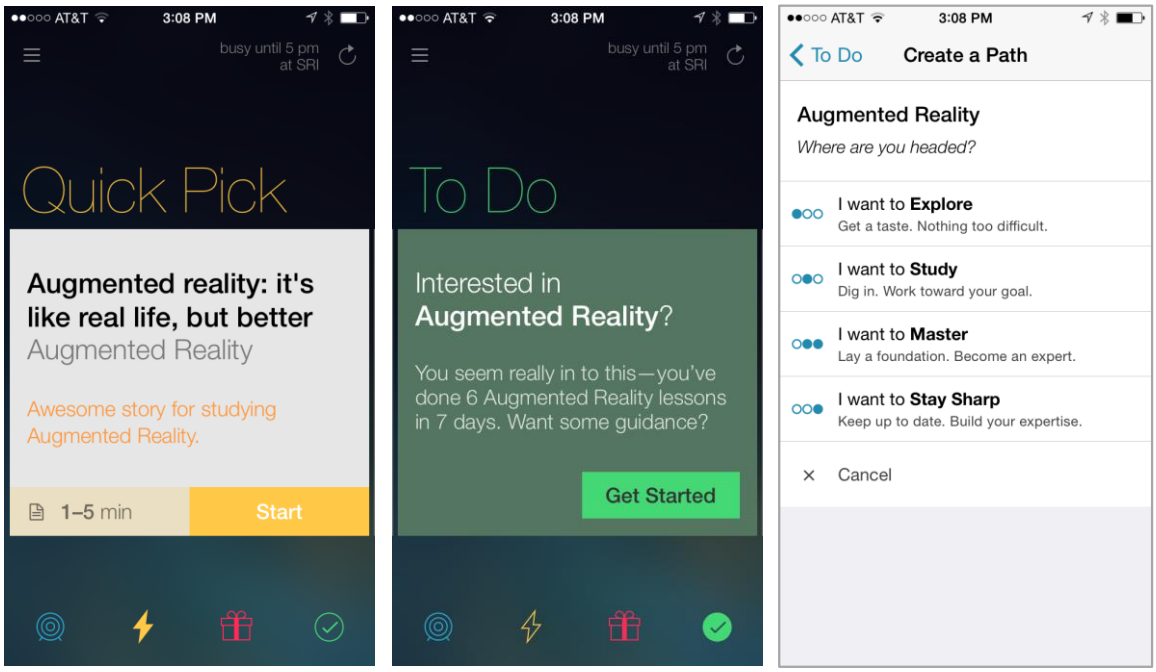

Figure 1. PERLS user interface showing (a) content card with "sell point", (b) action card with learning recommendation, (c) goal setting view

See Figure 2 for a graphic representation of the overall self-learning logic of the PERLS interface design.

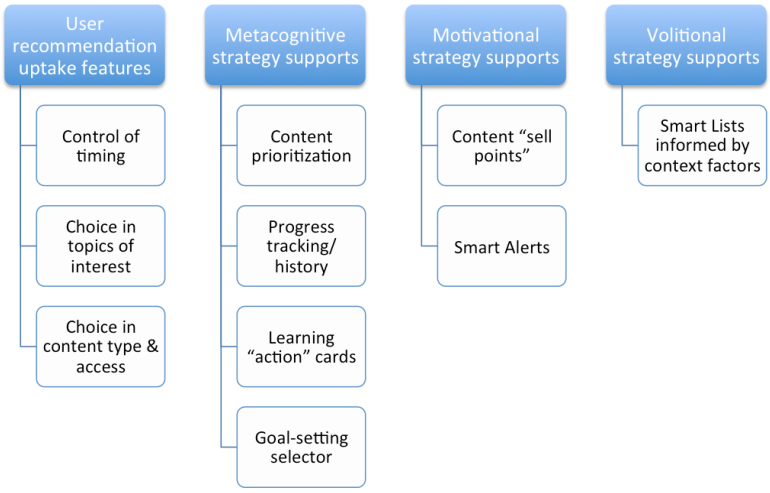

Figure 2. PERLS interface self-learning logic model

DESIGNING PERSUASIVE RECOMMENDATION TECHNOLOGY FOR SELF-LEARNING IN THE WORKPLACE: A CONCEPT VALIDATION STUDY

To address the remaining open questions about how best to implement the PERLS concept of persuasive recommendation, we have conducted a concept validation study, and we next plan to conduct a field study. The concept validation study involved adult learners in a corporate setting.

Purpose and Design of Concept Validation

This study honed in on their views of the desirability of two core features of the PERLS persuasive recommendation system: Smart Lists and Smart Alerts. The study engaged 24 corporate employees (15 females and 9 males; 7 aged under 30, 10 between 31–50 and 7 over 51; 6 working at the company less than 1 year, 5 between 2–4 years and 13 over 5 years).

First employees responded to a 28-question survey asking them to: (1) rate their level of agreement on a 5-level Likert scale with 7 possible challenges to self-learning related to finding time and resources, and making and gauging progress; (2) to estimate the amount of time they devoted each week to urgent and longer-term professional learning goals and personal learning goals; (3) to describe the types of topics they pursued in each of these three types of learning goals recently; and (4) to describe the types of resources and information-seeking technologies they employed in self-learning.

Second, the same employees (n = 23; 1 was unable to attend) participated in one of two 1-hour focus groups rating the desirability and value of a range of scenarios using the PERLS Smart Lists and Smart Alerts persuasive recommendation system. Ten storyboards were generated and organized into five pairs with contrasting uses of Smart Lists and Smart Alerts. Each of these storyboard pairs focused on one type of adult learning goal, from urgent professional to long-term personal, and a particular type of corporate content, such as a low-stakes general interest topic (e.g., interesting corporate accomplishment stories) or a high-stakes compliance topic (e.g., completing a required online course on hazardous materials).

In analysis, we examined descriptive frequencies of adult learning challenges and patterns, and we conducted a one-way ANOVA procedure to examine differences in ratings of Smart Lists and Smart Alerts and a hierarchical linear model (with survey items nested within person) for looking for general trends overall and by subgroup (e.g., age bracket, job role, gender).

Findings of Concept Validation

The findings report on the self-learning habits and challenges of the sample of adult corporate learners and their views of the PERLS concept of Smart Lists and Smart Alerts to develop and improve self-learning habits.

Adult learners in the corporate setting reported self-learning challenges and habits consistent with past research: "Finding time" posed the greatest challenge, followed by "finding resources to start learning" and "keeping on track with long-term goals." We found learning goals vary according to their work schedules. They estimated that most of the time (74%) they devoted to meeting "urgent" learning goals occurred during work hours, while up to the third of the time devoted to meeting broader "professional" learning goals occurred *outside* work hours, and—in a surprising finding—up to 22% of the time spent meeting "personal" learning goals occurred *during* work hours. These findings indicate that a self-learning tool should be useful for both work-related and personal learning purposes—and that the nature of the needs for self-learning support may vary by time of day.

Learners strongly preferred Smart Lists to Smart Alerts as the technological means of supporting self-learning. They said they liked the idea of learning resources prioritized by their interests, time availability, and location, and, in particular, they believed the Smart Lists would give them control around when to choose to use these resources. They generally disliked Smart Alerts as potentially intrusive, but appreciated them if they "nudged" them to meet desired learning goals.

We also found learners expressed a strong preference for preserving work content learning for work time and personal content for off-work time. They particularly disliked having any "push" of high-stakes compliance content recommended to them outside of work. Such content has low intrinsic interest. They embraced the idea of persuasive recommendations helping them carve out time during "down periods" for productive self-learning and finding ways to schedule urgent work learning tasks during the workday.

NEXT STEPS: FIELD TESTING WITH NEW EMPLOYEES

In summer and early fall of 2014, we plan to conduct field-testing. The field tests will unfold in two stages: Basic usability/desirability and Initial usage trends. We will briefly outline the design of these formative design evaluations and the evidence we plan to collect.

During field-testing, we will offer a range of onboarding content accessible through the PERLS system based on interviews with corporate content providers. We will also test out initial content contribution systems to support informal, crowd-sourced content generation.

The initial PERLS content corpus focuses on onboarding content since this is a group known to have high levels of learning need. We interviewed content providers to identify the primary sorts of content that new hires need and to understand how new hires cycle through content during their first year of employment. The types of work content address a range of urgent and long-term learning goals, as well as goals that we found in the concept validation corporate learners saw as strictly confined to completion during work hours and types of content that they saw as having broader personal value and utility during off-work hours.

The corporate learning content types are: *Practical Content*, which includes content for learning how to use corporate IT systems and equipment for specific tasks and that includes "tips" that convey information that is often not formally conveyed but learned the hard way on the job; *Corporate Lore Content*, which includes fun facts to build understanding of corporate history and engender a sense of belonging; *Professional Development Content*, which includes learning the corporate marketing strategies, how to write, and how to manage teams; and, *Compliance Content*, which includes long-term learning of required safety and documentation procedures to meet legal requirements. The corpus will be built out over the course of the field-testing phase. Some of this content, such as the professional development courses, is formal with sequences and external instructors, but most of this content is informal and unstructured.

Basic Usability/Desirability Sub-study

We plan a preliminary pilot test phase of the functionality of the PERLS system and interface. This phase will involve a participant sample of 2–3 corporate new hires selected by job role (management, non-management) from those signing up for weekly orientation sessions and according to approval by their hiring managers. In addition, we will have 2–3 "controls" that will be starting their new jobs but not using the PERLS system.

At the close of the normal corporate orientation, we will give each PERLS-using participant an iPod loaded with the PERLS system and a wireless connection to the corporate system. We will instruct them on how to use the system to find content. We will configure PERLS to their interests for both urgent and longer-term professional and personal learning goals and their expected hours of availability for self-learning. We will instruct them on how to configure the device with wireless servers outside of work and request that they do so to ensure they have access to PERLS at outside-work locations too. Non-PERLS participants will be introduced to the study too, and told that we want to understand their experiences of starting at the company.

We envision that in the first week of testing the focus will be on basic functionality. We will identify bugs and fix them immediately. Then we envision a second week of testing that will focus more on the usability of the interface and the content. For example, after training, we will engage the PERLS learners in some close-ended self-learning activities that direct them to seek out information in the system and we will engage them in some open-ended self-learning activities in the system that that they will self-select. PERLS learners will engage with both types of activities independently during one 24-hour period and then participate in a follow-up interview (by phone or in person) with a researcher the following day. The researcher will base these interviews on an interview protocol and data from the participants PERLS usage log file. Examples of research questions to be addressed by initial field-testing phase are:

1. How usable and desirable is the PERLS adaptive navigation interface (Smart Lists, Smart Alerts, sell points, action cards)?
2. How accurate are the recommendations made by the PERLS system based on learner interests and available self-learning times? How may uptake of these recommendations be improved to foster planning, reflection, and social learning?
3. What PERLS delivery of learning content and the learning content in the system provided perceived as useful and timely? Do perceptions vary by the job role of user or the type of content?
4. How shall we interpret the log files of their activity?

We will engage both the PERLS and non-PERLS learners in addressing the following research questions in the pilot-testing phase too:

5. How did the PERLS system influence their self-learning process as they started their new job?
6. What non-PERLS content was useful to them and how much time did it take to obtain that content?

At this stage, we seek to gather basic data from non-PERLS users of how corporate learners' self-learning goals evolve over the first month on the job. This will provide a rough characterization of the pace of initial learning without PERLS: What learning goals do they initially generate, how well do they meet them, and what new learning goals do they subsequently generate? Additionally, how much does PERLS' persuasive recommendation logic support planning, reflection, and social learning activities that foster self-learning? How well does PERLS deliver both formal content (e.g., linking learners to a structured course) and informal content (e.g., linking learners to unstructured content based on its presumed relevance based on metadata and/or user recommendation)? It will also provide some insight into the types of resources corporate learners use typically and how the PERLS content relates to that content and the ways they organize their time to engage in self-learning. We plan to conduct two brief telephone interviews with new hires participating (PERLs, non-PERLS) that addresses what self-learning goals they initially expected to have, what they have done and what resources they have used to meet those goals, and how successful they felt these approaches were.

We have an initial set of expectations about how much demand new hires will have for the different types of corporate onboarding content over the first two months on the job (see Table 1). We will refine this model based on

feedback from the first pilot study. In addition, we will use the data from the initial pilot test to refine the PERLS adaptive navigation tools, log files, and content contribution system as needed.

Table 1. Sample content interest priorities* for corporate new hires during first year and beyond

Onboarding Objective	Content Type	1st week	1st month	1st year	beyond
Org know-how	"Tips"	3	5	2	2
Becoming Insider	Lore/Env/News	3	3	3	3
Job skill	Prof. Development	1	2	3	4
Compliance	Compliance	3	2	1	1
Autonomy	Task support	-	-	-	-

*1 is low priority and 5 is high priority

Initial Usage Trends Sub-study

In the second phase of the field test, we will address a second level of research questions related to PERLS and self-learning, as follows:

1. How usable is the PERLS system for tracking and supporting self-learning over two months?
2. How effective is the PERLS system in using incoming log data to improve recommendations and address gaps in content?

For this phase, we will expand the number of participants to up to 30–40. To explore the self-learning question, we will engage half in using PERLS and half in not using PERLS. To address the log-file question, we will focus on the PERLS users only. In this case, we will offer PERLS for use on learners' iPhones (the prototype is available only in the Apple OS at this time). It is critical that PERLS be made available on the mobile phones that learners typically use rather than a dedicated phone for the purposes of this field-test. So, for these reasons of ecological validity, we will make having an iPhone a condition of study participation.

To examine self-learning, we will examine trends in how learners' goals, task completion, and goal generation evolve through qualitative data from two online surveys administered to participants and some selected embedded assessments periodically inserted into the PERLS interface. Further, we will link the log data about how much time they spend on certain learning content recommended by PERLS and collect data from both periodic queries embedded in PERLS and follow-up interviews to determine how log data about "time logged with content" and "type of learner activity" relates to achieving self-learning goals. We will use the findings from these periodic queries and interviews to improve the design of how log data informs recommendations for content, and check back with users to see if these recommendations are more accurate and useful.

At the conclusion of the two phases of field-testing, we will have a better model of how the PERLS adaptive navigation system works to support self-learning and different types of content. We expect that the findings will make a technical contribution to the field's knowledge about what types of contextual data can inform self-learning recommendations and about what types of persuasive recommendations related to planning, reflection, and social learning may be developed to improve the use and contribution of informal and formal learning content.

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