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14. ABSTRACT
This report describes the full cycle of contracted activities for design, development, testing, and transition of a financial readiness micro-learning mobile app training tool called Sen$e, from the Advanced Distributed Learning (ADL) initiative's R&D activity to the co-sponsoring Financial Readiness (FinRed) Office operational environment. This ADL initiative/FinRed partnership serves to provide the Sen$se mobile app to all Service component members and families, while allowing for test and evaluation of mobile micro-learning and the Experience API (xAPI) for learner activity recording as prescribed in DODI 1322.26. Formative testing with various representative user groups for initial design and development purposes was validated with target end users of each of the Services components through summative in-person user experience testing. Further details about the summative testing can be found in the report titled "Financial Readiness Personal Assistant for Learning – Summative Usability Test Results Report".

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Final Report

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1. Executive Summary

Sen$e is a mobile application designed to support service members and their families with financial readiness information using micro-learning, gamification, and other motivational techniques to cultivate life-long learning. Sen$e supports service member financial literacy and preparedness through engaging "bite-sized," personally relevant, multimedia content. To encourage continued use, Sen$e features motivational elements such as push notifications, gamification, and visual progress indicators. In addition to educational content, validated financial tools and resources are incorporated into this user-centered application. Sen$e was developed using human-centered design principles and Agile software development processes. This iterative approach allowed for significant front-end analyses, engagement with end-users, derivation of user needs into requirements, development, and testing throughout each phase of the project to ensure a holistic and user-friendly system. Project performance progressed through a three-phased development process. Deliveries made throughout each phase of the project underwent an extensive and thorough review process. The process of meeting the project goals for developing a useful, usable, and user-centered financial application, for service members and their families, is described, in detail, in the following final report.

2. Introduction

Background

While service members and their families receive unique financial benefits as a result of their service, the systems and processes required to negotiate these benefits are complex and often difficult to use. In addition, many service members enter military service without prior education in personal finance. As a result, service members may fall prey to predatory lending practices, high-pressure sales pitches and other financial pitfalls. Recent changes in the military's retirement systems offer service members more options when it comes to investing in their futures, but many are not prepared to make effective decisions in these areas. Issues with individual service member financial literacy affect the military at large. According to a 2015 report by the Military Compensation and Retirement Modernization Commission, improving financial literacy of service members could save the Department of Defense (DoD) up to $137M annually by reducing the number of service members separated from the military as a result of financial hardship.

To support financial literacy education, the DoD has implemented several initiatives. These include classroom training at military installations, individual service member counseling, and access to resource websites. Despite these efforts, the 2015 Blue Star Families Annual Lifestyle Survey found that only 12% of service members reported receiving financial literacy training through their command. Service members may not find the information easily accessible online due to security requirements such as Common Access Card (CAC) access. Finding the time to enroll in classroom training or visit a counselor may also be challenging. To address this gap, the ADL Initiative and Office of Financial Readiness (FinRed) have developed a Personal Assistant for Learning to provide military personnel financial literacy information anytime, anyplace, on mobile devices.

Service members' financial needs and goals change throughout their lives, both during their military service and after separation. To address these changing needs, 10 U.S. Code § 992 requires financial literacy training to be provided to service members at multiple stages throughout their careers. Service members are required to have financial literacy training during initial entry training, at their first duty station, on the date of their promotion (up to E-5 or O-3), when they vest in the Thrift Savings Plan (TSP), during leadership training, during pre- and post- deployment training, at major life events, and at separation.

To support this initiative, Quantum Improvements Consulting (QIC) in partnership with Float, developed a Financial Readiness - Personal Assistant for Learning (FR-PAL) called Sen$e. Sen$e supports service member financial literacy and preparedness through engaging "bite-sized," personally relevant, multimedia content. To encourage continued use, Sen$e features motivational elements such as push notifications, gamification, and

visual progress indicators. In addition to educational content, validated financial tools and resources are incorporated into this user-centered application.

Project Approach

Sen$e was developed using human-centered design principles and Agile software development processes. This iterative approach allowed for significant front-end analyses, engagement with end-users, derivation of user needs into requirements, development, and testing throughout each phase of the project to ensure a holistic and user-friendly system. Project performance progressed through a three-phased development process, with each phase resulting in a set of deliverables. Deliveries made throughout each phase underwent extensive internal (peer reviews within the project team) and external (Government and stakeholders) reviews.

3. Objectives

The goal of Phase I was to develop functional mockups of key aspects of the application's functionality. These include backend data management, data flows, user interactions, and feedback elements. To accomplish this development, the team conducted a front-end analysis to identify the needs of the end-user for implementation within the software. Needs of end-users including service members, their family, and administrators drove the software design aspects centered on the content ontology, content format, financial planning tools, and data flows. Content is focused on the crucial financial topics relating to service members including, but not limited to, budgeting, retirement, transition, education, and scam-avoidance information. Data flow of the application includes appropriate terminology, architecture, standard platform interactions, and desired push/pull information. The front-end analysis provided data to inform requirements development, content development strategy, and application design. Phase I culminated in wireframes and mockups simulating the general application layout and content delivery mechanisms, data flows, and user interactions. The application mockups were generated in a digital prototyping application, InVision, and were utilized to conduct the first instantiation of interactive usability testing. The Formative 1 Test was conducted with a local population of service members and veterans. Data garnered through this effort provided enhanced design recommendations.

In Phase II, the goal was to implement the wireframes and mockups into an alpha version of Sen$e. The application was designed and developed for utilization across Android and iOS platforms. Sample training content was developed and implemented within the content ontology for the purpose of testing. Information assurance documentation was developed and included with the release of the Phase II beta prototype along with the sample content. The second round of formative testing included testing of the Phase II beta prototype. This formative testing allowed potential end-users to provide input on the user interface (UI), site structure, content organization, and overall app functionality. Additional information was collected on user-satisfaction and user expectations regarding the application. Phase II culminated in the design and development of a limited functioning prototype system that produced initial positive usability results, which have been incorporated into the final design of Phase III.

Goals for Phase III included development of the final beta version of Sen$e, populated with training content, measures for data collection, and financial planning tools and calculators. Additionally, the system should be enjoyable to use, provide personalized and relevant information, maintain security over user data, and sustain capabilities. Towards these goals, extensive iterative summative testing was conducted to assess usability, user satisfaction, training effectiveness, quality assurance, and load testing. To ensure that Sen$e maintains sustained capabilities, a sustainment plan, usage guide, and developer and system administration documentation has also been developed and delivered along with the source code for the operational system. Phase III performance has resulted in the development and delivery of this final version of the Sen$e application under the current period of performance. The application is populated with financial readiness training content, the ability to collect usage information, and financial calculators and resources.

The following documentation details the design and development progress made throughout the contract period across the three phases.

4. Phase I

Requirements Collection & Documentation

Guiding Documentation

The development of Sen$e began with the collection and definition of requirements through a variety of knowledge elicitation activities. Guiding documentation provided by stakeholders was reviewed and analyzed. Specifically, FY16 NDAA Section 661 and 10 U.S. Code § 992 – Financial Literacy Training: Financial Services were reviewed to derive A-level requirements, providing the foundation for when training content should be provided to service members. Training is required to be provided at various "touchpoints" throughout a service member's military career. These touchpoints include:

- As a component of initial entry training
- Upon arrival at the first duty station
- Upon arrival at each subsequent duty station for E-4 or below or O-3 or below
- On the date of promotion for E-5 or below or O-4 or below
- When vested in the Thrift Savings Plan (TSP)
- When eligible to receive continuation pay
- At major life events including, marriage, divorce, birth of first child, disabling sickness or condition
- During leadership training
- During pre-deployment training and during post-deployment training
- At transition points including transition from regular component to reserve, separation, or retirement
- During periodically recurring required training

While the application is not meant to meet the requirements of mandatory training, it is anticipated to be used as a supplement, with relevant information pertaining to each touchpoint. Furthermore, while the touchpoints indicate *when* training should be provided, they do not prescribe *what* training should be provided. Requirements pertaining to content inclusion were derived from training content provided by Joint Knowledge Online (JKO) and Office of Force Education (OFE) resources. These documents were analyzed in search of common themes and most frequently discussed topics to ensure significant topics were included in the application. Such topics include Thrift Savings Plan (TSP), Blended Retirement System (BRS), financial preparation for deployment, budgeting, spending plan, SMART goal setting, Servicemembers Civil Relief Act (SCRA), and insurance.

The information extracted from the guiding documentation helped to inform the creation of the initial end-user interview protocol, namely, the items that would be ranked by end-users as either important or useful.

Initial End-User Interviews

As part of the initial requirements collection process, an interview protocol was developed to elicit broad financial behavior from an end-user pool. Demographic information as well as themes about common financial behavior (i.e., car ownership, home ownership, college savings, retirement savings, account usage) were collected and then weighted (ranked) by the participants in order of what they considered important, useful, and high priority. The interview protocol can be found in Appendix A. Interview responses were collected from five participants (M_{age} = 32.2), with an average time in service of 11.1 years., Individuals served in the Air Force, Army, and the Marine Corps and ranged from National Guard, Active, Reserve, and Retired statuses. When asked to rank 13 financially related items per the top priority or most important to them, all respondents ranked saving and budgeting, household finance, and personal banking and security in their top five.

Additionally, items of importance included retirement, credit, and credit cards. In a similar vein, all respondents ranked savings and retirement in their top five most useful financial calculators. Additional calculators related to debt (elimination or consolidation) and loans (payoff and rates). These findings were included in the initial thematic and organizational scheme for content development.

Marketplace Competitive Review

The competitive review process consisted of researching and aggregating all relevant information on products that provide similar financial services both commercially- and government-produced. This process helped designers better understand current products available in the market, what needs are being addressed, and how effectively those products are addressing those needs. Designers evaluated each product's goals, strengths, and weaknesses. This information was used to inform design recommendations for integration into the design of the new product. The competitive review process ensured that the delivered product leverages the best elements of comparable products, without their weaknesses, in order to deliver the best available product for end-users and stakeholders. The following (Table 1) is a list of the web-based software products and applications that were reviewed as part of this analysis.

Table 1.
Products Reviewed During the Competitive Review

Military America Saves	Making Better Money Habits	Learnvest	Simple	Mint
Prosper Daily	Money Matters	Military One Source	BBB Mobile Mi$$ion App	USAA
Military.com	Creditscorequiz .org	Credit.com	Quizzle	Saveandinvest.org
Credit Sesame	myFICO	Bankrate	Acorns	Payoff
SaveUp	Clarke Howard	Money Habitudes	Gen I Revolution	Love Your Money
PowerPay	myRA	CreditCards.com	Consumer Financial Protection Bureau	Treasury Direct
National 4H Curriculum and 4H Build A Million Club	FinAid	Myeddebt.ed.gov	Betterment	PocketGuard
You Need a Budget	GoodBudget	Mvelopes	HomeBudget	Wally
Level Money	Spendee	BUDGT	Unsplurge	

Persona Development

Personas are representations of end-users developed with the intent of providing the design and development team with a sense of realism surrounding the project. Personas are typically developed through the collection and analysis of qualitative data and convey information pertaining to users' goals, needs, and interests. Personas created under this effort represented major user groups of the system and helped the design team understand who their primary users are and what the system's primary functions should be. Here, end-users are defined by several user classes with their own representative characteristics. Used for persona development, user classes were designated, and descriptive demographics developed (Table 2).

Table 2.
Persona Identification and Descriptions

Persona Group Identification	Description
Enlisted New Service Members (E1-E4)	Novice, young, potentially little to no financial training or experience
Enlisted Middle Management (E5-E6)	Growing assets, career responsibilities increase, potential family, retirement is important and relevant now
Enlisted Upper Management (E7 and up)	May have personal experience in financial success and/or financial hardships, potential growing families, career responsibilities increase, benefits for oneself and/or family member, increased retirement focus
Officer New Service Members (O1-O3; W1-W2)	Novice, young, potentially little to no financial training or experience, potential education debt
Officer Upper Management (O4 and up; W3 and up)	Growing assets, career responsibilities increase, potential family, benefits for oneself and/or family member, increased retirement focus
Veterans	Wide range population; young, middle-aged and older, planned separation from service, unplanned separation from service, potential for education debt, potential for growing assets, potential medical and disability benefits focus, retirement focus, potential for other benefit/entitlement programs
Spouse and/or family member	Use for and by almost anyone; a military spouse, a non-military spouse, child, parent, other family member, may be closely involved with household financial decisions, may hold power of attorney for service member, etc.
Administrative	Content upkeep, content consistency and accuracy, maintenance, upkeep in relevant and accurate policies and local information changes, system admin functions, legal issues, security issues, protected information, information assurance

For additional details, see contract deliverable Initial Financial Readiness PAL Requirements Report 4.4.1 (Initial Financial Readiness PAL Requirements Report.pdf).

Content Development Strategy

The front-end analysis (review of guiding documentation, analysis of end-user interview data, and the marketplace competitive review) resulted in A-level requirements that drove the design of the application and defined the functions and features within. Additionally, the analysis and content sourcing that took place in the requirements collection produced vast amounts of relevant information on finances, financial health, financial readiness, and other similar content related to finance. This information was utilized for the content development strategy.

The Content Development Strategy (CDS) was created to detail how content was accumulated, prioritized, and designed for this application. The objective of the CDS is to outline and develop a strategy for defining the content that will reside in the application, the applicable learning objectives (LOs), relational models within and between content and LOs, and the site map architecture to accommodate the UI/UX within platform and device standard operating environments (SOE). The following sections briefly detail the tasks that comprise the CDS. For additional details, see contract deliverable Content Development Strategy 4.4.4 (Content Development Strategy.pdf)

Content Management

Content management was an ongoing and iterative process throughout the project. Content management for Sen$e consisted of a content and asset library and a traceability matrix. The content and asset library contained all content related to LOs, financial education and knowledge items, graphic assets, tools and calculators, and assessment modalities. The library contained all content media types including, but not limited to: Microsoft Word documents, PDFs, infographics and other graphical formats, tools and calculators, e-books, video files, audio files, weblinks, and mini-game executables. Lastly, content management followed a specified naming convention, the traceability matrix, that allowed items from each file, LO, and ontology location to be mapped to one another for easy and efficient traceability and cross-reference among all content assets. In this way, all assets could be traced to functional software components. Version control was also established to maintain the content and asset library after each iteration of internal and customer review processes and during content sourcing.

Content Modeling

Content modeling is the act of defining and structuring content and assets. This includes defining LOs and associated knowledge content; determining content-specific presentation mediums; determining relational models between content items; and developing a framework for adaptive features leveraging content, user-provided information, and application usage. In order to present both the LOs and educational content effectively, the appropriate content-specific presentation mediums were determined. This entailed leveraging micro-learning strategies (small units of information) and media rich delivery mechanisms to effectively present learning content in an engaging manner. To appropriately map differing media types to content, best practices in mobile design and development were leveraged. For example, a vignette was designed to narrate a story about a financial concept. The vignette was presented in either graphical or video format to effectively leverage both the mobile real-estate and also present strategically grouped content in order to deliver a micro-learning episode to the user. Knowledge assessment responses and associated feedback, responsive checklists, and tools and calculators all leveraged the content modeling process.

In order to create impactful content presentation, selected mediums need to meet user expectations, be intuitive, and efficient. Therefore, relational models between content items were presented within the database, content ontology, and navigational strategies provided by the UI. Related content, knowledge components, assessments, and tools were appropriately mapped within the application to provide a unified user experience. Navigation to and from the application home screen and within content sections included simple nested levels so that users knew their location within the application.

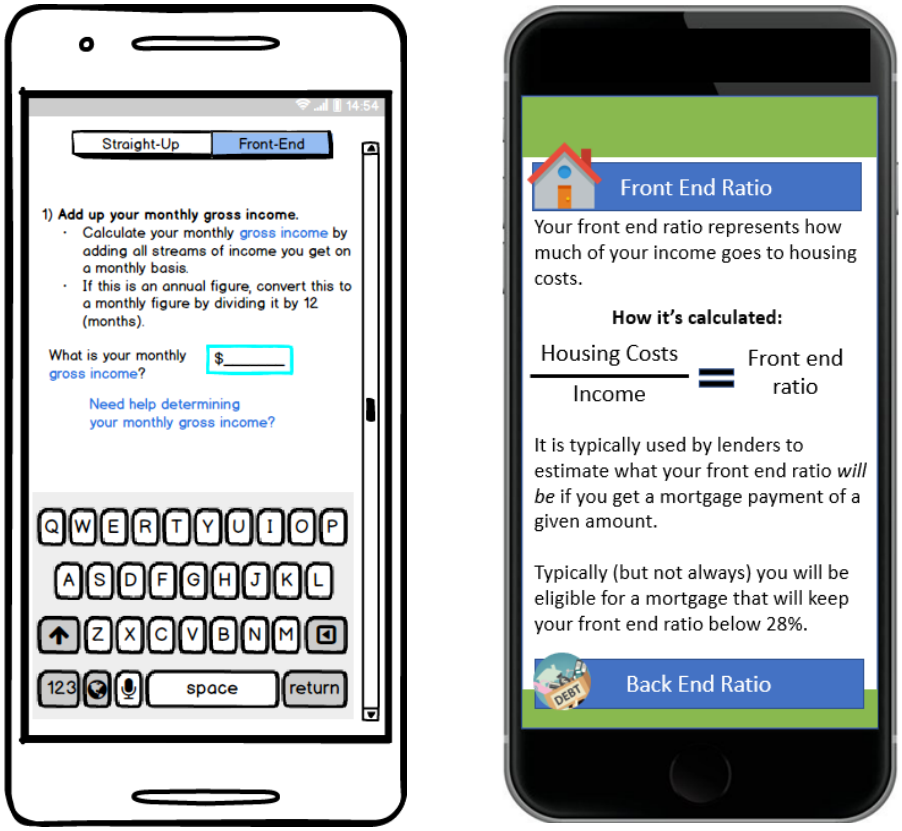
Prioritized Content

Content sourced as a result of the requirements collection process was prioritized for inclusion into the application. The stakeholder and end-user interview analyses, and mobile design strategies fueled design recommendations and requirements for the content prioritization. Interview analyses highlighted important themes found in the financial behaviors of the sampled end-users. These themes were also verified to be topics within JKO educational materials, 10 U.S. Code § 992, and other approved military resource websites. Based on the LOs developed for each financial category, the expected outcomes of learning could drive content

refinement in order to present users pedagogically relevant material. Content and asset libraries were iteratively updated to keep prioritized content at the forefront while version control and other applied nomenclature allowed dated or irrelevant materials to be archived. This tasking resulted in an organizational shell to be partially populated in the Phase II content development activities.

Wireframes and Mockups

With sourced, prioritized content in place for the LOs, the initial development of wireframes began. Wireframing consists of prototyping the design, look, and feel of the software product. The design of the software prototype involved developing the way the user interacts with the tools and elements within the application. Wireframing activities dealt with the layout of the application, design elements, and how the user navigates throughout the application. Project team members created wireframes using Balsamiq and Microsoft PowerPoint software (Figures 1a & 1b). After initial wireframing activities, the design team created a wireframe design generated within InVison for the interactive mockup of the application. Mockup screens applied the initial mood board styles (see Style Sheets and Mood Board section below) and were used to present the content and graphical user interface (GUI; Figure 2) The interactive InVision mockups were then used in the evaluation during formative usability testing. It was an iterative element of designing a clean, functional, and easy-to-use application that engages and interests the users. The wireframing and mockup activities were completed in concert with the content development activities of Phase I to ensure the design of the application would harmoniously accommodate the content.



Figures 1a & b. Balsamiq wireframe of conceptual screen layout; Microsoft PowerPoint wireframe of conceptual screen layout

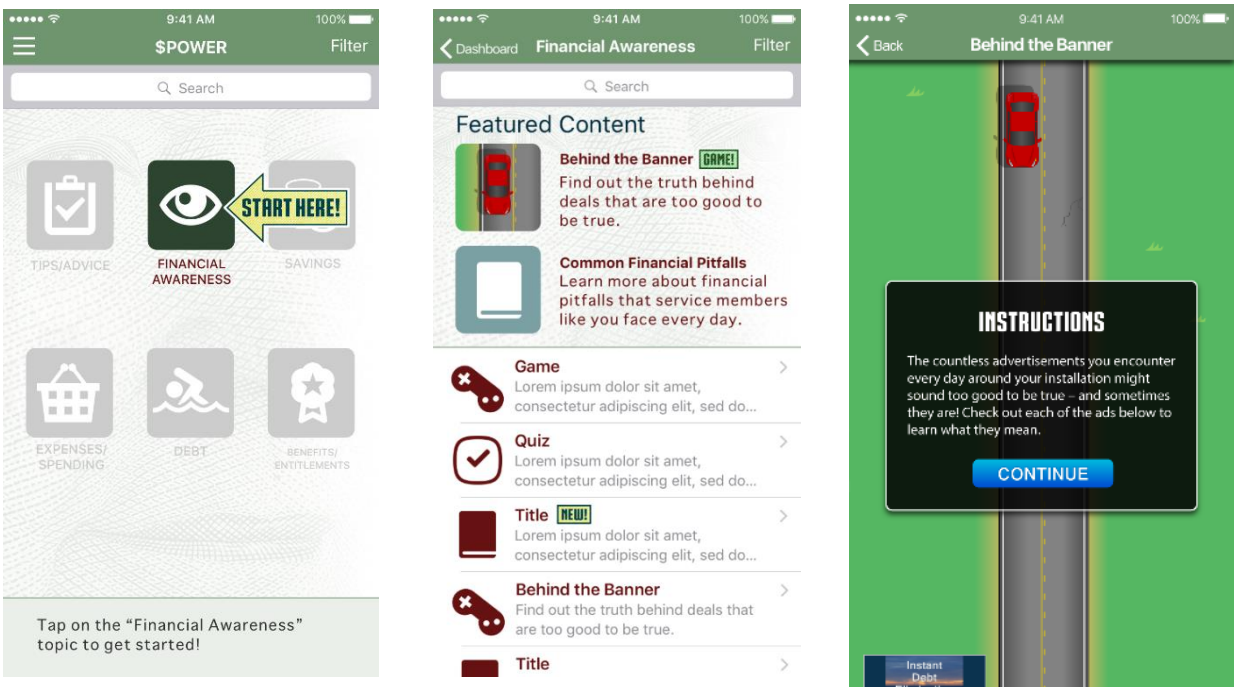


Figure 2. InVision mockup screens with "hotspots" for use in Formative I Usability Testing

Application Design

The application design took shape throughout Phase I and continued to be refined during Phase II. The bulk of the design decisions included architecture definition, (both front-end and back-end), the look and feel of the application through the use of style sheets and mood boards, and finally, the display of content through the use of mockups.

Site Map

A site map illustrates the different screens (pages) of an application. They are used in the planning stages to facilitate discussions between design and development teams regarding application structure, organization, and hierarchy. A high-level, user-centric site map was created for Sen$e outlining system first-time entry, user tools, and main content areas (Figure 3).

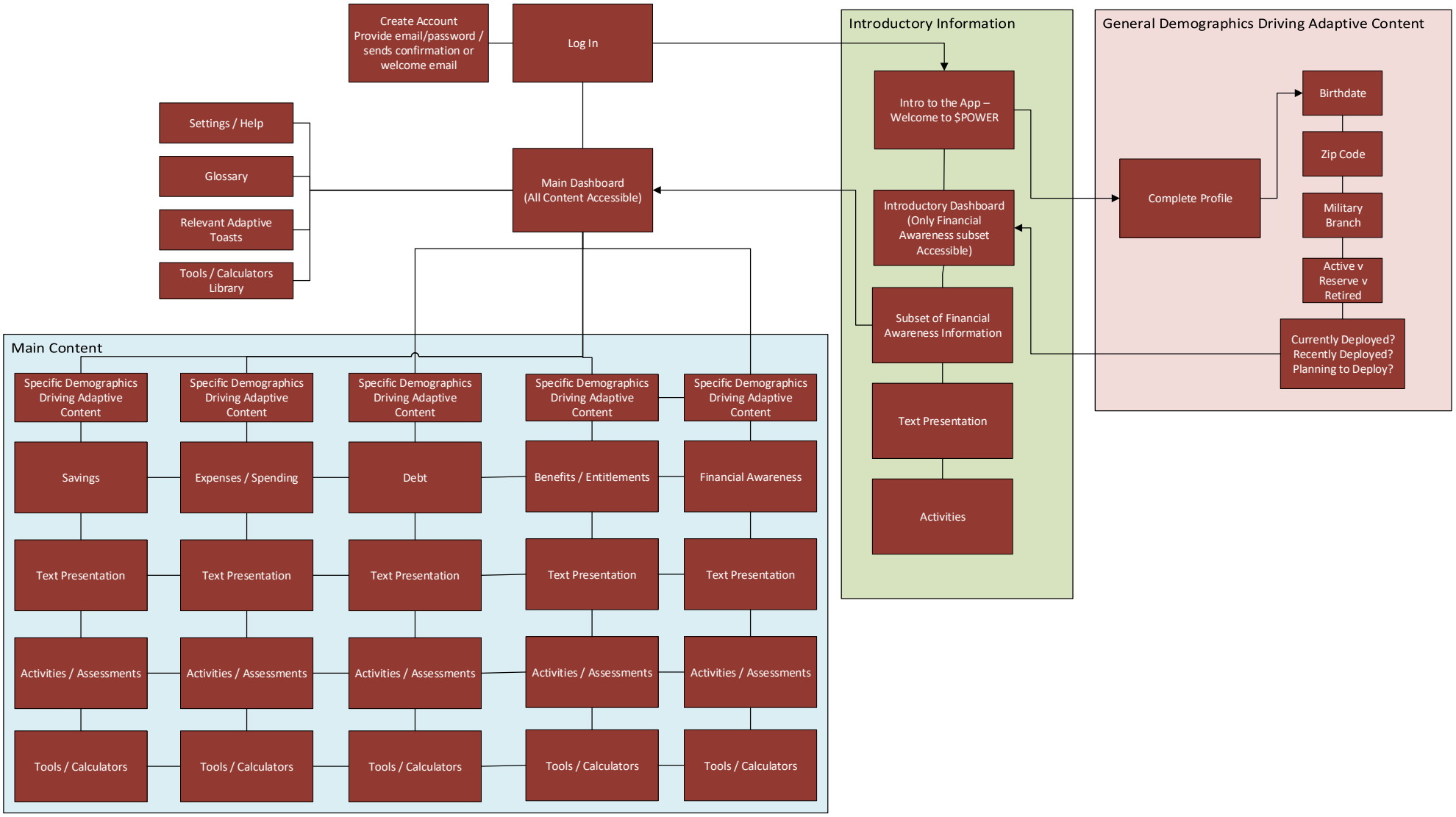


Figure 3. Site map

For additional details, see contract deliverable Site Map 4.4.2 (Site Map_4.4.2_W911QY-16-C-0163.pdf).

Style Sheets and Mood Board

Tandem to the development of the content strategy and content sourcing, the design team developed application style sheets and mood boards to visualize the initial look and feel of the application. Style sheets are guidelines for the human interface of the system. There are standards and best practices for creating within the Android and iOS environments and style sheets capture these elements with respect to device features, application architecture, system capabilities, user interaction, and visual design. Usually a style sheet is presented in code that will be applied to the design. While the style sheet leverages mobile design best practices and sets a foundation for standardizing content screen layouts, the mood board was designed to garner customer feedback regarding style, imagery, application concepts, typography, iconography, buttonology, colors, and other elements for the user interface (Figure 4). Style sheets describe the "how" and mood boards illustrate the "what" of the application. The development of the mood board was an iterative process (Figure 5), with direct feedback from the customer accounted for in the design (Figure 6). The style sheets and mood board concepts were then leveraged during the creation of wireframes, mockups, and storyboards, later, in the design process. For additional details, see contract deliverable Mood Board 4.4.2 (Mood Board_Deliverable_4.4.2_W911QY-16-C-0163.pdf).

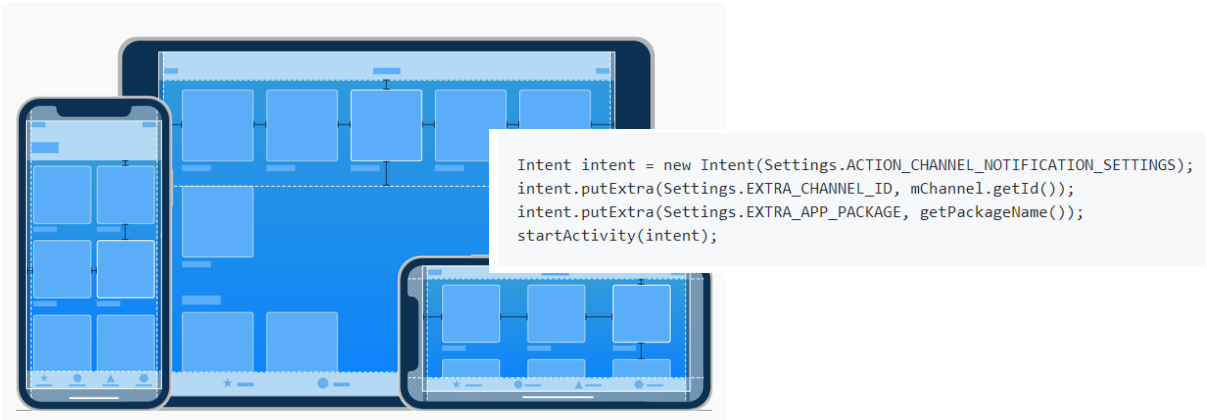


Figure 4. Example style sheet resources from Apple Developer website and Android Developer website

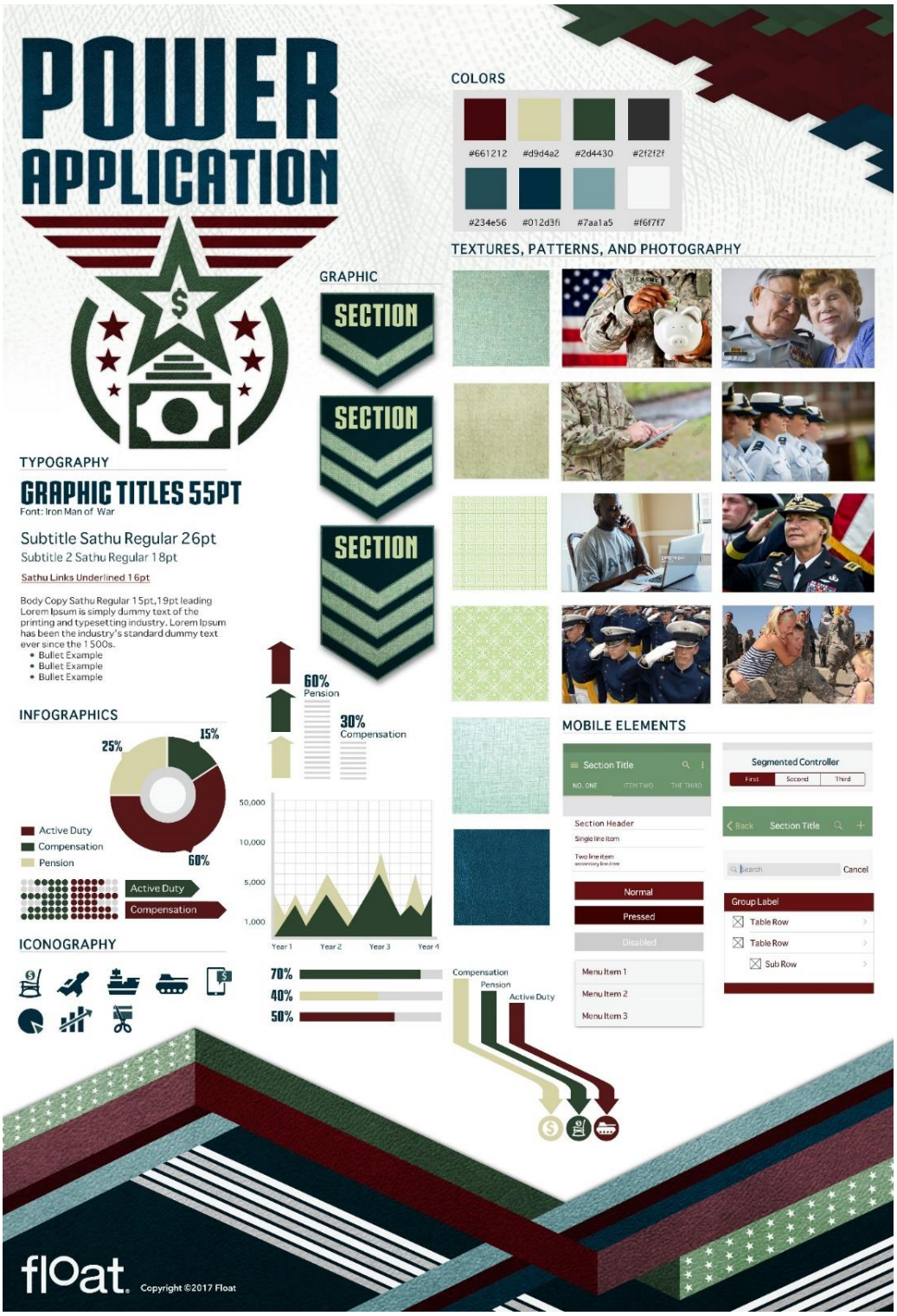


Figure 5. Initial mood board concept

Figure 6. Final mood board concept

Mockups

The Phase I mockups presented as part of the initial application design included screens representing the application log in, welcome, a demographics sample, dashboard, an activity sample, and an information sample. The goal in providing these mockups was to provide a representative sample of screens to begin providing stakeholders with a greater sense for the look and feel of the application. A collection of the mockups that were part of the deliverable are presented below (Figures 7 & 8).

Figure 7. Application Log in and Dashboard – Initial concepts

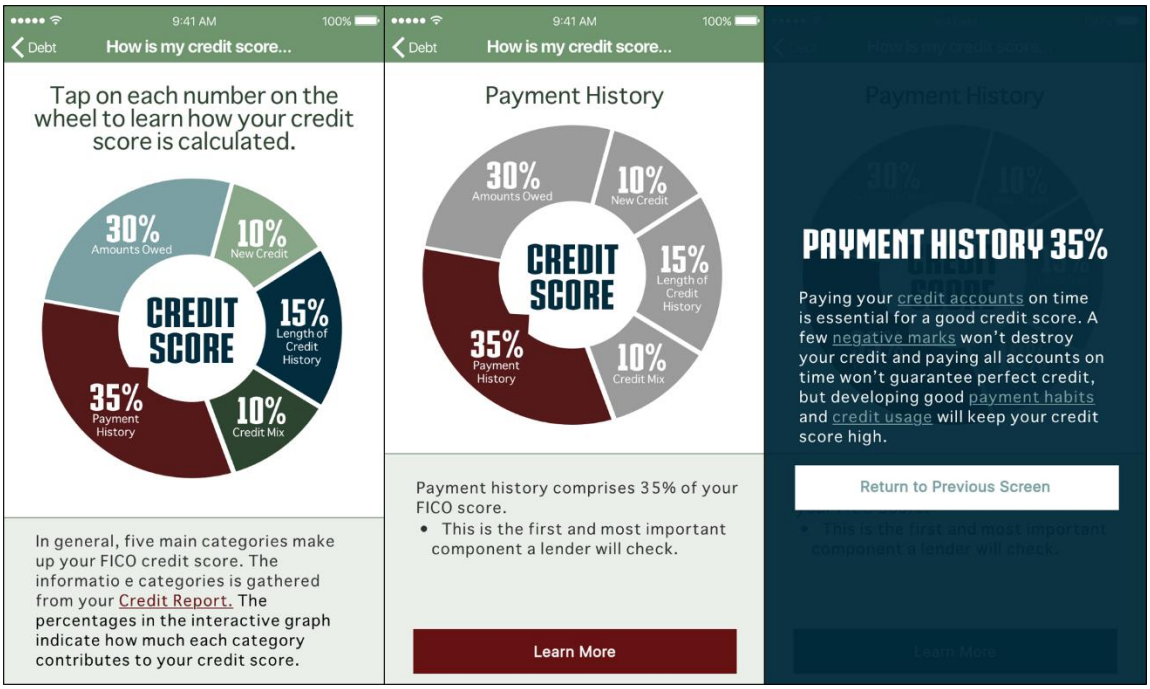


Figure 8. Application content - Initial concepts

For additional details, see contract deliverable Mockups 4.4.2 (Mockups_Deliverable_4.4.2_W911QY-16-C-0163.pdf).

Information Assurance Design and Implementation

The initial Information Assurance Management Strategy (IAMS) documentation was created in Phase I and updated throughout the period of performance, as necessary. The IAMS documentation defined the IA strategy for shared security controls, the application and database servers, and the web and mobile applications. Such strategies included user identification and authentication, password storage, account management, logon attempts, permitted actions without authentication, security updates for dependencies, physical protections, encryption, and user-sensitive data. Defined system monitoring included system availability, access logs, and maintenance. As this was the first draft of the IAMS documentation and the application was still in the early design phases, some notable items were unable to be defined at this time but were defined in subsequent phases of the period of performance. Those items included determining who the hosting provider would be as well as the fact that some functional requirements had not yet been defined.

For additional details, see contract deliverable Information Assurance Management Strategy 4.4.3 (Information Assurance Management Strategy_4.4.3_W911QY-16-C-0163.pdf).

Research Design and Protocol Development

The Multi-Phased Research Design Document describes the assessment protocol used to implement the multi-phased research design for conducting usability and training effectiveness testing throughout the development of Sen$e. During Phase I, a cumulative Research Design and Protocol document was developed for three assessments that were to occur throughout the design lifecycle, using progressively higher fidelity prototypes. The three assessments included two formative assessments and one summative assessment. Generally, formative assessments included usability evaluations conducted during the first two phases of the project, to help inform iterative prototypes by uncovering any issues early in the design. The summative assessment was conducted on a nearly final product to provide usability benchmarks. The summative assessment was conducted during Phase III of the project.

When content was incorporated into the application, the effectiveness in providing learning gains was evaluated in the summative assessment. The evaluation was based on the New World Kirkpatrick Model (NWKM) of training evaluation (Kirkpatrick & Kirkpatrick, 2016). The NWKM holds the same four Levels of the original model but includes additional explanations within each level. We conducted both Level 1 (Reactions) and Level 2 (Learning) evaluations. Level 1 addressed reaction through the usability aspects of our evaluation. We captured users' responses to guided interactions with Sen$e through measures of satisfaction and perceived usability. Qualitative feedback was collected using think-aloud protocols during these interactions. Level 2 addressed learning, where we evaluated a subset of the training content in the Sen$e application. This was assessed using post- knowledge tests.

The research design and protocol incorporated state-of-science methodologies in conducting usability and effectiveness evaluations and leveraged standardized and validated questionnaires and subjective feedback elicitation methods. The assessments used in the effectiveness evaluation were cross-checked by several members of the project team. The protocols for each of the three-phased approaches all underwent professional institutional review board (IRB) evaluation and all researchers on the project team are certified in human-subjects research through the CITI certification process. For additional details, see contract deliverable MultiPhased Research Design 4.4.5 (Multi-Phased Research Design_4.4.5_W911QY-16-C-0163.pdf)

Usability Protocol Development

Usability testing is a process by which designers can optimize how users interact with a product and can be conducted in both formative and summative fashions, harnessing users' expectations. The objectives of usability testing included: extracting user-expectations of site structure, content organization, and terminology; establishing user-satisfaction and expectations of the UI and functionality; identifying benefits of the interface

and overall application as well as potential design concerns. Discussions took place with researchers, so users could share their interactions with the software as well as their thoughts and concerns while doing so. Usability testing was integral to the success of the software system because the process optimized how users interact with the product. The usability testing produced quantitative (e.g., the time it took to complete a task) as well as qualitative data (e.g., users' overall experience).

The development of the usability protocol included identifying the objectives, participants, tasks (use cases/test scenarios), and testing documents. The objectives included: extracting user-expectations of site structure, content organization, and terminology; establishing user-satisfaction and expectations of the UI and functionality; identifying benefits of the interface and overall application as well as potential design concerns. In order to meet the objectives, researchers identified the desired participants and developed four test scenarios. A test scenario is a description of how users should perform tasks on the Sen$e application. Test scenarios include a list of user actions and the system's response to that action. The desired user actions and system response must result in the achievement of the specified task. Test scenarios were identified by the team based on the available functionality of the application and reflected tasks which are likely to be executed by the end-users.

Once the test scenarios were developed, the research team compiled the remaining documents required to perform the usability assessment. The documents included an informed consent form, researcher script, and pre- and post- questionnaires. The consent form provided potential participants with an explanation of the proposed usability testing and the nature of the participation. This allowed participants to decide whether they want to participate in the testing or not. The script was developed for the facilitators to verbally describe the consent form, purpose of the study, and the tasks participants are asked to perform. The script also described the role of the facilitator, note-taker, and participant. Facilitators used the script to ask participants to think-aloud and respond verbally to several questions as part of a subjective questionnaire. The script also described the questionnaires used in the usability testing, which included a demographic questionnaire, the Satisfaction Questionnaire (SQ; Lewis, 1995), Subjective Usability Questionnaire (SUQ; Lewis, 1995), and System Usability Scale (SUS; Brooke, 1996). The IRB determined the Phase I Formative Testing to be "exempt" under 32 CFR 219.101(b)(2). Therefore, the IRB protocol did not require a higher IRB review.

Formative Testing

Usability Testing

Over the project lifecycle and across all three phases, Sen$e was subjected to iterative usability testing. In Phase I, a formative evaluation on an interactive mockup within InVision allowed the project team to identify issues early in the development lifecycle. The Formative I Usability Evaluation identified benefits of the interface and overall application as well as potential design concerns. Recommendations resulting from the usability evaluation were presented as the basis for design enhancements going forward. Human factors and usability experts conducted a heuristic analysis on the prototype to compare against the usability findings to further support the design enhancements. The findings from the heuristic analysis are integrated into the findings and recommendations throughout the remainder of this section.

Method

Eight participants local to Orlando, FL were recruited to participate in this study. Three participants had previous military experience (one served in the U.S. Marine Corps and two served in the U.S. Army). Researchers provided a brief training to the participants on how to perform a think-aloud procedure. Participants then completed four test scenarios, while "thinking aloud." Meanwhile, the facilitator directly observed their actions and asked questions throughout their interaction. The note taker also observed their behavior, took notes, and asked any questions to help clarify their responses.

The participants' "work flow" or the path taken during each scenario was observed and noted. The team noted critical errors (i.e., deviations from the end targets of the scenario), such as navigating to wrong areas within the application. Participants may or may not have been aware that the task goal was incorrect or incomplete.

Subjective data was collected using a "think aloud" protocol. As each participant executed the scenarios, they were asked to discuss what they were doing and why they were doing it. Additionally, participants completed the SQ (Lewis, 1995), SUQ (Lewis, 1995), and SUS (Brooke, 1996). The SQ is a semantic differential five-item questionnaire that assesses the user's perceived satisfaction with the overall system. Ratings are indicated using 9-point Likert items. The SUQ is a semantic differential questionnaire but is comprised of 16 items broken up into four main categories: 1) screen, 2) terminology and system information, 3) learning, 4) system capabilities. Ratings are indicated using 9-point Likert items. The SUS is a 10-item questionnaire focused on perceived usability of the system and requires users to rate their subjective responses using 5-point Likert items. Finally, participants verbally discussed their likes, dislikes, and suggestions about Sen$e when prompted by the researcher.

Results

Participants performed four test scenarios and although they were partially successful in completing the tasks, the overall first impressions were very positive. Participants felt the application has a strong potential to provide educational information in a unique way. The general perspective across all the surveys was that the application was useful, was rated 'good' in terms of user-friendliness, and has a lot of potential to reach the application goal. The debrief questions asked at the end of the evaluation also helped to capture users' perceived usability and satisfaction with the application. Insights into users' likes, dislikes, and suggested improvements to the application were noted. Through the assessments and responses to the debrief questions, specific recommendations were extracted to help improve the application further. The recommendations were extracted from thematic synthesis of user data and parsed into main categories: navigation, content, interaction, iconography, buttonology, status, authentication, and aesthetics. By categorizing the recommendations, data-driven updates and improvements to Sen$e were prioritized. These findings provided opportunities for maximizing the utility of the Sen$e application for use with our target audience of service members and their families. Together this provided a holistic assessment resulting in valuable end-user recommendations.

For additional details, see contract deliverable FR PAL Formative Testing 1 Results Report 4.4.8 (FR PAL Formative Testing 1 Results Report.pdf).

Application Development

During Phase I, the Sen$e application was defined as being comprised of a mobile application and supporting back-end infrastructure. The mobile application would be used by end-users for accessing the content and tools and the back-end would be for administrative and content management activities.

Mobile Application

Development of the mobile application began by identifying key user stories and goals. Paired with a design direction and aesthetic, those stories were developed into a prototype application. The prototype application was developed using InVisionApp and demonstrated a high-level overview of the user experience of the application. The prototype application covered the onboarding experience, showed how content would be grouped by category, and illustrated how users would browse categories and select specific topics to review.

The original InVisionApp prototype is available here: https://invis.io/BJAC0A8F7.

The overall experience was divided into two parts: browsing/searching available content and consuming content. To give each topic some freedom in how the content was presented, but enforce a consistent aesthetic

and experience, the Adapt authoring tool and framework were selected for content design and development. Additionally, to adhere to current learning standards, the Experience API (xAPI) was selected as the foundation of communication between the content and the rest of the application.

Back-end

Drupal was selected as the content management system for the content in the Sen$e application. Drupal is the leading open-source CMS for ambitious digital experiences and offers a thriving community and rich opportunities for future development and enhancements. Drupal is a PHP/MySQL based CMS and thus requires a dedicated application and database server.

A database server was established to store all application content and user data. Users are identified by their personal email address. It was recommended that the entire database be encrypted using AES with a 128-bit key to ensure security of data at-rest. The database will maintain application-level permissions and application access logs. The server will be protected by a firewall to only allow access by the application server (by default).

An application server environment (Figure 9) has also been established to host the Web application (providing a Web interface for managing content and an API for mobile applications). For a production environment, the recommended server environment is comprised of multiple application servers behind a load balancer to assist in dynamically scaling server resources in response to application demand (Figure 10). The application server is responsible for running the Web application. The Web application provides a Web-based interface for managing application content and an API utilized by the mobile application for accessing content and syncing user data.

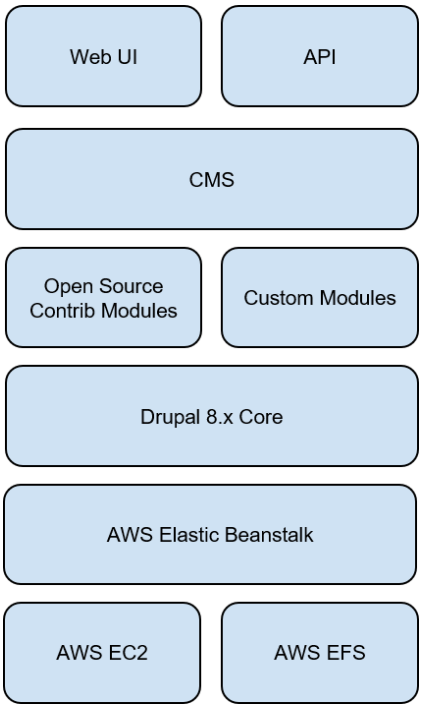


Figure 9. Recommended back-end architecture based on AWS

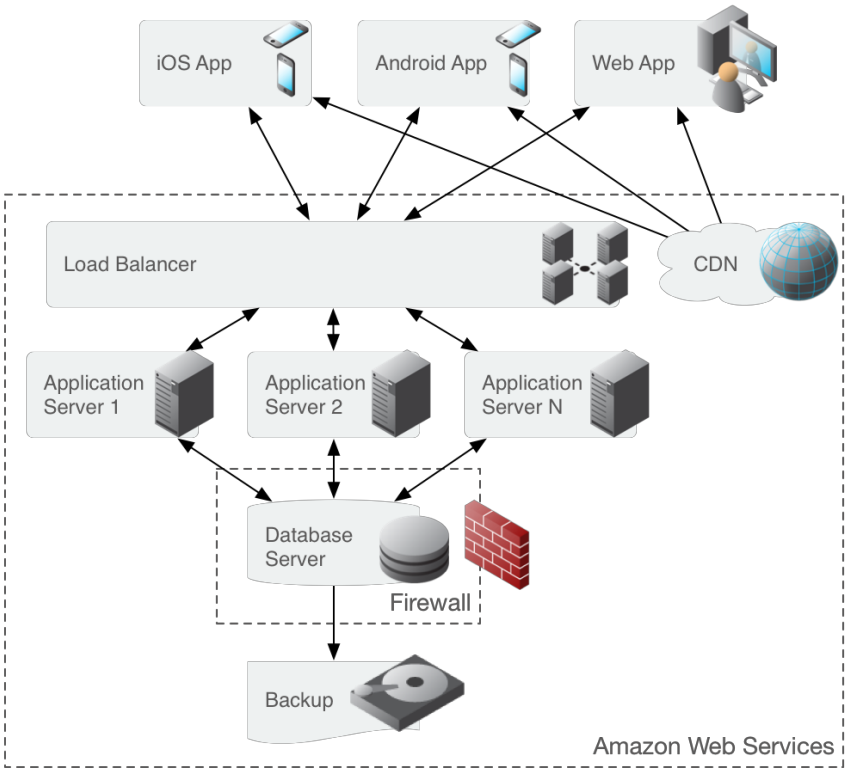


Figure 10. Recommended back-end infrastructure

For additional details, see contract deliverable FR PAL Functional Prototype 4.4.7 (FR PAL Functional Prototype).

5. Phase II

Instructional Design and Content Development

Content Library Ontology

A content ontology is a graphical representation of system information, naming conventions (taxonomy), themes, and relationships between assets within the system. The content ontology allows designers and developers to view system concepts related to the content and content assets at a high level. During Phase II, design strategies for an ontology were fully developed into a graphical representation of the Sen$e content library ontology. The ontology consisted of content (themes, sub-themes, categories), adaptive and interactive elements (contextual awareness, user-centric data), instructional design strategies (mobile learning, multi-media), and analytic measures (tools, app usage, assessments). For the development of the content library ontology, content was sorted and mapped to establish meaningful relationships between content assets. Content mapping is an approach that establishes workflows based on user intent and helps align the content with the needs of the targeted audience. Once the scope of LOs and associated content necessary to meet the those LOs were identified, a content library ontology (Figure 11) operationalized these LOs into an atomized, relational model (representative LOs, their properties, and relationships between them).

High-level themes were developed as the transaction between an individual (the user) and their flow of money which resulted in money coming "In," money going "Out," and money they will "Keep." These terms are

highly elementary; however, they established the foundation for categorizing content based on financial knowledge and behaviors required at each of these junctions. To further define "In," "Out," and "Keep," sub-themes and categories were created on a more granular level and addressed specific content rooted in requirements from military touchpoints.

User interactions and instructional design strategies were outlined for the ontology in tandem to the content categorization. Establishing how content would be presented to the user based on touchpoints, need, or self-guided exploration within the application was presented in the ontology as contextual awareness. Contextual awareness also addressed how potential content adaptation or prioritization could be triggered within the application. Additionally, the content library ontology provided a repository for content media types that were to be included in the application as well as tools and calculators that would be used to support financial literacy and learning. These assets are housed under "Instructional Strategy" in the ontology. Lastly, varying measures and methods for assessing user learning and capturing re user-analytics and user-data were included in the ontology as "Standards" and included knowledge assessments and tool-use.

This strategy was identified to link content with the LOs for each category with their associated touchpoint information. First, LOs were analyzed for presentation relevancy across each of the touchpoints (LOs that seem to logically fall within certain touchpoints and not others). There were cases where LOs were duplicated across multiple touchpoints (e.g., when the LO related to generalized financial information or when it referred to spending plans or budgeting, in which case those financial tools need to be updated periodically and across various touchpoints). After each LO for the category (Savings, Financial Awareness, Expenses and Spending, Debt, and Benefits and Entitlements) was parsed across each of the touchpoints (i.e., Initial Entry Training, Pre-deployment Training, etc.), the associated content was then tailored to include additional information pertaining to that specific touchpoint. In this way, depending on the content prioritization taking place, the user may see content specifically related to them at point-of-need, during a touchpoint occurring in their life, and referencing the content category they selected to view. This content mapping strategy was developed in tandem to the adaptation strategy development in Phase I.

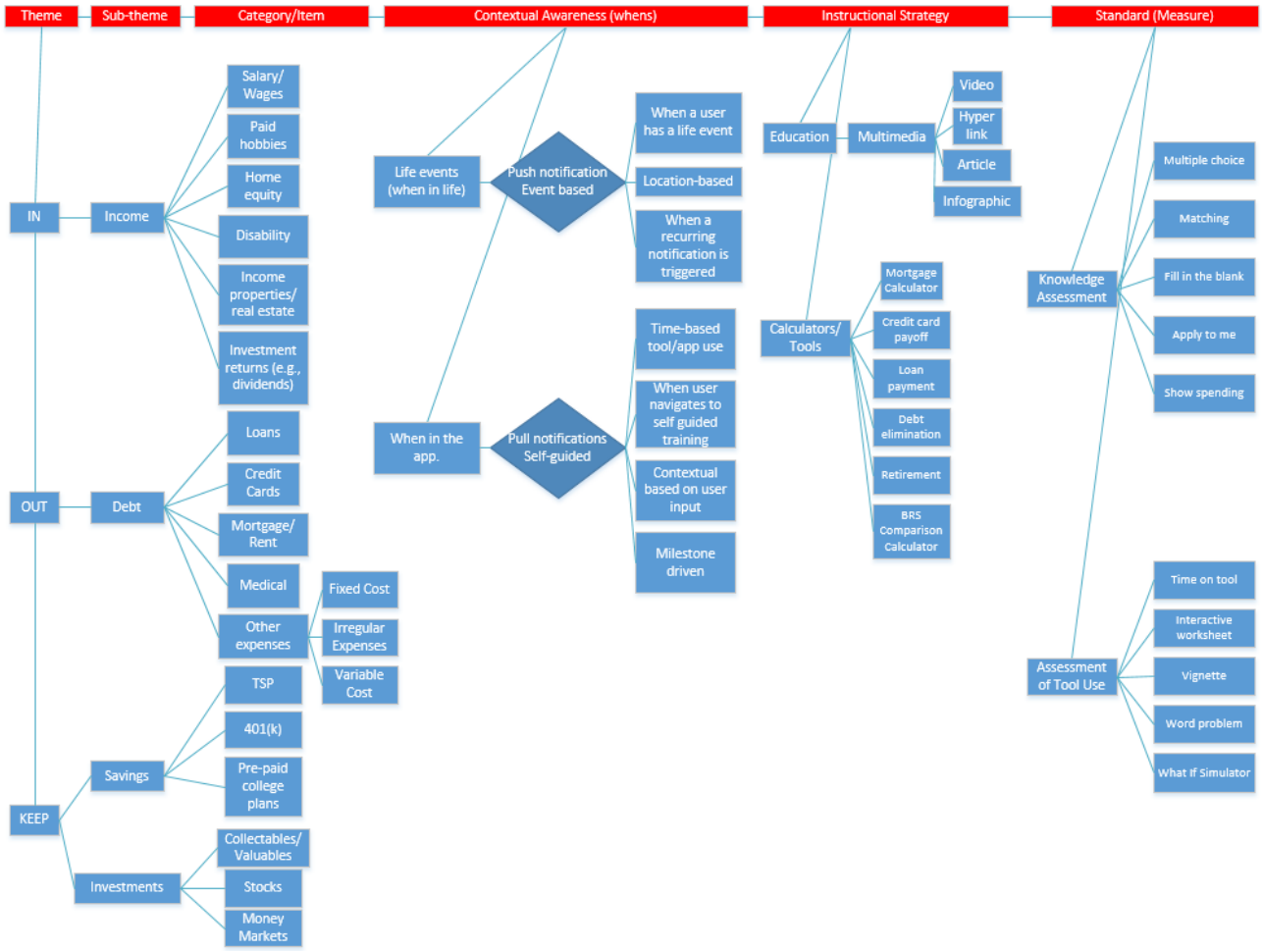


Figure 11. Abbreviated Content Ontology

Learning Objectives

Learning objectives (LOs) are statements about the expected outcome of a student's learning after an instructional intervention (course, class, experiential learning episode, etc.). They help create a foundation of instructional strategy and most often closely follow Blooms Taxonomy of educational objectives (Anderson & Krathwohl, 2001; Bloom, 1956). The LOs created for Sen$e aim to cover broad categories of pertinent financial concepts and financial readiness and were strongly influenced by the front-end analysis. The first iteration of LOs included learner statements about financial awareness, savings, expenses and spending, debt and credit cards, and benefits and entitlements, for example, "Users should know the signs of a legitimate debt management firm," or "Users should be able to know the purpose of the Servicemembers Civil Relief Act (SCRA)." The goals of these LOs were to promote the understanding about common financial terms, how to develop healthy money habits, and how to translate financial plans and goals into actions. They were also used to gain insight on personal financial habits and behavior. After the initial LO statement was written, the LO was then broken down into its component parts, application location was detailed, and methods for assessing user learning was designed. After the LOs were decomposed in this way, they were incorporated into the design of the CDS and wireframes.

Adaptive Content

In Phase I, strategies were developed to deliver a personalized learning experience, in which end users are guided to tailored content. Leveraging concepts from adaptive training, whereby adaptation of content,

instructional methods, or both to support the needs of the learner based on knowledge, abilities, skills, and preferences (Landsberg, Astwood, Van Buskirk, Townsend, & Steinhauser, 2012), tailoring content would facilitate users getting the right information at the right time. The team identified ways to tailor the content for each user. Methods to tailor content are based on macro-adaptation. Macro-level adaptive strategies are often based on characteristics of the learner in which a planned course of action is mapped through existing and available content. These strategies can be employed in order to determine content recommendations as well as adjust content format based on system wide preference settings, for instance, or specified through point of need. In the context of financial literacy, user's demographic information and touchpoints influence the prioritization of content. Prioritizing content based on touchpoints (including those listed in FY16 NDAA Section 661) such as arrival at first duty station, marriage, divorce, birth of first child, disabling sickness or other condition, and planned separation date from the military would offer new content recommendations as new touchpoints occur. Designs for content organization prioritization based on assessment performance were also developed to help further tailor content to the user's needs. Allowing objective data collection opportunities, through the use of assessments, would provide valuable insight into what users know and how they navigate the application. This information can be leveraged in future design iterations, allowing for more robust adaptation to take place across content organization, content presentation, and content recommendations.

Use Case Development

A use case is a document that describes how users will interact with a system to achieve a goal. The use case document details the user input and the expected system response. A use case is written with the user in mind and from the user perspective such that *optimal work flows*, those in which the goal is achieved as efficiently as possible, are considered main "flows." A use case can utilize other design documents as reference points to text descriptions, however high-fidelity mockups are not necessarily a requirement to create detailed and thorough use cases. A task description (user goal), users, necessary pre-conditions to system state, main flow, alternate flows (something outside the purview of the main goal), post-conditions, and any special requirements of the system (e.g., system save data, system logic specific to interactions pertaining to the use case, etc.) are written into the use cases in shall/should statements (Figures 12 & 13). Use cases were developed for the content within partially populated content library to detail user/system interactions for main content and pre- and post-assessments for each of the following sections: Benefits and Entitlements, Credit, Debt, Expenses and Spending, Financial Awareness, and Savings. Each use case developed for these sections contained detailed user actions and intended system responses for every possible interaction contained within each main flow and alternate flow(s). The use cases were also designed to cross-reference other use cases for the system such that pre-conditions and post-conditions could accurately be described within the use case library (all the use cases developed for Sen$e). Only areas that had populated content were detailed in the use cases. Areas of main content per touchpoint or category and associated assessments have use case reference numbers (numeric labelling system assigned to each use case), whereas all other use cases that were designed as placeholders have a reference label *To Be Determined* or *TBD* (e.g., home screen, content section main screens, etc.). The content ontology, node-maps, and other organizational reference materials were paramount during the creation of the use cases to understand the interdependencies, relational models, and cross-references needed for this task. This document is one of many tools used by development and design teams to communicate system specifications for user-centered design.

D.3.0 Debt-To-Income (DTI) Ratio

User should know how to calculate their debt-to-income (DTI) ratio and be able to explain what debt category they fall into, and what that means for them going forward (Text/Infographics)

Description
This 'Debt' section will focus providing information on calculating debt-to-income (DTI) ration, explain the debt category they fall into, and what that means for them. The information will be displayed in a combination of text, infographics, and simple interactions (e.g. input numbers into a text box). Hyperlinks are embedded in the text to bring them to other related content (such as definitions).

Actors
1. Users of this information are all Service members 2. Users that have a verbal/written learning style preference

Pre-conditions
1. User must have logged into the Sen$e application 2. User must have gone through financial awareness initial use case to unlock the rest of the content 3. User must complete the Pre-assessment for this module; Use Case D.3.5 4. User could access this module from in app links if the content has been unlocked after first time use

Flow of Events		
Flow Identifier: Navigate throughout the content and interact with the infographics.		
Step	User Action	System Response
	Tap "Continue on to the module" from D.3.5 Step 5	Navigate to intro content

Figure 12. Example section of DTI Ratio Use Case (description, actors, pre-conditions)

Alternative Flows		
The alternative flows (AF) describe events that occur outside of the main flow. Typically, these events are related to navigation, less common interactions with the system, and interactions related to exiting the system.		
AF 1 – Re-taking the Post-Assessment		
Flow Identifier: Retaking the post-assessment		
Step	User Action	System Response
1	From step 6 of the main flow – user taps to re-take the assessment if the option is presented to them (if they answered any question(s) wrong)	Navigates to the Financial Hurdles post-assessment first screen (step 1 of this main flow)
AF 2 – Navigating to the Financial Awareness Main Screen		
Flow Identifier: Navigating to previous main screen		
Step	User Action	System Response
1	From any step in the main flow - User taps back	Navigates to the Financial Awareness main screen (UC TBD)
AF 3 – Navigating to the home screen		
Flow Identifier: Navigating to the home screen of the application (aka the Sen$e Dashboard)		
Step	User Action	System Response
1	From any step in the main flow - User taps home button	Navigates to the home screen (UC TBD)
AF 4 – Exiting the application		
Flow Identifier: Exiting the application (using the system's hardware)		
Step	User Action	System Response
1	From any step in the main flow - User taps the hardware "home" button	Closes the Sen$e app (to the background) and navigates user to phone home screen
Post-conditions		
1. Financial Hurdles Post-Assessment (Step 1 of main flow) 2. Financial Awareness main screen (UC TBD) 3. Home screen (UC TBD) 4. Exit application (phone home screen) 5. Last screen user was on before accessing the post-assessment		
Special Requirements		
System save parameters		
System shall save the following information: - Fill in		
Post-assessment Access		

After a user has interacted with all the content within the Financial Hurdles content:
 	
- The post-assessment for this content becomes "unlocked" for them to take
- System presents a flag/overlay/popup that says the post-assessment is now available
  o "Congratulations!! You've completed the Financial Hurdles content."
  ▪ Option to take the post-assessment immediately "Take the Financial Hurdles post-assessment now!"
  ▪ Option to take the post-assessment later "Take me back to the Financial Hurdles content main screen to review the content first."		

Figure 13. Example section of Financial Awareness Use Case (alternate flows, post-conditions, special requirements)

Content Architecture

Given the updated priorities, additional LOs were created and associated content was sourced from government and military publications. Given the inclusion of more learning objectives, the content was restructured in an effort to deliver effective and efficient micro-learning modules. Content fell into three main categories. These categories were 1) touchpoints (military career touchpoints – e.g., 1st Duty Station), 2) point of need (personal milestones – e.g., birth of a child, retirement), and 3) general content (e.g., debt, financial awareness). As a result, the team revised the content library to include these terms and created a graphical representation of the content architecture (Figure 14). The content architecture is more detailed than the content ontology library such that the architecture provides the project team an overview of specific content organizational structure, workflow (application dashboard, screen, and page), and implementation of specified learning objectives with associated knowledge assessments.

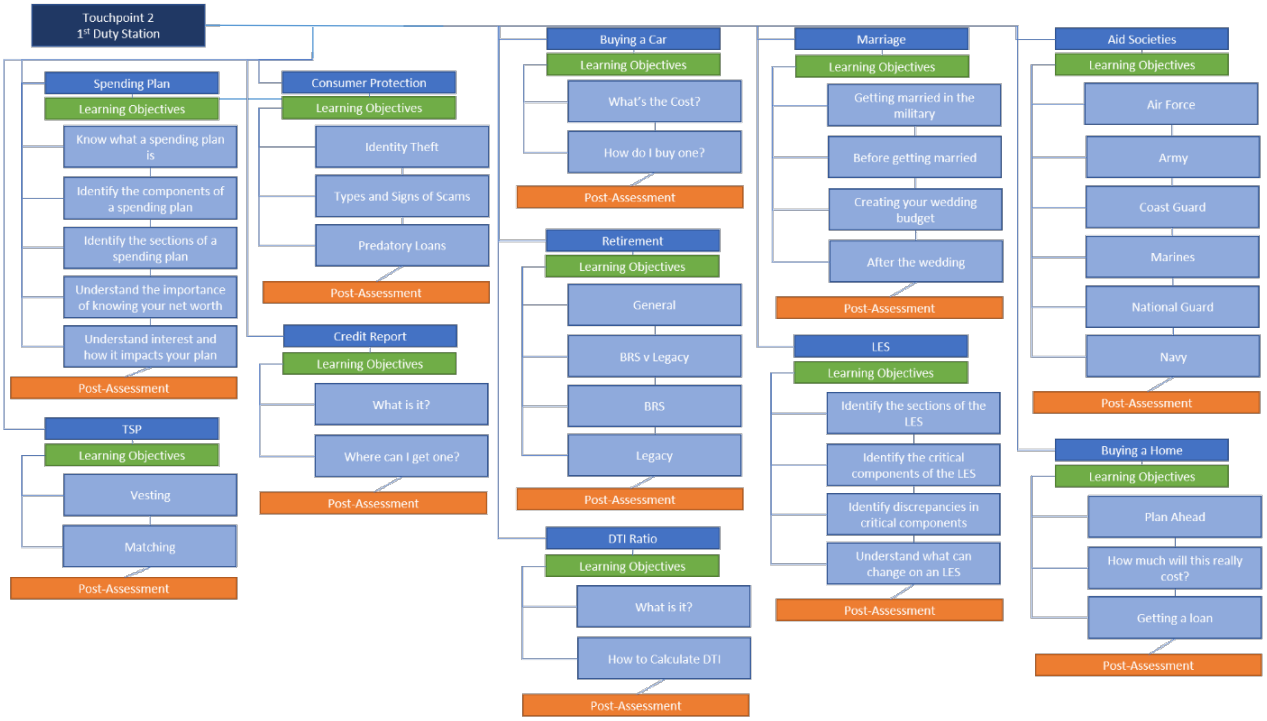


Figure 14. Content Architecture for 1st Duty Station touchpoint

Node-map

A node-map is used as a planning tool in web and application design to visualize the structure of an experience to be designed and developed by a software development team. The node -maps represent each state (or screen) of the application as well as the entry points for that state and the exit paths. These states directly relate to the wireframes to further document how each state works (Figure 15). The node-maps created for Sen$e define interactions for each piece of content characterized in the content architecture. A node-map was created and placed at the beginning of each wireframe document to depict highly detailed, functional interactions between system and user to further detail user workflow. Content presentation style is also captured by the icons represented in each node-map. Icons represent either viewable components such as text or an image and interactive components like a button, overlay, video, flipbook, accordion menu, text box, or filmstrip. Additional icons also represented features such as in-application links, hyperlinks to outside websites, or glossary terms.

At quick glance, the project team can see that "Impact of PCS", for instance, contains textual and graphical assets, has several interactive components (buttons, glossary items, and overlays) and roughly five states (LO screen, main content screen, two overlays, and a post-assessment screen).

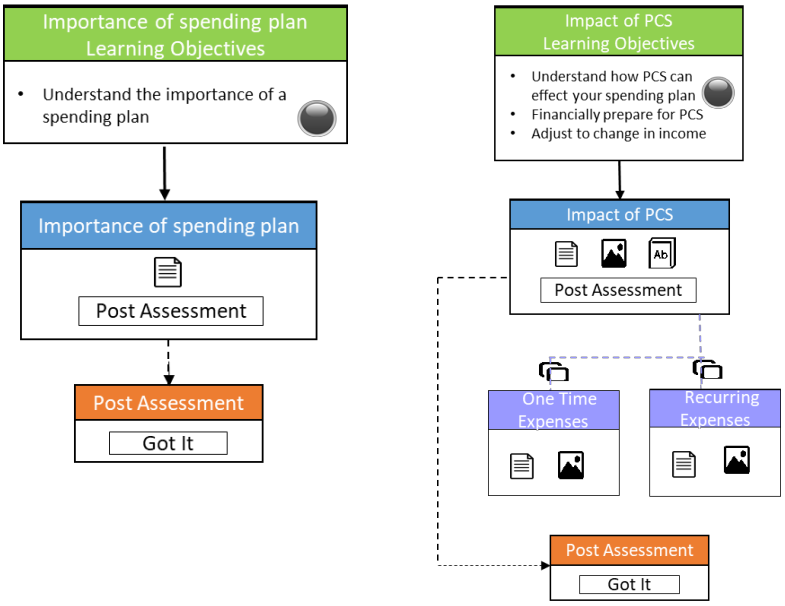


Figure 15. Example node maps for "Touchpoint – Subsequent Duty Station," "Spending Plan"

Wireframes and Mockups

Wireframes are a vital part of the design phase in order to convey content design and composition. Hierarchical typography choices, image size and placement, navigational design, and user experience design were all explored at this phase in order to confirm the design was functional. In each wireframe, key interactive elements were annotated with a more detailed description regarding their expected functionality. The wireframes were delivered alongside the node map. Designed in a collaborative fashion by the development and the design team, wireframes served as a foundational deliverable and are a crucial part of application design. A wireframe is more of an engineering document than it is an artistic document, with the emphasis on completeness and accuracy rather than artfulness (see Figure 16).

Wireframes were reviewed in a presentation to allow the production team to provide a narrative to the design as well as field any initial questions regarding why certain design decisions were made. Iterative changes produced improvements to some elements within the initial wireframes, however, the intent of the UI/UX in the wireframes was a solid foundation for development and testing.

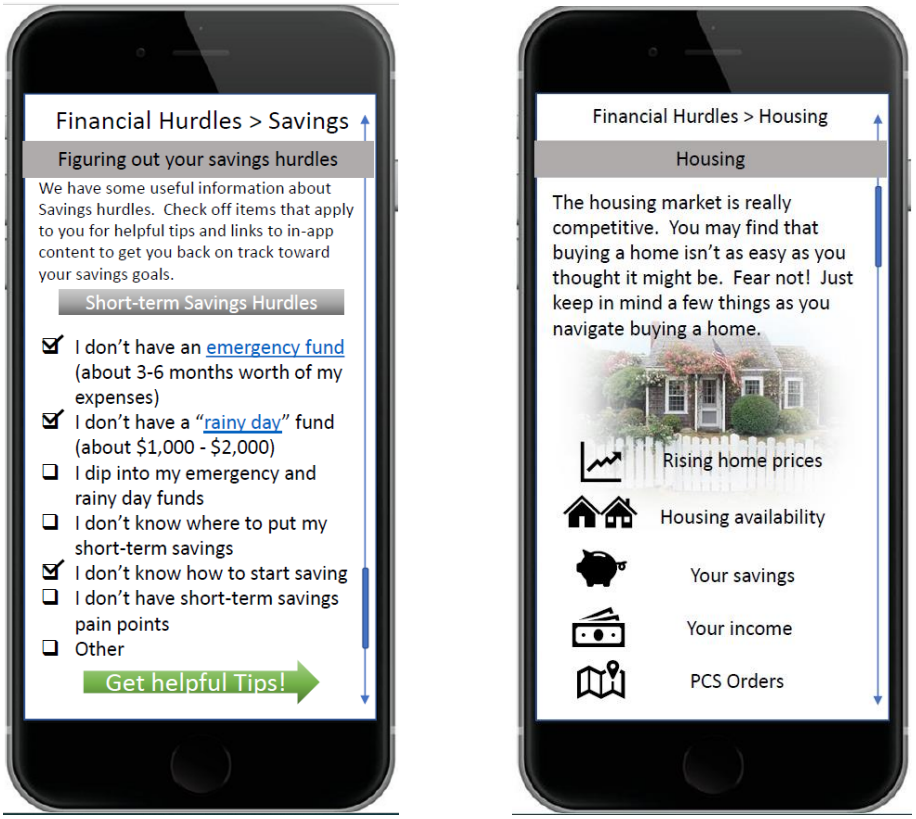


Figure 16. Example wireframes created in Microsoft PowerPoint

A design mockup is a full expression of the UI for the experience. A successful mockup is easily translated to design by a development team with a minimal confusion. Mockups can be very time consuming to produce based on fidelity of the renderings. Special attention also needs to be made to keep mockups current, as the design evolves or the development effort demands. Because mockups are so time-consuming to produce, mockups are often only produced for "key" application states (while wireframes are typically created for each application state; see Figure 17).

Produced by the design team, under advice (input and high-level direction from the developers), the mockups were reviewed to identify graphic design areas for enhancement and issues. This included elements like color, image choice(s), final font, and typography layout, etc. At this point, UI control elements and UI layout were approved and verified during the wireframe phase. Once updates were made to fix issues brought up during the team review, the mockup was shared with the software development team.

Figure 17. Mockup screen examples

Motivational Elements

To encourage continued use and engagement with the application, various types of motivational elements were identified for inclusion in the design and development of Sen$e. Engagement with the application and continued motivation to use the application was addressed by instantiating gamification elements within and throughout the entirety of the application. A popular countermeasure to mitigate boredom and the loss of motivation is incorporating gameplay. Games are empirically found to influence the learners' motivational processing through game appeal, game involvement, and game structure (Huang, Johnson, & Han., 2013). Hamari, Koivisto, and Sarsa (2014) further identified the gamification elements that are empirically supported to involve motivational affordances. These elements include points, leaderboards, achievements/badges, levels, story/theme, clear goals, feedback, rewards, progress, and challenge.

Leveraging the Marketplace Competitive Review data for application "best features" and in-house expertise in the field, elements for motivational engagement were identified. Featured gamification elements under consideration include tools to track learner progress through content and materials (pre- and post-assessments, progress bar), system usage feedback, ability to favorite or like content, development of an avatar, creation of user profiles, mini-games that will leverage financially complex materials as game content, and a points and scoring system which will overtly gamify the UI to support engagement. In Phase I, these motivation elements were identified and included in the content ontology throughout various levels as a system-wide gamification strategy.

As the mockups were being developed, additional motivational elements were incorporated. These motivational elements include but are not limited to games, knowledge assessments, Green Pig, and a point system.

Games

Games were created to leverage learning within the application and allow the user to apply their knowledge. Games are also an innovative tool to help distinguish Sen$e from traditional content or tool driven financial applications. By transforming financial content into interactive gameplay, engagement and immersion in the application could be enhanced. The project team first created conceptual drafts of several mobile-based games that drew inspiration from popular game genres like action, adventure, trivia, simulation, puzzle, role playing, strategy, and casual game genres Concept game names included Whack-a-Goal, Journey to Hale Crater, Money Mummy, Credit Score Power Plant, Word Scrambler, Finance Ninja, and Battle Ship. The goal was to create financial games that would appeal to the diversity of end-users (e.g., from initial entry service members to retired spouses) represented in the application. Moving from the initial concept, several game ideas (e.g., Word Jumbler, Financial Carnival, Word Search) were selected based off feasibility and alignment with overall project needs. These ideas were further fleshed out into a detailed conceptual game design document to track the overall gameplay concept, such as the storyline or game environment and visual style. The gameplay UI, mechanics, controls, scores, and feedback were all included in the Game Design Document. Questions as well as correct and incorrect answers were also derived for the sourced content in the mockups. Game mockups were then created in addition to content libraries and game logic algorithms, to be handed off to the developers for development and integration into the application. Further details regarding the integrated mobile games are described below:

Word Jumbler: Users are asked to unscramble four jumbled financial terms containing letters that reveal the answer to a financial question. Key financial terms were extracted directly from the content and were organized in Excel according to content section. Each content has its own Word Jumbler that contains content specific terminology in addition to the overall Word Jumbler that is located in the main Games and Resources section that contains terminology from all content areas. This game follows an adventure-style puzzle game, where users embark on an adventure with their guide, *G.P. Jones* (Green Pig Jones), to complete quests, or financial jumbles, to uncover pieces of the adventure map. The setting is an ancient jungle containing archeological artifacts that can be earned, along with points, as the user completes more quests and unlocks more pieces of the adventure map. The use of rewards, a point system, and the transparency of the user's progress come together to support user engagement and motivation within the game. The landing screen for this game can be seen in Figure 18.

Figure 18. Landing screen for Word Jumbler game

Financial Carnival: Embodying the classic carnival theme, users are prompted to answer financial trivia questions from Hambone the clown to obtain darts for a virtual dart table that is presented after completing the questions. By tapping on a moving green pig, players can attempt to pop the pigs with the darts. Players are motivated to correctly answer the trivia questions in order to maximize the amount of darts earned. Financial concepts are tested through targeted questions that were extracted directly from each content area. Users can either access the Financial Carnival game in each content for content-specific questions, or in the Games and Resources menu that tests all financial concepts presented in the application. The landing screen for this game can be seen in Figure 19.

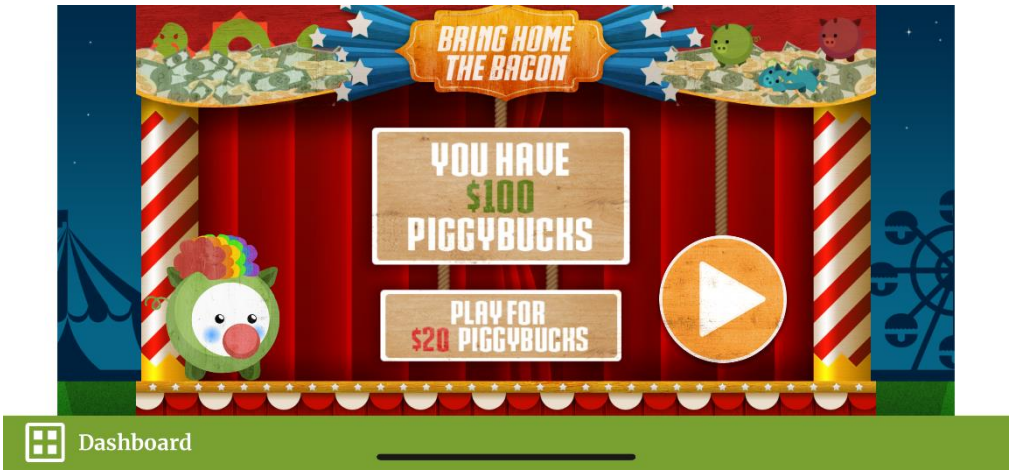


Figure 19. Landing screen for Financial Carnival: Bring Home the Bacon game

Word Search: Encompassing the classic pen and paper Word Search puzzle, A financial Word Search game was created that tests user's knowledge of key financial terms used in the application. A glossary was generated in Excel that accurately captures the full scope of financial terms. Users swipe up, down, left, and right, to highlight terms and upon each successful word identification, a pop-up reveals the term definition. Users can earn points by successfully locating all financial terms in a given word search. Further motivation is achieved by including a timer that challenges the users to complete the word search as fast as possible for more points. The landing screen for this game can be seen in Figure 20.

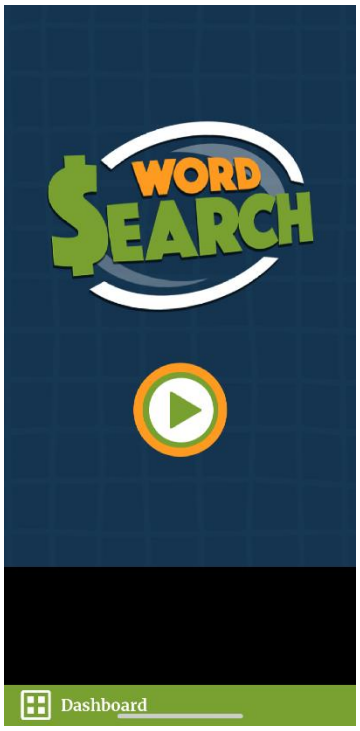


Figure 20. Landing screen for Word Search game

Knowledge Assessments

Post assessments were created based on the LOs and sourced content. The post-assessments are scenario-based questions, which gauge the user's understanding of a specific financial subject (Figure 21). The content author and team reviewed the assessments to check for errors and typos as well as to verify that the questions and answer choices corresponded with the content.

Figure 21. Example wireframe of a Knowledge Assessment

Green Pig

Green Pig was a pedagogical agent developed to create motivation by creating a more entertaining, likeable, and engaging environment within Sen$e. Pedagogical agents are frequently seen in eLearning environments and can be used to enhance learning by facilitating effective communication between humans and machines. Green Pig was designed to resemble a green piggy bank because of the established use of piggy banks as a financial symbol, and because of associations between green and money, as well as green and the military. Green Pig has a simple persona of a financial pal who presents dense financial information into user-friendly learning, highlights important information, and provides a personal feel to the application, while giving the users something to connect with. Green Pig went through an iterative process that started with a concept of a simple green pig that was incorporated into wireframes and mockups early on. Based off end-user and customer feedback, Green Pig was iterated on to include more personalization and human elements like the design of different Green Pig personalities (e.g., Wizard Green Pig', 'Snow Day Green Pig', and 'Surfer Green Pig') through character costumes and speech bubbles (see Figure 22 for concept variant of Green Pig). Content wireframes and mockups were designed with the rethemed Green Pig and delivered to the developers for integration into the application.

Figure 22. Concept variants of Green Pig

Progress Bar and Tracking System

A progress bar is a graphical, feedback representation of progress through or percent-complete. Users can monitor progress by this standard GUI element. Generally, it is suggested users prefer feedback about progress (Branaghan & Sanchez, 2009), and that progress bars may provide encouragement to users (Villar, Callegaro, & Yang, 2013). To represent percent-complete in any one area of content, the use of a progress bar was instantiated into the application design. This variable-rate progress bar measures viewed content compared to all content within a particular section. To view all content will include expanding every accordion menu and viewing each page of a flipbook or film strip interaction (for example). The progress bar will track progression through content in this way (Figure 23).

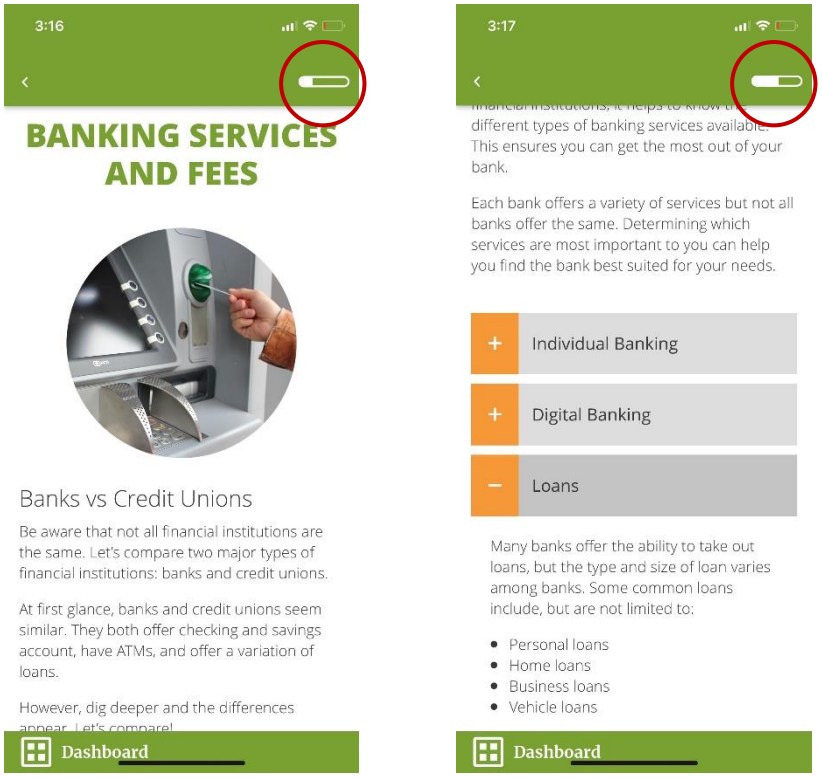


Figure 23. Progress bar example

Iterative Review Process

The sourced content was large, in breadth, volume, detail, and scope. Additional supplemental content was created for each of the content categories and touchpoints like a *Tips of the Day* feature, glossary terms and

definitions, as well as a library of all verified weblinks for inclusion in the application (i.e., hyperlinks). Interaction node maps were created to illustrate user interactions and system response as well as the updated content architecture. In order to maintain content accuracy and versioning control, content creation underwent an iterative review process.

The review process for developed content can be seen in Figure 24. Of note, the content underwent various reviews from the project team, the development team, management, and a subject matter expert. Upon completion of each review, changes and refinements were incorporated. Once the content was determined to be complete, the ancillary features and functions that were impacted by new content were updated and reviewed. This included a review of LOs, tips of the day, glossary terms and their definitions, post assessments, and interaction node maps. For additional details, see contract deliverable Financial Readiness Content Library (Partially Populated) 4.4.12 folder containing files for pre- and post-assessments word files, mockup PDFs, and use case word files.

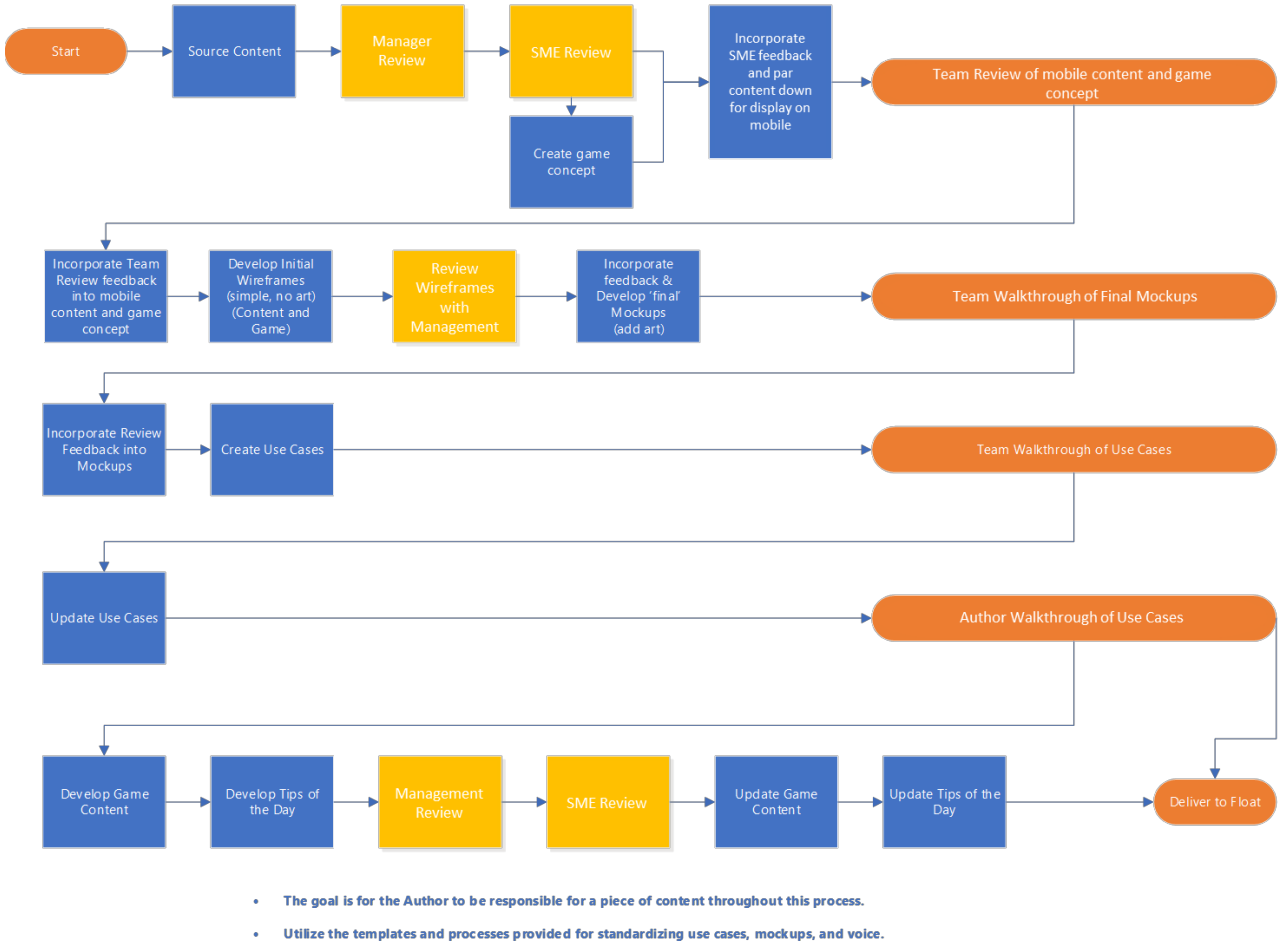


Figure 24. Content Development Review Process

Requirements Collection

Requirements continued to be derived and refined throughout the beginning of Phase II. Requirements were derived from the Phase I formative testing as well as additional knowledge elicitation activities and meetings with stakeholders. As new requirements were identified, and old requirements were modified, the relevant design artifacts were updated including the content ontology, learning objectives, content, mockups, etc.

The formative results enabled a user-centered design, and recommendations were incorporated into the prototype. The design team also had an opportunity to speak with participants of the Office of Financial Readiness Microlearning Event held in Alexandria, VA. Participants of the 3-day microlearning event consisted of financial readiness policy-makers, curriculum developers, and financial advisors, all of whom currently hold leadership roles in their respective Services (Army, Navy, Marine Corps, Air Force, Guard), responsible for the execution of financial readiness training within their Service. Additionally, individuals responsible for the Transition curriculum and individuals from the Consumer Financial Protection Bureau were present. The event was used to determine microlearning training topics being developed by FinRed separate from development of Sen$e, however, Sen$e utilizes microlearning concepts and may leverage the microlearning content being developed. During the event, a concept mapping task took place to elicit top level priorities and financial concepts by touchpoint membership. Figure 25 depicts two touchpoints and associated financial concepts.

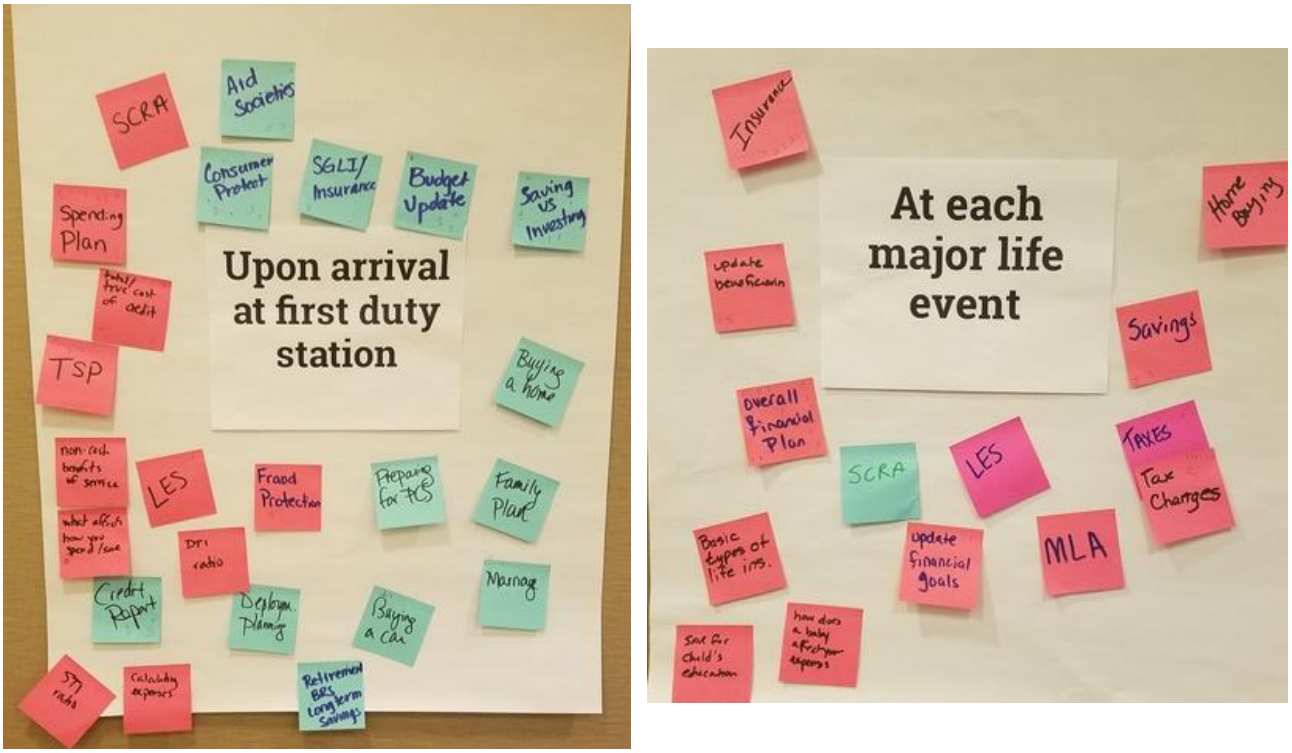


Figure 25. Concept map for touchpoints at the Financial Readiness Microlearning Event

This activity yielded priority issues across the military touchpoints for each branch of the service (Table 3).

Table 3.
Service-identified Financial Priorities per 10 U.S. Code § 992 Touchpoints

Touchpoint	Main Topic
At Entry Training	LES
Upon Arrival at First Duty Station	Spending Plan
Upon Arrival at Each Subsequent Duty Station	Update your Financial Plan
Upon Promotion	Adjust your Financial Plan
When Vested in TSP	Matching
When Entitled to Receive Continuation Pay	Tax Implications
At Each Major Life Event	Overall Financial Plan
During Leadership Training	Identify Appropriate Resources / Recognize Warning Signs
During Pre- and Post-Deployment Training	Budget / Changes in Pay / Pay Entitlements
At Transition Points	Managing TSP / Budget
As Part of Required Recurrent Training	Finance Overview

With new priorities in place, the team conducted a gap analysis to identify which priorities did not already have content. The team began sourcing additional content from government and military internet sources once they identified the gaps within the content.

For additional details, see contract deliverable Financial Readiness PAL Requirements Report Update 4.4.9 (Financial Readiness PAL Requirements Report Update_4.4.9_W911QY-16-C-0163.pdf).

Information Assurance Design and Implementation

The interim Information Assurance Management Strategy (IAMS) documentation was updated during Phase II with additional information that was a result of additional design and development activities throughout the phase.

The document was clarified to be more specific about the types of personal information would be tracked based on the content design and development. Additionally, the encryption strategies were broadened to ensure the entire database was encrypted at-rest instead of individual fields. The document was peer reviewed by the project team and delivered in September 2017.

For additional details, see contract deliverable Information Assurance Interim Documentation 4.4.10 (Information Assurance Interim Documentation_4.4.10_W911QY-16-C-0163.pdf).

Application Development

During Phase II, the prototype application from Phase I was formalized and developed into a working proof-of-concept iOS and Android application.

The application was created using Microsoft's Xamarin development environment and the UI was developed using the open-source Xamarin Forms cross-platform UI framework (Figure 26). The Xamarin toolkit allows for native iOS and Android applications to be developed from a shared codebase. About 80-90% of the application code base is shared between the iOS and Android applications. The shared code base allows for better feature parity and lower maintenance costs between the two platforms. The mobile application supports

iOS 10 and later and Android 5.0 and later. The UI is optimized for the phone form factor but is responsive and supports larger screens.

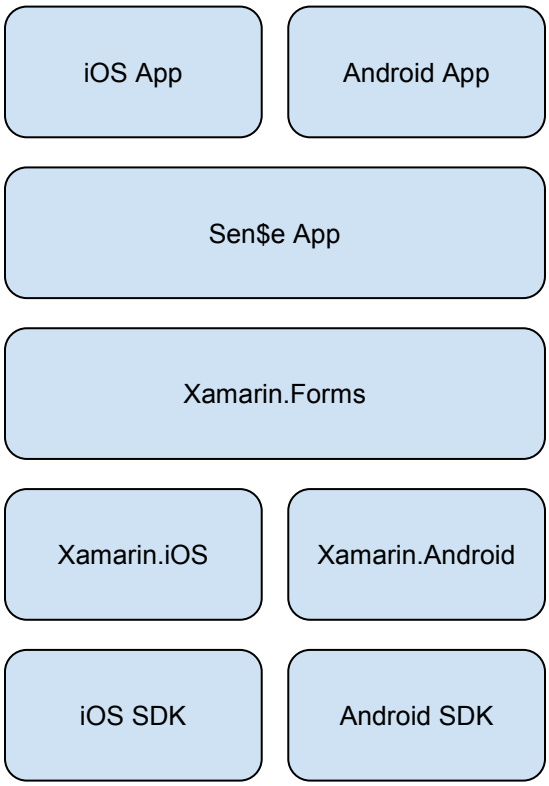


Figure 26. Mobile application architecture

Throughout Phase II, a series of alpha and beta builds were released through HockeyApp and demonstrated the continuously evolving capabilities. Bugs were tracked based on feedback from the QA team and the client. Crashes and other errors were automatically tracked using HockeyApp's crash reporting functionality. A final build was released via HockeyApp in September 2017.

Additionally, a custom theme was developed for the Adapt framework to provide a consistent visual aesthetic between the native application and learning content. All approved content was implemented in the Adapt framework and added to the application. The application also featured three games to help enforce key financial concepts and terminology.

Back-end

A simplified version of the recommended back-end infrastructure was implemented for Phase II. Because the expected number of users was going to be low, a load balancer and CDN were not yet necessary.

A Drupal CMS was configured and further customized via a variety of contributed and custom modules. Custom modules were developed to enable email-based user authentication, provide a JSON API for use by the mobile app, enforce security controls identified in the IAMS document, track awarded points, and provide tools for importing and managing application content.

At the close of Phase II, the back-end was implemented in AWS to provide a stable evaluation environment for user testing and client review. An EC2 instance was provisioned for the application server with and RDS instance for hosting the database.

For additional details, see contract deliverable Back End Architecture 4.4.2 (Back End Architecture_4.4.2_W911QY-16-C-0163.pdf) and contract deliverable Financial Readiness PAL Functional Prototype Phase II 4.4.13 (FRPAL Functional Prototype_4.4.13_W911QY-16-C-0163.iOS.ipa; FRPAL. Functional Prototype_4.4.13_W911QY-16-C-0163.apk).

Formative Testing

The second round of Formative Testing, during Phase II of the period of performance, leveraged the multi-phased research design that was delivered during Phase I. The research design and protocol focused on the usability of the Sen$e interfaces, user flows, and other aspects of the application that were currently available at the time of Phase II testing. The development of the research design and protocol followed state-of-science methodologies in conducting usability evaluations. This included leveraging standardized and validated questionnaires and subjective feedback elicitation methods. The protocol for this Formative II Usability Evaluation approach underwent professional IRB evaluation where the IRB determined the Phase II Formative Testing to be "exempt" under 32 CFR 219.101(b)(2). Therefore, the IRB protocol did not require a higher IRB review. Furthermore, all researchers on the project team were already certified in human-subjects research through the CITI certification process.

Method

Five users local to Orlando, FL were recruited to participate in this study. Five users had previous military experience (one U.S. Marine Corps, one U.S. Navy, one U.S. Coast Guard, and two served in the U.S. Army). The alpha version of the application was presented on either a Galaxy S7 phone with the Android operating system or an Apple iPhone 7 with the iOS operating system. Users performed the tasks on the type of device they indicated they were most comfortable using. Researchers provided a brief training to the participants on how to perform a think-aloud procedure. Participants then completed six test scenarios, while "thinking aloud." Meanwhile, the facilitator directly observed their actions and asked questions throughout their interaction. The note taker also observed their behavior, took notes, and asked any questions to help clarify their responses.

Test scenarios were identified by the team based on the available functionality of the application at the time of Phase II testing and reflected tasks which are likely to be executed by the end-users. The test scenarios were as follows:

The participants' 'work flow' or the path taken during each scenario was observed and noted. The team noted critical errors (i.e., deviations from the end targets of the scenario), such as navigating to wrong areas within the application. Participants may or may not have been aware that the task goal was incorrect or incomplete.

Subjective data was collected using a "think aloud" protocol. As each participant executed the scenarios, they were asked to discuss what they were doing and why they were doing it. Additionally, participants completed the SQ (Lewis, 1995), SUQ (Lewis, 1995), and SUS (Brooke, 1996). Finally, participants verbally discussed their likes, dislikes, and suggestions about Sen$e when prompted by the researcher.

Results

This usability evaluation identified benefits of the interface and overall application as well as potential design concerns. Benefits included the clean, intuitive, and simple design and display of information while there were some concerns with respect to navigation, content organization, and interaction with the system. Overall, users

liked the idea and direction of the Sen$e application and described it as a "one-stop-shop" for obtaining pertinent financial information. This bodes well for the breadth of the application's target audience. Aligning with our goal, users were able to efficiently extract key information by quickly entering and exiting the application. This experience is reflective of how users are expected to use the application in the real-world. While current financial applications overload the user with too much information, Sen$e successfully balances between too much and too little by presenting content in bite-sized and manageable chunks. Users across the board found the content to be straightforward and useful, and they appreciated the option to explore content in more detail through overlays, accessing content outside of the application, and exploring infographics and accordion content. Users specifically liked the integration of an accordion design to help manage large chunks of information by intuitively revealing and concealing information. In general, the navigation and interaction were intuitive and met the user's expectations when tapping on hyperlinks, exploring different types of menus and scrolling through the content. Specifically, users liked how the backwards navigation returned the user to their previous position, the "mentally comforting" loading screen, and the ability to update preferences and demographics in the user profile at a later date. In general, users enjoyed having a mascot for Sen$e although they recommended creating a new mascot that was more reflective of the military. While the overall impression of the Sen$e application was very positive, user actions indicated room for improvement in how content is organized, clarity of interactions, and general aesthetics.

For additional details, see contract deliverable FR PAL Phase II Formative Test Report 4.4.14 (FRPAL Phase II Formative Test Report.pdf).

Lifecycle Planning and Documentation

A Lifecycle Planning and Documentation effort was also completed in Phase II to ensure there was an adequate plan in place to allow for sustained use and maintenance of the application.

The key focus of the document was to offer recommendations for technical maintenance of the application (both the mobile application and supporting back-end). The document provided:

- an overview of the entire system,
- implementation recommendations based on using AWS as the hosting provider,
- suggested processes for monitoring the system, providing end-user support, and analyzing how users are using content, and
- requirements for maintaining each system component.

For additional details, see contract deliverable Interim Lifecycle Sustainment Plan 4.4.11 (Interim Lifecycle Sustainment Plan_4.4.11_W911QY-16-C-0163.pdf)

6. Phase III

Information Assurance Design and Implementation

The IAMS document was updated to clarify recommendations for the back-end infrastructure, but the implementation details were removed now that the Office of Personnel Management (OPM) is responsible for the implementation and long-term maintenance.

The security controls and other functional protocols remained unchanged from phase II.

For additional details, see contract deliverable Information Assurance Final Review 4.4.15 (Information Assurance Final Review_4.4.15_W911QY-16-C-0163.pdf).

Instructional Design and Content Development

Iterative Review Process

Throughout the development lifecycle and through Phase III, the project team continued to iteratively review content. As the review process extended outside the project team to include customer review feedback (through thorough, expert working groups), the instructional design and content development strategies adapted to not only incorporate the feedback, but to improve upon system usability, content accuracy, and content presentation within Sen$e. A review process was put into place to manage and mitigate version issues as well as prioritize and execute the instantiation of recommended improvements, feedback updates, and addressed review comments. The review process guided the extensive asset management across expert comments/feedback, the project team investigative reports, pre- and post-working group adjudication, integration strategy, content development and refinement, quality assurance (QA), and final incorporation. To track comments and subsequent updates to content, all comments were first entered into a spreadsheet (with a separate sheet for each section). Each comment was entered into its own row, with separate columns to track pertinent information, such as the slide number and reviewer. Once all comments were entered, they were reviewed by the project manager and were assigned one of the following categories: 1) "incorporate" if the comment was to be incorporated into updated content; 2) "do not incorporate" if the comment should not be incorporated into the content; 3) "investigating" if the content required investigation by the content author to determine the path forward; 4) "discuss" if the meaning of the comment was unclear and required discussion with the commenter; or 5) "duplicate" if there was more than one of the same comment, then the first comment would be categorized as above and the remaining would be marked "duplicate." A separate column described a path forward that detailed how to make changes, if the comment was to be incorporated. If there were any items marked as "discuss," a working group meeting was held to determine a path forward, after which a new category (as indicated above) was marked in a new column. Once decisions were made about the path forward for each comment, the author would update the content and described the changes that were made to the content, the date changes were made, and the new slide number (if appropriate) in separate columns. A final quality assurance editor reviewed the comments and the updated content to determine whether updates sufficiently addressed the comment and indicated whether the comments were addressed in a new column.

Comments were considered "closed" if any one of the following conditions was met.

1. It was marked as "incorporate" **and** the content was subsequently updated to address the comment.
2. It was marked as duplicate.
3. It was marked as do not incorporate.

A separate spreadsheet was created to manage statistics of comment status for all content sections. This sheet contained formulas to track the number of the comments in each section (based on a count of the number of comments), the number of comments in each category before and after working group meetings (based on a count of each category type), the number comments that were addressed in content updates (based on a count of the "incorporate" comments that had author comments about changes made), the amount of comments that had received a quality assurance review (based on the percent of "incorporate" comments that were adequately addressed in the updated content), and the number of closed comments (based on the number of comments that met any of the completed conditions above). Figure 27 outlines the review process for content updates and quality assurance tasking that took place during continued content development tasking.

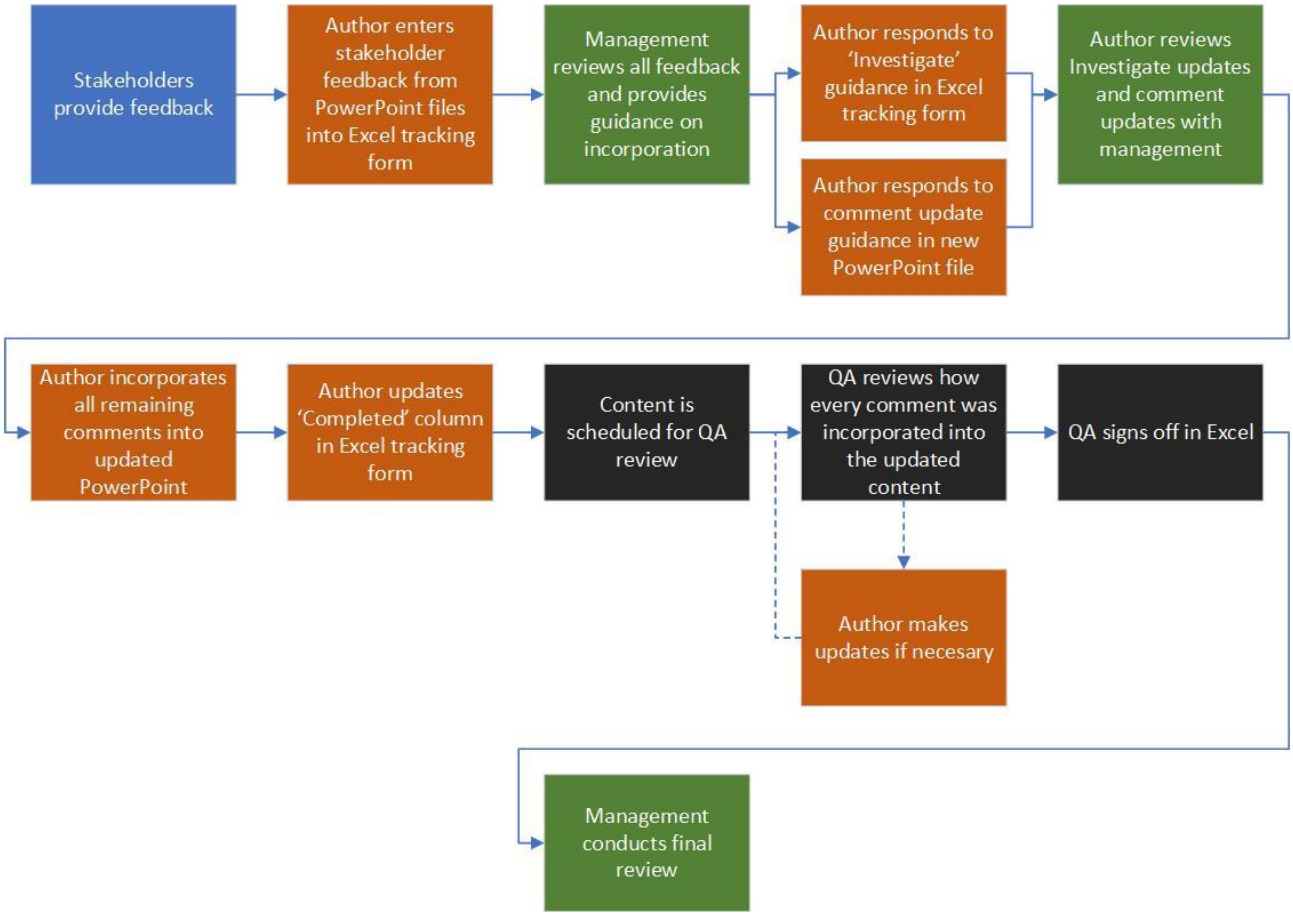


Figure 27. Review Process for content updates and quality assurance

Keyword Library

To aid in the creation of the search functionality of the application, a keyword library was created for all content and the respective content categories and touchpoints (17 categories in total). Keywords or key phrases were entered in the library based on association with the content, glossary items, *buzz words* (notable words found in content sourcing), common search terms, and word derivatives (plurals, acronyms, conversational terms, etc.). For example, Vehicle Purchasing content resulted in key words/key phrases such as "APR," "annual percental rate," "car," "vehicle," "auto," etc. Across all content categories, over 4,000 words and phrases were populated in the keyword library for potential inclusion in the search functionality logic.

Formalized Glossary

Across all phases of content development, definition terms, key items of interest, and uncommon/unfamiliar terms had been identified for inclusion in a complete formalized Glossary (Figure 28). Terms and associated reference citations were categorized and then alphabetized into a complete file for inclusion into a Glossary section within the application.

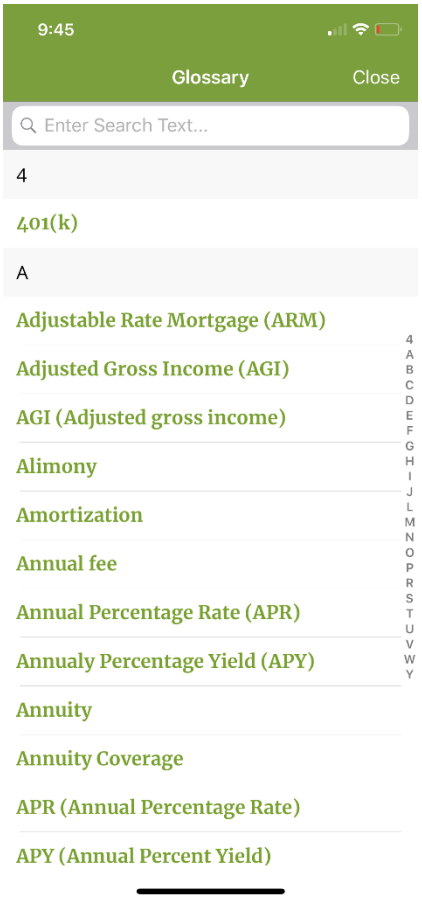


Figure 28. Formalized Glossary

Formalized "Tips of the Day"

Leveraging similar strategies used in the creation of the formalized Glossary, "Tips of the Day" for each content section were created. Tips of the day are any interesting fact, uncommon financial information, or helpful strategies found while content sourcing. Tips range in variety, financial category, and either contain action items, links, or just helpful tidbits of information for the user. A strategy for providing tips at scheduled,

periodic events as push notifications was developed (Figure 29). An extensive library of tips was compiled and categorized. Over 360 tips (at least one per day) were created for inclusion into the Sen$e content.

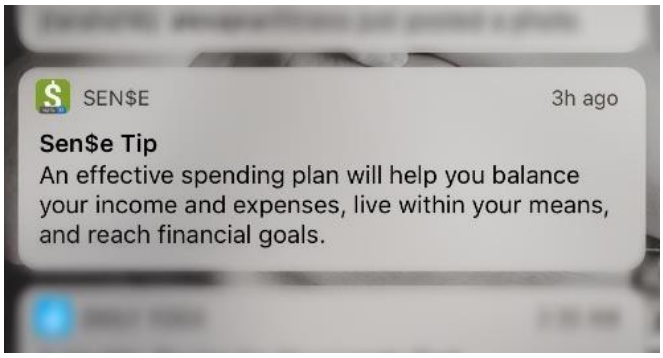
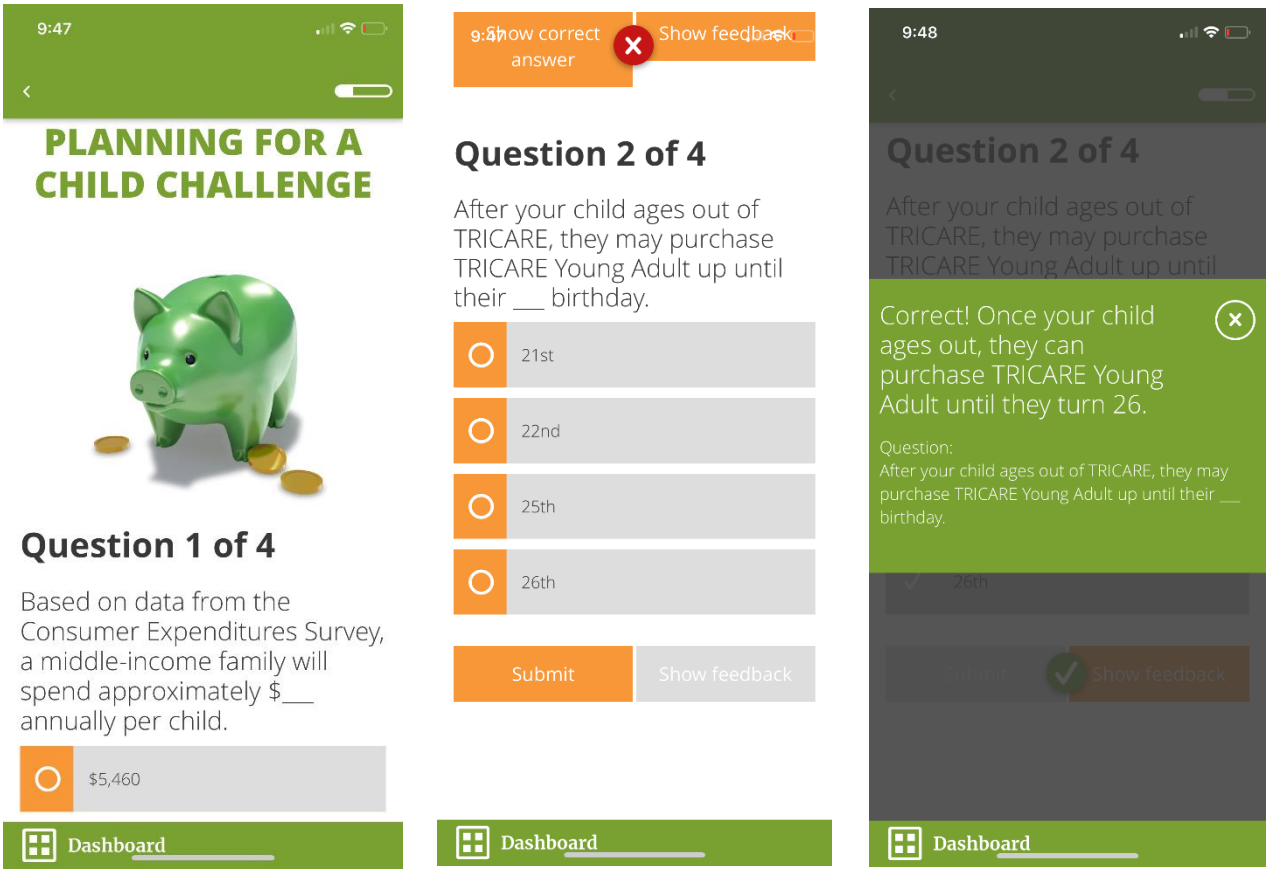


Figure 29. Example of a tip of the day being pushed to notifications

Formalized Knowledge Assessments

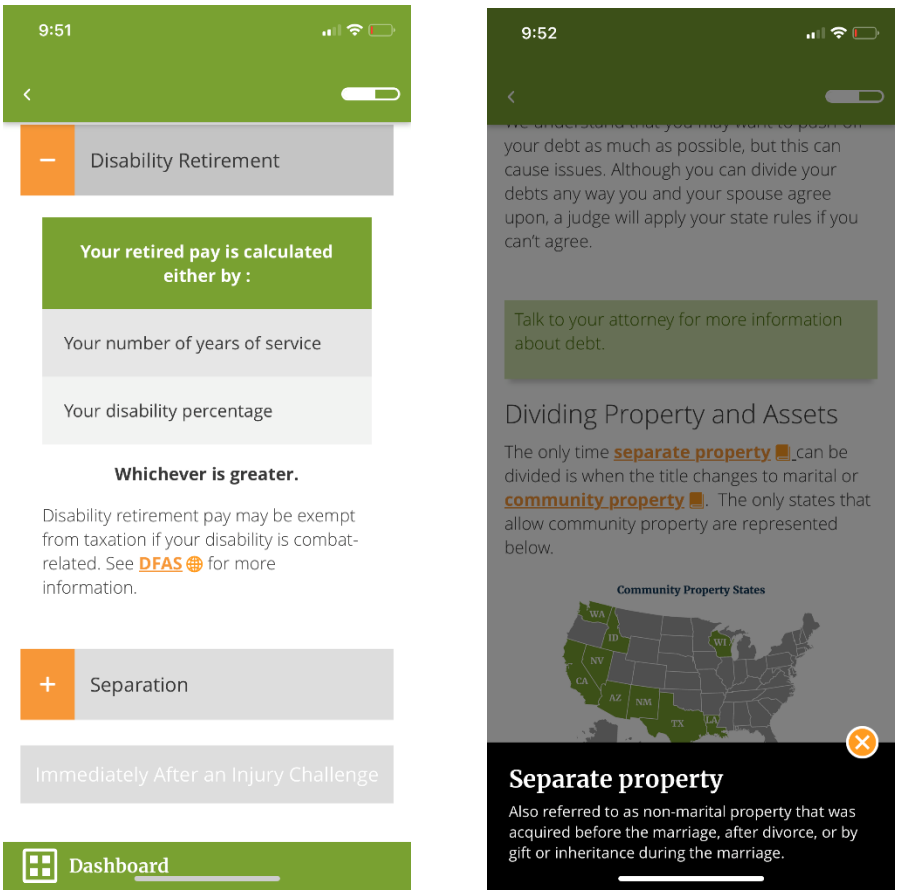
All assessment questions created for each content section were compiled into a centralized and formalized file. The knowledge assessment library was developed to be extendable in order to accept new knowledge assessment questions with the addition of new/updated content with future iterations. The assessment library contains each assessment question, answer choices, correct and incorrect feedback, and an answer key (Figures 30a, b, & c). All questions are categorized based on financial category from which each assessment was created.



Figures 30a, b, & c. Formalized Knowledge Challenge

Content Hyperlinks

Using multi-media, as part of the micro-learning strategy, hyperlinks were utilized throughout the Sen$e application. Glossary terms are hyperlinked to allow a pop-up feature within content, reference in-application locations are hyperlinked to allow users to navigate quickly and seamlessly to other areas in the app, and outside web-links are hyperlinked to allow users to visit verified and approved government sites (.gov, .mil) for more information (Figures 31a & b). Hyperlink management was created to compile a reference library of all hyperlinked media contained within the application. Cross-references to in-application locations were verified as well as web-links to outside sources.



Figures 31a & b. Content hyperlinks - web links; glossary terms

For additional details, see contract deliverable Financial Readiness Content Library (Populated) 4.4.17 folder containing the keyword file, formalized glossary file, formalized tips file, formalized knowledge assessment file, mockup PDFs, and use case word files.

Research Design and Protocol Development

The same methodologies that were applied in the Phase I and Phase II Research Design and Protocol Development tasks were followed here in the Phase III Research Design and Protocol Development. Additional considerations were made for the current state of the application, the number of participants required to complete usability and effectiveness testing, and the location in which the evaluation would take place. Finally, because of the inclusion of the effectiveness testing, and IRB protocol needed to be updated, resubmitted for full review, and approved.

Our approach to evaluation was based on the NWKM of training evaluation (Kirkpatrick & Kirkpatrick, 2016). We conducted Level 1 (Reactions) and Level 2 (Learning) evaluations in the Phase III Summative Evaluation. Level 1 addressed reactions through usability aspects. We captured users' responses to guided interactions with Sen$e through measures of satisfaction and perceived usability. Qualitative feedback was collected using think-aloud protocols during these interactions. Level 2 addressed training effectiveness through participant performance on knowledge challenge questions whereby we evaluated the training content from the populated content library.

Summative Protocol Development

A beta version of the application was available for testing, meaning the majority of content and functionality was present. Usability test scenarios were developed to access a wide array of functionality and content throughout the application, and those sections accessed were representative of the rest of the application. Functionality included general dashboard navigation, navigation within course content, use of accordion menus, slideshows, and scrolling. Content accessed included Expenses and Spending, Basic Finance, Birth of a Child, and Compound Interest.

The effectiveness protocol allowed for the consumption and subsequent testing of participants on a variety of representative topics including Basic Finance, Birth of a Child, Disability, Divorce, and Vehicle Purchasing. The test scenarios used in the Phase III Summative Evaluation were identified by the team based on the available functionality of the application at the time of Phase III testing and reflected tasks which are likely to be executed by the end-users as well as included a variety of in-application interactions and financial content. Results from the data collected was qualitatively and quantitatively analyzed with descriptive statistics to guide project designs, inform the project team of critical errors and areas of improvement with application interaction and incorporate feedback into system recommendations. The protocol for the Summative Evaluation approach underwent professional IRB evaluation. For additional details, see contract deliverable Summative Testing Protocol and Human Protection Documentation 4.4.16 (Summative_PAL_Protocol-v3_5.2.18_4.4.16_W911QY-16-C-0163.pdf; Certification for Study IRB Approval_4.4.16_W911QY-16-C-0163.pdf)

Summative Testing

A summative evaluation was conducted to gauge usability, user experience, user satisfaction, and application effectiveness. Eight current service members completed usability testing to determine the extent to which user expectations of the application structure, content, interfaces, and functionality were met. This usability evaluation identified benefits of the interface and overall application as well as potential design concerns and areas for enhancement. Benefits included the clean, intuitive, and simple design and display of information. There were some concerns with respect to navigation and content organization within the system. Twenty-seven service members completed the effectiveness evaluation where knowledge gained from the application was assessed. Participant feedback was collected through semi-structured interviews. By and large, participants said that Sen$e was easy to use, useful, helpful, and contained important and relevant information.

Usability- Method

Eight participants from across four branches of the military (U.S. Navy, U.S. Air Force, U.S. Marine Corps, and U.S. Army) stationed at Joint Base Pearl Harbor-Hickam, Marine Corps Base Hawaii, and Schofield Barracks, respectively, on the island of Oahu, HI were recruited to participate in this study. All participants are currently serving in the military. The study team utilized the same methods carried out in the two previous formative usability protocols to conduct and collect data in the Phase III usability portion of the Phase III Summative Evaluation.

Usability- Results

Overall, participants felt the application was useful and saw the potential for providing financial education. The general perspective across all the surveys was that the application was useful and rated 'excellent' in terms of user-friendliness, therefore, meeting the application goal. By and large, participants said that the application was easy to use, useful, and contained important and relevant information. When participants mentioned wanting something different, they indicated a desire for more detailed content and more tools. The main usability issues related to navigation and specifically to content categorization and organizational structure. Participants also did not understand what the term "Touchpoint" meant, as this was cause for several of the navigational errors encountered. Users rated the interface regarding the characters and icons as clear and easy to read; however, the ratings suggest that the organization of information on the screen as well as the sequence of screens could be improved. Terminology and system information was rated as highly consistent throughout application content. Users felt that the application was easy to learn, and it was easy to explore new features through trial and error. Users found help messages on the screen to be helpful and found the supplemental reference materials to be clear. They also felt that the tasks could be performed in a straight-forward manner. Lastly, regarding system capabilities, users thought they could easily correct their mistakes while interacting with the application.

Effectiveness- Method

Twenty-eight participants from across four branches of the military (U.S. Navy, U.S. Air Force, U.S. Marine Corps, and U.S. Army) stationed at Joint Base Pearl Harbor-Hickam, Marine Corps Base Hawaii, and Schofield Barracks, respectively, on the island of Oahu, HI were recruited to participant in this study. All participants are currently serving in the military. Participants used the type of phone they indicated they were most comfortable using for the duration of the study (iPhone 7 Plus, iPhone 6s, Samsung Galaxy S7, or Google Pixel). A high functioning beta version of the application was presented on one of the four phones. Participants were invited to take five minutes to freely explore the Sen$e application. Afterwards, participants reviewed a total of five content areas, one area at a time, and completed a knowledge challenge for each content area. The version of the application used during testing was not able to store participant responses, so paper-based challenge questions were administered that tested their knowledge and understanding of the content. Participants were allowed to use the application while answering the knowledge challenge questions, if needed. At the conclusion of the evaluation, participants were asked to respond verbally to several debrief questions regarding their experience with the application.

Each scenario required participants to access and review content in a different content category from the dashboard. Their respective knowledge challenges ranged from three to four questions, and participants were allowed to use their devices while taking the challenges, if needed. All questions were scenario-based and were cross-validated for applicability and difficulty by at least two other members of the project team.

Objective data were collected using participant responses to knowledge challenge questions. Seventeen questions, in total, across five content categories were created utilizing the challenge questions located within each content area in the application. Content categories Divorce, Birth of a Child, Disability, Basic Finance, and Vehicle Purchasing were included in the knowledge challenge. At the time of the evaluation, the application was unable to store participant responses to the challenge questions, so paper-based questions were created.

Effectiveness- Results

Participant responses for the knowledge challenge questions were recorded and graded across each of the 17 questions and within each of the five content sections (Divorce, Birth of a Child, Disability, Basic Finance, and Vehicle Purchasing). Overall, participants scored an average of 82.57% (SD = 17.05) correct, with 71.60% (SD = 33.20) correct responses in the "Divorce" content, 93.83% (SD = 2.14) correct responses in the "Birth

of a Child" content, 81.48% (*SD* = 13.52) correct responses in the "Disability" content, 100% (*SD* = 0) correct responses in the "Basic Finance" content, and 70.37% (*SD* = 29.78) correct responses in the "Vehicle Purchasing" content. Data were presented across all participants, by military branch, and by age range. Age ranges were selected to capture equal numbers in each range. Overall, participants were successful in obtaining and remembering financial concepts by navigating and reviewing content in the application. The results of the effectiveness evaluation suggest that Sen$e is an effective learning tool.

Semi-structured Interviews

All participants were asked open-ended, semi-structured interview questions regarding their likes, dislikes, and suggested improvements for the Sen$e application. The qualitative debrief findings for both groups of participants are consolidated here and a summary of participant responses is presented. A synthesis on the findings from these data have been incorporated into the list of recommendations.

Semi-structured Interview Results

Interview data were collected from 36 participants in total. Feedback was coded into 27 unique codes relating to overall application usability, usefulness, and application specific items (i.e., content location, navigation, visualization, etc.). The number of times codes occurred across participants was summed and grouped into high-level themes made up of navigation, content, interaction, buttonology, status, aesthetics. These themes helped to drive the overall recommendations stemming from the finding of the summative evaluation. At a high level, the majority of participants specifically mentioned that Sen$e was easy to use, useful or helpful, that they learned something, the interactions were what they expected, the information was useful or relevant, the terminology was good, and that they were able to navigate the application easily.

User opinions garnered through semi-structured interviews revealed that participants found the content to be straightforward and useful. They appreciated the option to explore content in more detail through overlays, accessing content outside of the application, and exploring infographics and other interactions to reveal additional content. Participants specifically liked the integration of an accordion design to help manage large chunks of information by intuitively revealing and concealing information. In general, the navigation and interactions were intuitive and met the participant's expectations when tapping on hyperlinks, exploring different types of menus, and scrolling through the content. While the overall impression of the Sen$e application was very positive, participant actions indicated room for improvement in how content is organized and clarity of nomenclature. Based on areas of improvement, the project team provided recommendations for consideration. Participants specified that categories like "Basic Finance," "Compound Interest," and "DTI Ratio" belong in the "General" category. The dashboard category term "Touchpoints" was generally misunderstood, and participants suggested renaming the category to something *career-specific*, like "Military Touchpoints," "Military Career," or "Career Milestones." Additionally, the requirement to view all content before accessing the associated "Challenge" was confusing and considered burdensome to participants.

For additional details, see contract deliverable FR PAL Phase III Summative Test Report 4.4.19 (SenSe Summative Usability Test Results Report.pdf).

Application Development

Mobile app

Based on user feedback and internal review from Phase II, Phase III focused on continued enhancements to the application. The following key features were added during Phase III:

- Offline support – once content is downloaded, the application can be used without an active internet connection; user activity and progress are stored locally and synced with the server later when an internet connection is available.
- Overhauled application user experience – based on user feedback, the dashboard and related screens were redesigned to make content easier to discover and find.
- Improved content user experience – user progress is now remembered, and users are offered the ability to resume a topic wherever they left off.
- Tip of the Week – once a week, users will optionally receive a notification containing a financial tip to help encourage them back to the application and toward better financial habits.
- Improved content architecture – based on client and user feedback, content was reorganized into touchpoints and life events to make relevant content easier to find.
- Searching – users can now search for content and glossary terms based on keywords.
- Enhanced application security – the application now encourages users to enable a passcode and encryption on their device to ensure any financial information they enter into the application is kept secure; additionally, users may optionally protect the app using the biometric authentication (if available on their device)
- Ability to edit user profile – users can now make changes to their user profile.

Additionally, the content library was significantly expanded with new topics and calculators designed to better meet the needs of end-users.

As with Phase II, a series of alpha and beta builds were released through HockeyApp and demonstrated the continuously evolving capabilities. Bugs were tracked based on feedback from the QA team and the client. Crashes and other errors were automatically tracked using HockeyApp's crash reporting functionality. A final build was released via HockeyApp in September 2018.

Back-end

The CMS required only minor changes in Phase III to support the improved dashboard designs. The concept of "activity groups" in the content management system was revised to allow content to be a part of multiple groups. This is reflected in the app when a piece of content appears in more than one place.

The back-end was maintained throughout Phase III with security patches being applied to the development environment as they were published by the Drupal community.

Additionally, OPM was selected as the group responsible for long-term maintenance of the back-end. The team collaborated with OPM to share the requirements and recommendations for the back-end infrastructure. OPM is now responsible for implementation and maintenance of the back-end.

User Guide Development

Float created screencast videos to help illustrate and explain key application features. These videos are capable to be deployed as internal or external facing content for use in promotional purposes as well.

For additional details, see contract deliverable How-to Usage Guide 4.4.21 (How To Usage Guide_4.4.21_W911QY-16-C-0163.mp4).

Lifecycle Planning and Documentation

The document outlining lifecycle planning was updated to provide only a general overview of the back-end infrastructure. The implementation details were removed now that OPM is responsible for the implementation and long-term maintenance.

For additional details, see contract deliverable Lifecycle Sustainment Plan Report 4.4.20 (Lifecycle Sustainment Plan_4.4.20_W911QY-16-C-0163.pdf)

Developer and System Administrator Documentation and Training Package for Lifecycle Trainers, Developers and System Admins

As part of Phase III, the team developed a set of documentation describing the specifications and architecture utilized by the Sen$e application and related components. It provides an overview of these components and how they interact. System administrators should use this document to build a strategy for performing basic troubleshooting and maintenance tasks during the life of this application. Developers should use this document to build an understanding of the key system components, so they can be maintained and extended as the application evolves. Lifecycle trainers can utilize this document in order to understand how to add and distribute the content to the application.

For system administrators, the document provides the technical information necessary for maintaining the Drupal CMS to ensure stability and security. It covered how to properly monitor Drupal, perform updates, and implement system backups. The document did not cover basic database and Apache system administration as those tasks are not specific to Sen$e.

For developers, the document provided detailed insights into how the mobile application and back-end were developed. Developers are provided guidance in establishing a local development environment and high-level overview of the code design and structure to assist in onboarding of a new developer. The documentation does not cover basics of code signing or other general knowledge requirements for building and distributing mobile applications as those tasks are also not specific to Sen$e.

Finally, for lifecycle trainers, the document provided detailed steps and screenshots showing how to manage content for the application. It covers how key content (activities and glossary terms) can be added, removed, and organized.

For additional details, see contract deliverable Developer and System Administrator Documentation & Training Package for Lifecycle Trainers, Developers and System Administrators. (Developer and SA Documentation and Training Package_4.4.22_W911QY-16-C-0163.pdf).

Government Acceptance Coordination

Throughout the Government Acceptance Coordination period, extensive meetings were conducted with ADL, FinRed, and OPM to ensure successful transition of the application from a prototype state to a deployable and functional application. The project team provided support to implement processes to establish requirements for future implementation of the application. The final deliverables include the operational system with documentation, source code and content.

For additional details, see contract deliverable Operational System with Documentation 4.4.24 and Final Operational System with Documentation 4.4.25.

7. Conclusions

In support of financial literacy education initiatives set forth by the DoD, specifically 10 U.S. Code § 992 which requires financial literacy training to be provided to service members at multiple stages throughout their careers a Financial Readiness Personal Assistant for Learning (FR-PAL) was developed. Sen$e supports service member financial literacy and preparedness through engaging "bite-sized," personally relevant, multimedia content. Across the three-phased project lifecycle, Sen$e has been iteratively designed, developed, and tested.

In Phase I, the project team strategized and developed a requirements report containing a front-end analysis consisting of user-needs, a literature review of guiding documentation, and a thorough marketplace competitive review. Findings from the front-end analysis provided the foundation for initial application designs and content development strategies. The project team applied state-of-science instructional design methodologies during content creation for instantiation of optimal micro-learning events in future design iterations. To ensure persistent user-centered design, Phase I tasking included designing and executing a formative usability evaluation on the mockup prototype of the Sen$e application. Results revealed insights in participant satisfaction, perceived usability, likes, dislikes, and areas needing improvement. These results fueled the iterative design and development process for future phases.

In Phase II, the project team was heavily focused on delivering developed content through a high fidelity, beta prototype version of Sen$e. Instructional design and content development strategies were executed utilizing best-practices in mobile-learning and micro-learning paradigms. Rigorous content development ensued to partially populate the asset list within the content library ontology. Phase II culminated in the design and development of a limited functioning prototype application that produced positive usability results from a second formative usability evaluation (conducted in Phase II).

Phase III tasking produced refinements to content and application interactions leveraging extensive and thorough review processes that took place. Formalized content libraries were created and asset libraries within the content library ontology were cross-checked and verified. A final evaluation was executed on a high functioning, beta prototype version of Sen$e. The final evaluation included usability testing as well as an effectiveness evaluation. Aligning with our goal, users were able to efficiently extract key information as seen through the results of the effectiveness evaluation. This experience is reflective of how users are expected to use the application in the real-world. Users, across the board and across all phases of the project life cycle, found the content to be, helpful, relevant, straightforward, and useful. The application was easy to use, and users were satisfied during their interactions with the application. From objective and subjective data analyses across usability testing and the effectiveness evaluation, the project team provided recommendations for consideration during future design and development iterations of the Sen$e application. Overall, the project goals for developing a useful, usable, and user-centered financial application, for service members and their families, were met.

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