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TAMPERE UNIVERSITY OF TECHNOLOGY

MOHAMMED AL-MUSAWI

DEVELOPMENT AND USER TESTING OF A WELLNESS DATA VISUALIZATION SOLUTION

Master of Science thesis

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ABSTRACT

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Use of information technology in health and wellness attracts a lot of attention these days from the general public, health care professionals, and the research community. A significant amount of research has been done lately in order to find ways to visualize health and wellness data in a holistic way which is easy to use and understand.

The main objective of the thesis was to develop a health and wellness solution for visualizing the health and wellness status of an individual and monitoring his/her progress in the health and wellness coaching. The research focused on three main issues: 1) Developing a Progress data component which allows for monitoring the adherence of clients to tasks and to see their performance, 2) integrating the component with two other components in the system to create a Health and wellness overview solution, and 3) testing and evaluation of the component and the solution to assess usability issues and to gather user feedback.

The research followed a user-centered approach by focusing on the users and tasks from the beginning of the design process. This approach also included iterative design, with cycles of design, test, measure, and redesign. This approach was chosen to reach a high level of usability and user satisfaction by obtaining direct and indirect user feedback and requirements throughout the design process.

After implementation, testing and evaluations were conducted in two phases, namely after the implementation of the Progress data component, and after the integration of the component with the rest of the system. The evaluations were conducted with two different types of potential users: general users, and experts in usability issues. Many different techniques and methods were used in the evaluation studies. These included four standardized usability questionnaires, and the comparison of the data between them, in order to obtain high levels of reliability of the data.

The results showed a high level of satisfaction with all the metrics of usability of the system, with average responses between 5.66 and 6.60 in the 7-point Likert scale. With regard to overall user satisfaction, the results were equally positive in all four questionnaires, with scores between 6.02 and 6.46 in the Likert scale.

Some issues of interaction between the different components of the system still need further development, and the design should be evaluated on and, if need be, redesigned for, devices with different screen sizes. The results indicate that successful visualization can help people understand better their holistic health and wellness data.

PREFACE

The work for this thesis was conducted in the Signal Processing Department of the Tampere University of Technology in the Personal Health Informatics Research Group.

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Tampere, 4 October 2015

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APPENDIX A: INFORMED CONSENT FORMS

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APPENDIX C: USABILITY QUESTIONNAIRES USED IN THE RESEARCH

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LIST OF SYMBOLS AND ABBREVIATIONS

ASQ	After-Scenario Questionnaire
AJAX	Asynchronous JavaScript and XML
CSUQ	Computer System Usability Questionnaire
CSS	Cascading Style Sheets
EUCS	End-User Computing Satisfaction Questionnaire
HTML	Hypertext Markup Language
JavaScript	Scripting language
JQuery	JavaScript library
JSON	JavaScript Object Notation
ICT	Information and Communication Technology
PUTQ	Perdue Usability Testing Questionnaire
UCD	User-centered design
UCSD	User-centered system design
UI	User Interface
URL	Uniform Resource Locator
USE	Usefulness, Satisfaction, and Ease of user
SUMI	Software Usability Measurement Inventory
SUS	System Usability Scale
TUT	Tampere University of Technology

1. INTRODUCTION

This chapter offers an introduction to this research and thesis, including the motivation, and the objectives and the structure of the thesis.

1.1 Motivation

Wellness and awareness of personal health are increasingly important both for individuals and the public in general in most advanced societies [1]. Lifestyle related health and wellness problems, such as obesity, unhealthy and irregular diet, physical inactivity, and stress are prevalent all over the world [2]. Still, in Europe for example, countries spend, on average, 97% of healthcare budgets on treatment and only 3% on prevention, although health promotion and primary prevention measures provide value for money and increase the cost effectiveness of healthcare spending [3].

It is important to look at ways to induce change in human behavior with regard to their habits affecting their health and wellness. Not only will a healthier lifestyle improve the individual's quality of life, but it also has wider implications to the society as a whole through decreased sick days, increased productivity, and less need for expensive public healthcare. [1]

Hundreds of modern information and communications technology (ICT) systems are already used in healthcare to assist healthcare professionals in their work, and they are often proposed to be used also in personal wellness management. In the developed world, most people have access to a personal computer and mobile ICT devices, connected to the Internet. This makes ICT tools a natural platform to develop personal wellness management on. [2]

Many devices and ways to access one's health data already exist, such as wellness devices, web-based health records, and mobile wellness applications, and they are used by the general public. If combined, this information can help people to understand their health and wellness data better and encourage them to make the necessary changes in their lifestyle or to monitor their health status. It also allows the healthcare providers to have a holistic view of a client's health and wellness status and enhance the overall management of the client's care. Effective visualization of the data is crucial for achieving this. [4]

Many studies suggest that healthcare information systems suffer from numerous usability problems [5]. This despite the fact that usability issues are critical for visualization,

which, in turn, is a vital building block for ease of use, user satisfaction, and efficiency [6].

Therefore, usability issues need to be tested and evaluated in health and wellness visualization solutions, in order to reach a maximum level of usability and user satisfaction.

1.2 Objective of the thesis

The objective of this research was to develop a solution for visualizing the health status of an individual and his/her progress in health and wellness coaching. This helps the person and the coach to track changes in the health status, to support decisions related to health or to the individual's goals, to motivate the individual to reach his/her goals, and, ultimately, assists the individual to reach an improved status of health.

In this thesis a Progress data component was implemented, which was then integrated to a Health and wellness overview solution (hFigures) developed in an earlier project. The usability of the system, both the Progress data component and the integrated Health and wellness overview solution, was tested and evaluated.

The evaluations of the Progress data component and the integrated solution were done to assess the different aspects of usability of the solution, namely: System Usefulness, Information Quality, Interface Quality, User Satisfaction, Ease of Use, Ease of Learning, Effectiveness, and Efficiency. Results from the evaluations were used to identify further development areas for the solution. Different usability testing methodologies were compared, and the most suitable ones were selected for the tests.

The objectives can be summed up as follows:

1. Developing a visualization-oriented Progress data component in health and wellness coaching, with graphic presentations, for effective monitoring of the progress by both the individual and the coach;
2. Evaluating the Progress data component through user testing in order to assess usability and to identify further areas of development in the component;
3. Integrating the Progress data component to the hFigures health and wellness status visualization to create a Health and wellness overview solution in order to find a suitable user interface for the integrated solution;
4. Evaluating the Health and wellness overview solution through user testing in order to assess usability and to identify further areas of development in the solution.

1.3 Structure of the thesis

This thesis is organized in the following manner:

Chapter 2 includes the theoretical background of the concept of health and wellness, and describes the state-of-the-art in health and wellness visualization, with the related information visualization solutions in this field. Chapter 3 describes the theoretical background of user-centered design and usability evaluation. Chapter 4 explains the design and implementation phases of the Progress data component and its integration with the other systems to create the Health and wellness overview solution. Chapter 5 highlights the user evaluation framework for the Progress data component in health and wellness coaching, and for the Health and wellness overview solution, and the details of each step of the said framework. Chapters 6 and 7 detail the results of the evaluation study with the Progress data component of the system and the integrated Health and wellness overview solution, respectively. Chapter 8 discusses the results and the possibilities for future work. The last chapter provides a conclusion of the thesis work.

2. HEALTH AND WELLNESS VISUALIZATION

This chapter focuses on the theoretical background of the concept of health and wellness, and the related information visualization solutions in this field. A vast majority of costs of illnesses in the developed world – 77% in Europe, for example – are caused by chronic diseases, such as diabetes, and heart-related illnesses, which could be managed or avoided by lifestyle changes. Coaching applications using information technology exist widely, and several studies have shown that such applications are effective in realizing health promotion through changes in behavior and lifestyle. [7]

2.1 Concept of wellness and wellness coaching

This section explains the definitions and concepts of wellness and wellness coaching.

2.1.1 Definition of wellness

There are many definitions of wellness. In the 1950s, Dr. Halbert Dunn presented the term wellness as '*an integrated method of functioning which is oriented toward maximizing the potential of which the individual is capable of functioning within the environment.* [8] [9]'.

The World Health Organization (WHO) defines health as '*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity* [10]', while in 2006, they define wellness *'Wellness is the optimal state of health of individuals and groups. There are two focal concerns: the realization of the fullest potential of an individual physically, psychologically, socially, spiritually and economically, and the fulfillment of one's role expectations in the family, community, place of worship, workplace and other setting* [11]*'*. It can be seen that health and wellness are interrelated, but the wellness concept covers also other dimensions not covered by the health concept, including the spiritual, economical, emotional, and social aspects.

The national wellness institute defines wellness as '*an active process of becoming aware of and making choices toward a more successful existence*. [12]'

Being aware, in this definition, means continuously seeking more information about how one can improve. Choices means that we there are several options to select from, and one chooses the ones that seem most beneficial. Success refers to one's personal accomplishments. [12]

Wellness is multidimensional with 6 to 8 dimensional models [13], but many universities, corporates and public health programs take into consideration only the six dimensions as illustrated in Figure 2.1 and briefly explained as follows [12] [14]:

Physical: The human need for physical activity, diet, sleep and nutrition, and personal responsibility of one's physical body, with or without illness.

Social: One's position, connections, and contribution with regards to others and the environment, and the interdependence between these factors.

Intellectual: One's creative, stimulating mental activities and abilities, and the pursuit of ways to increase one's knowledge and skills.

Emotional: Awareness, recognition, and acceptance of one's feelings. Emotional wellness includes the degree to which one feels positive and enthusiastic about one's self and life in general.

Spiritual: Search for and sense of meaning and purpose in human existence.

Vocational or Occupational: Personal satisfaction and enrichment derived from one's work or other meaningful activities.

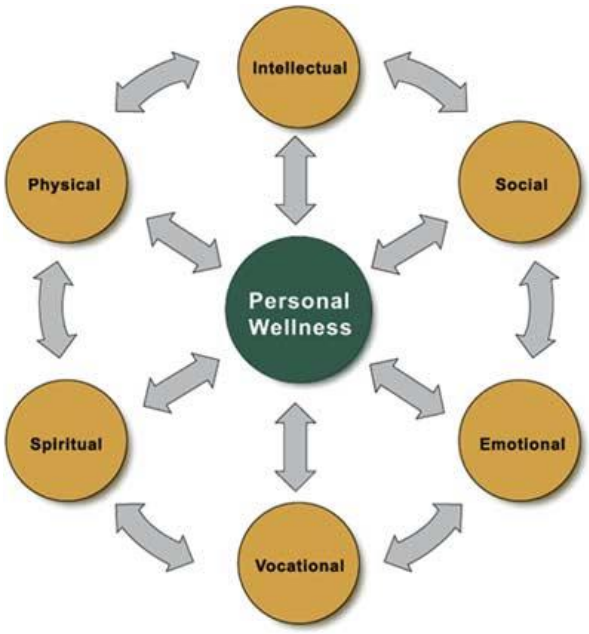


Figure 2.1. *Whole-person wellness model by Jan Montague, 1994* ***[14]****.*

2.1.2 Wellness coaching

Wellness coaching focuses on the health and wellbeing of clients by working with them to help improve all areas of wellness. This includes fitness, nutrition, weight, stress,

health, and life management issues. Wellness coaches are usually health professionals with specific training in this field. [15] [16]

A close relationship between the coach and the client gives structure, accountability, expertise, and motivation to the client, with the aim of supporting the clients in an individualized way to reach goals they would not be able to reach by themselves. The coach needs to actively engage with the client in order to identify his or her priorities, goals, and life values. This is meant to lead to a positive change in attitude and behavior and ultimately focuses on the desired results and making the client the master of his or her own wellbeing. [15] [16]

Information technology gives the coaches, and the clients, the possibility to monitor the wellness status of the client and to identify issues that need special attention and further motivation. Various system screens, with graphs and colors, provide a holistic view of the client's health and wellness status. The use of such technologies allows the wellness coach to manage a group of clients efficiently and individually. [17]

2.2 Health and wellness visualization

This section gives background information on information visualization, especially in the field of health and wellness, and the state-of-the-art visualization in this field. Through effective visualization in health and wellness, both healthcare providers and clients can gain better insight into the client's holistic health and wellness data, and allows for better management of the health and wellness status of the client [18].

Visualization is often defined as 'the act or process of interpreting in visual terms or of putting into visible form [19]'. In information visualization, which is a field of visualization, it is used to present information in a graphical way in order to make it easier to make the information understood more easily and efficiently. It allows for clear, precise, and coherent presentation of complicated information. It also makes it possible to compare complex data and to discover details and patterns which might otherwise be overlooked. [19]

Thomas and Cook define information visualization as 'Visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once. Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways [20]'.

Information visualization can be applied to health and wellness in various situations. In recent years, health data visualization applications have become more common. They generally target clinical research, as well as personal health and governmental functions. [21]

In medicine, the goals of information visualization can be grouped in three categories. Firstly, medical data which is presented in a visual form is easier to understand, to recognize, and to navigate. Secondly, information visualization allows for easier detection of diagnostic or therapeutic aspects which affect patient management and the healing process. Thirdly, it presents information in a concise way allowing caregivers to manage larger amounts of information without information overload. [19]

When monitoring the health status of a client, an integrated visualization tool can help reduce the cognitive load on the caregiver and present a holistic view of the client's state of health and wellbeing [22]. The information for the integrated tool needs to be gathered from different sources, which, at times, presents a challenge. Graphical visualizations can significantly assist both caregivers and clients in decision-making concerning the client's health and wellness. [23]

There are different techniques to visualize and present data. These techniques are also used in information visualization in health and wellness. The choice of technique depends on data type, structure, data dimensionality, and user task. The following is a collection of such techniques used in personal health and wellness data visualization. [24]

Lists and tables: Text and numerical data are the predominant component of the client record.

Plots and charts: Plots are intended to express numerical data. Provide an easier way to understand subtle trends and differences, especially with large amounts of data. These include, for example, bar charts, histograms, pie charts, and line and scatter plots. Some of these are illustrated in Figure 2.2 below.

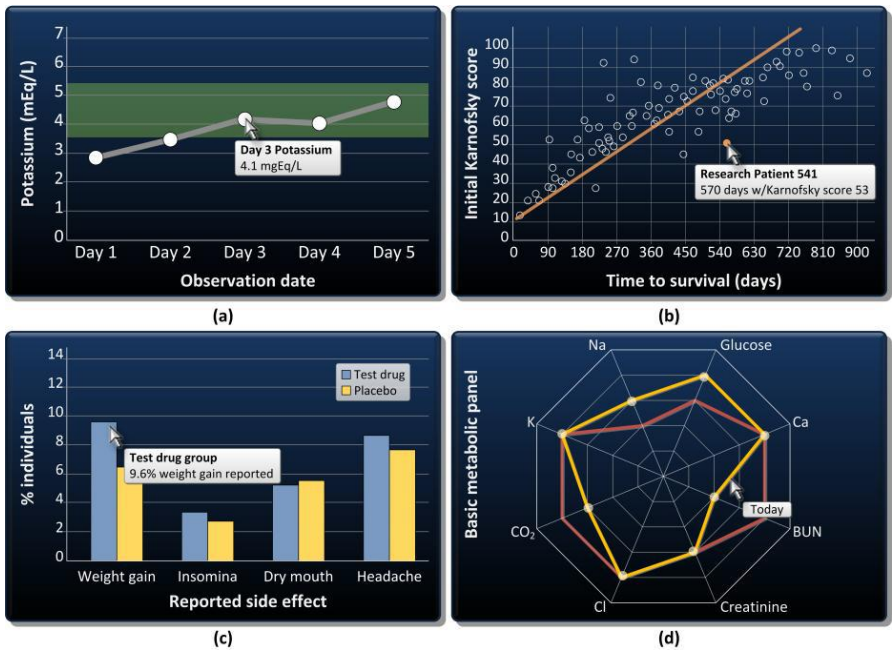


Figure 2.2. *Examples of plots and charts* ***[24]****. (A) Line plot. (B) Scatter plot. (C) Bar chart. (D) Radar chart.*

Graphs and trees: Designed to demonstrate relations between concepts. A graph is a network of objects, comprised of nodes and edges, and is said to be directed if the edges are arrows defining a path between nodes. A tree is a directed acyclic graph in which each node only has one parent. See Figure 2.3.

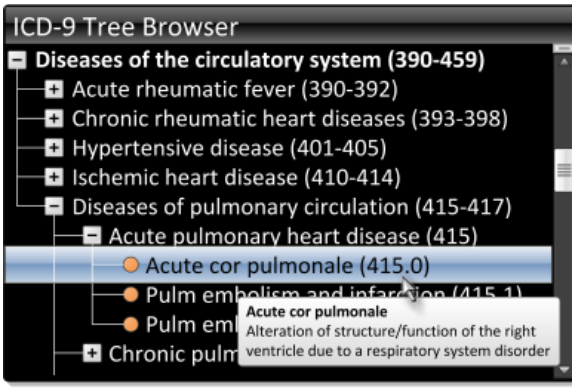


Figure 2.3. *Example of tree display* ***[24]****.*

Pictogram: A graphical symbol that represents a concept or entity [24]. There are four different types of pictograms used with medical data, namely icons, maps, diagrams, and images.

Icons are small pictograms, and are a familiar component of modern graphical user interfaces representing an action or data object, see Figure 2.4. Maps are larger pictograms being mainly concerned with a spatial frame-work. Diagrams are illustrated figures that present an abstraction or conceptual metaphor, and images are physical representations of the real world. [24]

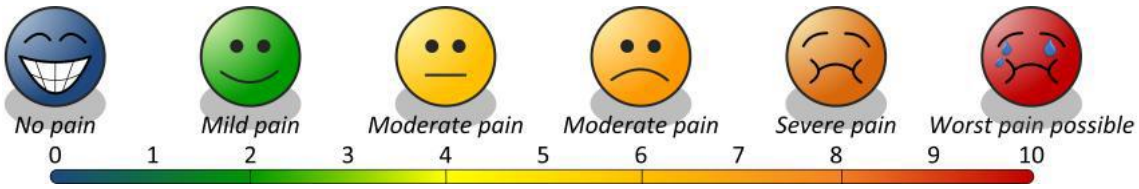


Figure 2.4. *Example of icons* ***[24]****.*

Temporal data type is particularly relevant in the visualization of health information. A timeline is a graphical representation of events in chronological order. In a timeline, there may be a problem of limited amount of display space, but this can be solved by making it possible to zoom in and out of the timeline, or by the option to move along the time axis. [6]

The timeline approach is particularly useful in providing information on time-related health data which can assist health care professionals to identify which symptoms lead to which diseases and what treatment needs to be taken into account [21].

There are many prototypes of data visualization in health care and personal health record using the timeline approach. One example is LifeLines from the late 1990s [25], which was used to visualize health data, such as personal histories and medical records, by using timeline techniques. It was developed further into LifeLines2 visualization tool, which used categorical point event data across multiple records. Another example is the TimeLine system [26], which has been described as a tool for 'problem-centric temporal visualization of client records'. This system integrates the electronic health record data, reorganizes it, and displays it using the timeline technique. See Figure 2.5.

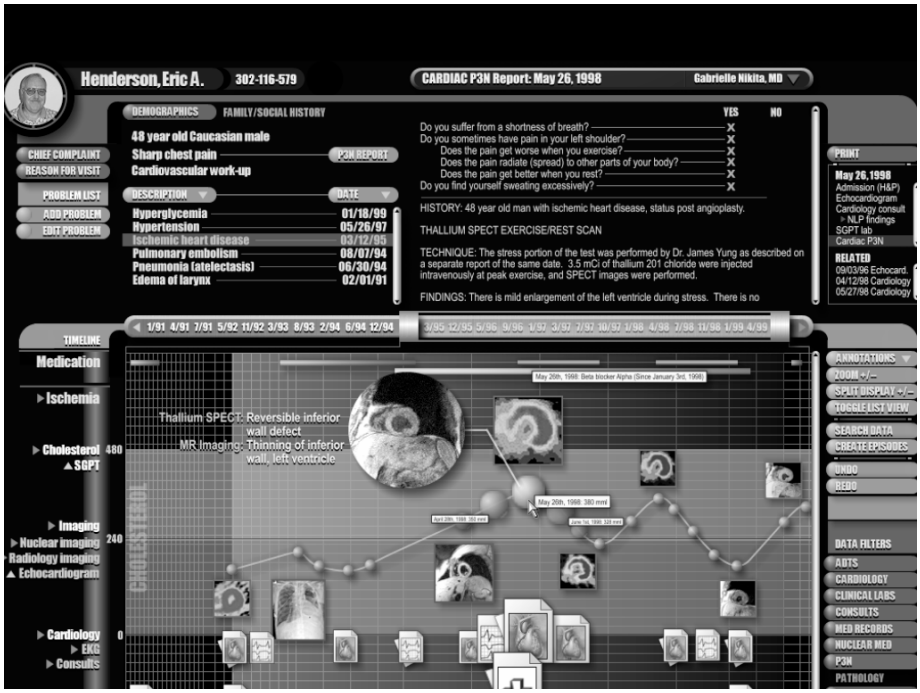


Figure 2.5. *Image caption of the TimeLine system* ***[26]****.*

Several advanced applications and web-based visualization interfaces in health and wellness promotion and coaching exist. Such state-of-the-art visualization often uses dashboard style visualization techniques of a client's health data, and uses standard line graphs and interactive elements. In order to better understand our health, so-called 'smart dashboards' are needed which combine data from different sources [4]. A dashboard can also combine different visualization techniques and displays, such as pie charts, graphs, or icons. A state-of-the-art dashboard system is interactive and can combine different activities in the display, and may also include a social media component allowing the user to share some of the data with other users. An example of a state-of-the-art dashboard is that of Fitbit [27], a company producing health and wellness related products for consumers, see Figure 2.6.

Figure 2.6. *Fitbit dashboard* ***[27]****.*

Another example of a state-of-the-art visualization system is the dashboard developed by NexJ Systems Inc. It delivers person-centered software with the aim of reaching positive behavior change in the users. In the system, all client data is captured in NexJ Connected Wellness and the health care provider, or coach, can monitor the progress of his or her entire population of clients using online dashboards. [28] See Figure 2.7.

Figure 2.7. *NexJ Health dashboard* ***[28]****.*

3. USER-CENTERED DESIGN AND USABILITY EVALUATION

User-centered design and user evaluation during the development of eHealth technologies is crucial to successful adoption of these technologies by a large number of users [29]. This chapter focuses on the theoretical background of user-centered design and usability evaluation.

3.1 User-centered design

The definition of User-centered design (UCD) or User-centered system design (UCSD) concept has not been commonly agreed upon [30]. Even if there are many definitions on UCD, they all focus on the user and integrating the user perspective in the design throughout the design process [31].

One of the definitions states that User-centered design is '*an approach to user interface design and development that involves users throughout the application design and development process. It not only focuses on understanding the users of a computer system under development but also requires an understanding of the tasks that users will perform with the system and of the environment (organizational, social, and physical) in which they will use the system*' [32].

Another definition, by to *Preece et al.,* states that UCD is '*an approach which views knowledge about users and their involvement in the design process as a central concern'* [33]. Furthermore, *Gulliksen et al*. introduce in their study [30] a new definition of UCD as '*a process focusing on usability throughout the entire development process and further throughout the system like cycle*'. This contains twelve principles from existing research, namely User focus, Active user involvement, Evolutionary systems development, Simple design representation, Prototyping, Evaluate use in context, Explicit and conscious design activities, A professional attitude, Usability champion, Holistic design, Process customization, and User-centered attitude.

The user-centered approach was initially based on three basic principles of that were provided by Gould and Lewis [34] to lead to a useful and easy to use computer system. Later, Gould developed them further into four basic principles [35]:

1. **Early focus on users and tasks** means understanding the users of the system and their characteristics such as their behavior, experience, needs, attributes, context of use etc.

2. **Empirical measurements,** meaning involving the users early on in the design process through prototypes and simulations and observing and analyzing their reactions and performance.
3. **Iterative design** means using the iterative loop of design, test, measure, and re-design, repeated as often as required.
4. **Integrated design** refers to all aspects of usability being under one focus or person [36].

Involving the user throughout the design process leads to many benefits for the service provider [32]. These include reduced maintenance costs, increased overall user satisfaction, increased sales and revenues, positive brand image, and decreased training and support costs. ISO 13407 from 1999 also mentions significant economic and social benefits in this regard, such as improvements in user productivity and operational efficiency, reduced user discomfort and stress, and improved product quality and competitive advantage [37] [38].

3.1.1 User-centered design cycle

ISO 13407 standard from 1999 "provides guidance on human-centred design activities throughout the life cycle of the computer-based interactive system" [37]. It describes four main activities of UCD, and presents them in a design cycle.

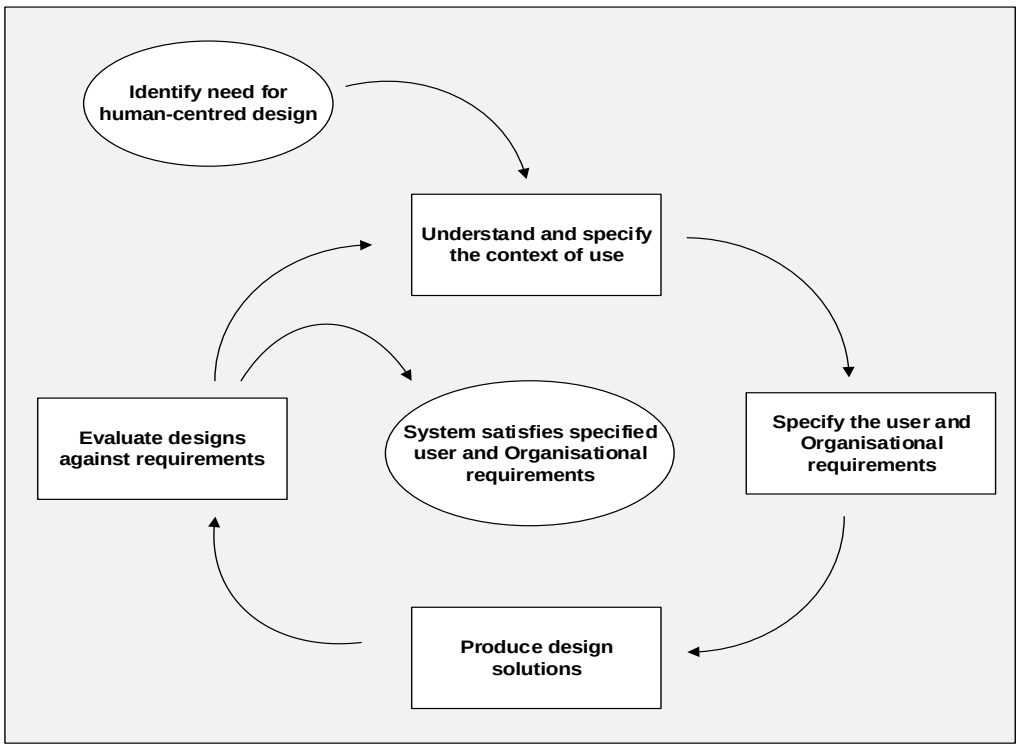


Figure 3.1. *The design process from ISO-13407* ***[37]*** *– Human-centered design process*

The four activities can be summarized as follows:

***Understand and specify the context of use*:** This activity is required in order to know the users of the system, the environment that the users will use the system in, and the tasks that the users require from the system.

Specify the User and Organizational Requirement: The aim is to analyze and determine all the requirements of the system in order to fulfill user expectations.

Produce Design Solutions: This means providing a solution with visual and interactive design, and with usability. This could be done by providing a prototype of the system or actual implementation.

Evaluate Designs against Requirements: This is needed in order to make user assessments and usability evaluations to assess the design against user tasks.

3.1.2 User-centered design methods

There is a variety of methods that are used in user-centered design approach in different phases of the design and for different purposes. The choice of methods depends on the kind of information that needs to be collected. Below are brief descriptions of a selection of methods [32] [33] [39] [40]:

Card Sort: The users sort the cards which contain information into categories and explain the reasons for the categorization. A quick and cheap method, but does not reveal interface problems. Generally done with a group of 10 to 20.

Contextual Inquiry: Designers visit real users' actual working environment and analyze the context. Makes it possible to see users in their actual environment using the device for actual work of function, but may be time-consuming. Number of participants can vary.

Focus Group: Users participate in a moderated discussion to share ideas and opinions about the system. Large amount of data in a short time, but requires an experienced facilitator and can cause a domination effect in a group discussion. Usually organized in groups of 6 to 10.

Interview: Designers ask semi-structured questions either face-to-face, or online. A low-cost and direct way to gather data and to identify user needs, but may not reveal all the data or may be difficult to organize and schedule, depending on the willingness of participants. The number of participants can vary.

Paper Prototype Testing: Users try a low-fidelity version of the system and give comments of their choices and experiences. Allows cheap, fast and quick testing of individual components of the system, but is not context-specific, and components need to be tested again with real products. Organized in groups of 5 to 7.

Survey: Users are asked a standard set of questions in the form of a questionnaire either on paper, online, or in person. Possibility to gather data from many users quickly, but may face reliability and accuracy issues, depending on the choice of participants. Number of participants can vary.

Task Analysis: By observing the users, designers identify all the steps required for users to reach their goals. Can reveal new information to be used in the software design, but can be time-consuming and needs both expert and novice users. Usually organized in groups of at least 5 users.

Usability Test: Users work with an electronic prototype and designers observe their performance using the actual system. Finds more authentic problems with the design with a small number of users, but can be time-consuming to plan and analyze. Generally organized with 5 to 12 users.

Heuristic Evaluation: Participants assess the system and try to identify usability problems by working with the system. A quick, easy, and low-cost way to identify usability problems, but needs a participant who is an expert in usability. Organized with a small number of people, usually 3 to 5.

Walkthroughs: Evaluator leads the user through the system and asks questions. Can reveal expectations that the user might not express with other methods, but must be conducted carefully to avoid leading questions or comments, or the designers' personal conclusions. Number of participants can vary.

Expert View: Design experts examine the system and give detailed comments and identify possible problems. Through expert opinion, reveals usability problems efficiently, but is not sufficient on its own. Done with some 3 to 5 expert users.

3.2 Usability evaluation

In the 21st century, the growing use of information technology in health-related fields has resulted in increased significance of evaluation studies in usability [41].

There are many definitions for usability. One of them, cited widely in research literature when referring to interactive systems, is the ISO 9241-210 standard from 2010. It describes usability as follows: '*Usability is the extent to which a system can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'* [42]. Furthermore, the ISO 9241-210 mentions several benefits of usability: '*Usable systems can provide a number of benefits, including improved productivity, enhanced user well-being, avoidance of stress, increased accessibility and reduced risk of harm'* [42] [5].

Another often used definition is that of Jakob Nielsen, who states that *'usability has multiple components and is traditionally associated with the five usability attributes, which are learnability, efficiency, memorability, errors, and satisfaction'* [43].

From these definitions, one can derive the concept of usability as a model of understanding and measuring parameters against a set of predefined goals, based on the user perspective, the context of use, and purpose.

3.2.1 Utilized usability evaluation methods

In chapter 3.1.2, the different evaluation methods are explained. This chapter highlights the methods selected by the researcher to be used in the evaluation studies in this research.

Heuristic evaluation: This method is an inspection method which can help identify usability problems with the user interface design, which are not necessarily found in user testing. If two or more usability experts are used in the heuristic evaluation, more than half of the usability problems can be discovered. Normally, 3 to 5 experts in usability are required to evaluate the user interface based on their knowledge of human cognition and interface design rules of thumb or heuristics [32] [43]. Nielsen used a ten-question questionnaire which the experts were asked to answer in order to receive their feedback on the usability issues. [43] [33] [44] [45]

This said, heuristics is not standardized, and much depends on the expertise of the participants in order to achieve good and reliable results [43].

Controlled user testing: Testing in a controlled environment can validate interface design decisions and lead to the discovery of design problems. Alternative designs can also be tested at the same time. This method collects both objective data, such as user performance metrics (e.g. time to accomplish task, non-crucial errors, completion rate), and subjective data, such as audible user comments during the walkthrough of the system [43] [44]. These comments are received through task scenarios which the users need to step through while thinking aloud or performing the task silently, while being observed [45].

The evaluation walkthrough or a pluralistic walkthrough is one of the ways of controlled user testing. In this walkthrough, the usability expert, or evaluator, walks through the system with potential users and observes their reactions and performance, and gives comments. [43] [45]

Usability questionnaires: This method gathers self-reported data on identified tasks. The questionnaires measure user experience and help identify usability problems in the system which need improvement and further development. Normally, such questionnaires measure parameters such as user satisfaction, effectiveness, usefulness, ease of

use, and interface quality. Many valid and reliable usability questionnaires exist online, some as open source. Some examples include System Usability Scale (SUS), Questionnaire for User Interaction Satisfaction (QUIS), Computer System Usability Questionnaire (CSUQ), Software Usability Measurement Inventory (SUMI), After Scenario Questionnaire (ASQ), Usefulness, Satisfaction and Ease of Use Questionnaire (USE), Perdue Usability Testing Questionnaire (PUTQ), and End-User Computing Satisfaction Questionnaire (EUCS). [33] [44] [45]

3.2.2 Review of usability questionnaires

This section reviews the three standard usability questionnaires selected to be used in this research. In all three, the scaling uses the 7-point Likert scale, with 1 indicating 'strongly disagree' and 7 'strongly agree'. Links to the questionnaire tools are in appendix C.

Computer System Usability Questionnaire (CSUQ): This open source questionnaire was developed by IBM to do an overall assessment of the appeal and usability of the interface at non-laboratory settings. IBM modified the Post-Study System Usability Questionnaire (PSSUQ) for this purpose. It measures three factors: system usefulness, information quality, and interface quality. The overall CSUQ coefficient alpha, which reflects the reliability of the tool, is 0.95, while the coefficient alpha for system usefulness, information quality, and interface quality is 0.93, 0.91, and 0.89 respectively [46]. The validity and reliability of CSUQ is similar to that of PSSUQ. [47] [45]

CSUQ consists of 19 statements. Statements 1 through 8 refer to System Usefulness, statements 9 through 15 to Information Quality, whereas statements 16 through 18 refer to Interface Quality. The last statement, with the overall of the three metrics mentioned above, provide the overall satisfaction score. [47]

After Scenario Questionnaire (ASQ): This questionnaire was also designed by IBM to measure user satisfaction with three statements, and is available freely online. It is meant to be completed directly after a scenario usability study, and measures ease of task completion (Efficiency), time required to complete the task (Effectiveness), and satisfaction with support information. The ASQ coefficient alpha is 0.93 [48]. [47]

Usefulness, Satisfaction and Ease of Use Questionnaire (USE): Designed by Arnold M. Lund, this nonproprietary questionnaire can be used to measure any interface. It is a 30-item questionnaire measuring the following metrics: Usefulness, satisfaction, ease of learning, and ease of use of an interface. According to Lund, usefulness and ease of use, two of the metrics measured by this questionnaire, correlate with each other and, when combined, provide more accurate results. [49] [45]

Table 3.1 below summarizes the main characteristics of the questionnaires.

Table 3.1 *The main characteristics of the questionnaires*

Survey Name	Designed by	Survey Length	Reliability	Availability	Metrics
Computer System Usability Questionnaire (CSUQ)	IBM	19 Items	0.95	Free	System Usefulness, Information Quality, Interface Quality Overall Usability
After Scenario Questionnaire (ASQ)	IBM	3 Items	0.93	Free	Efficiency Effectiveness Satisfaction
Usefulness, Satisfaction and Ease of Use Question-	Lund	30 Items	Not Reported	Free	Usefulness Ease of Use

4. DESIGN AND IMPLEMENTATION

This chapter explains the concept of the system developed for monitoring the progress in wellness coaching (Progress data component), as well as details on the design and implementation of this component, which was part of this research. The chapter also highlights the process and end result of the integration of this component with the other two components of the Health and wellness overview solution, and the reasoning behind this integration. These two components, namely hFigures and Curves, were designed and implemented by a member of the research group Andres Ledesma and Hannu Nieminen [50] who also participated in the integration process.

4.1 System concept

The reasoning behind developing the Progress data component is to combine health data from the coaching program in a way that illustrates the tasks, results, and progress, or lack thereof, in the health and wellness status of the user. The component gives an overview of the user's performance, which is meant to help the general user, and the health coach, to adhere to the plan, to motivate the user, and to manage their progress to achieve the set goals.

4.2 System overview

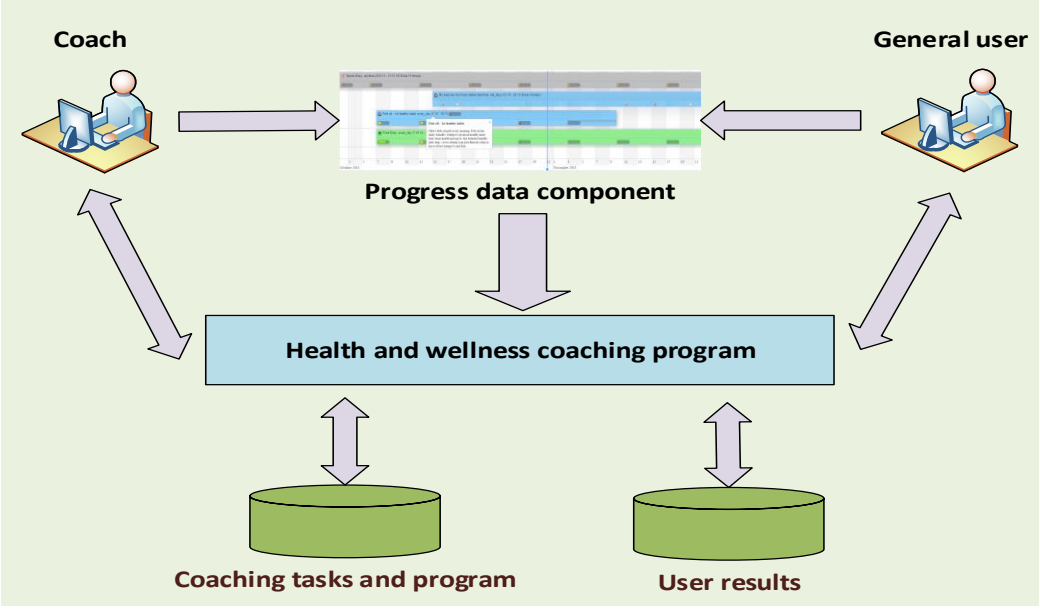


Figure 4.1. *Progress data component overview.*

As illustrated in Figure 4.1, this system contains different types of users who have access to the Progress data component, namely general users, who are the patients or individuals whose health and wellness status needs to be improved, and coaches, who are health or wellness professionals, caregivers, or other similar individuals. Both kinds of users have equal access to the functionalities of the component.

The component retrieves the data from the Health and wellness coaching program developed by Movendos company [50], and visualizes it in a summarized and understandable way. The Movendos system breaks down the coaching process into different health and wellness tasks related to sleep, relaxation, nutrition, exercise, etc. which allows the coach and the client to define the frequency and duration of each task, and to monitor progress, as shown in Figure 4.2. The main data required for the component is Coaching tasks and program, and User results. These are stored in separate databases, and interact with the component through the Health and wellness coaching program. The frequency of tasks could be, for example, every day, twice per week, on specific days, or whenever you want. For example, in the task 'My sports diary' in the figure below, the person can do any kind of sport activity whenever he/she wants between the 24th and 31st of March.

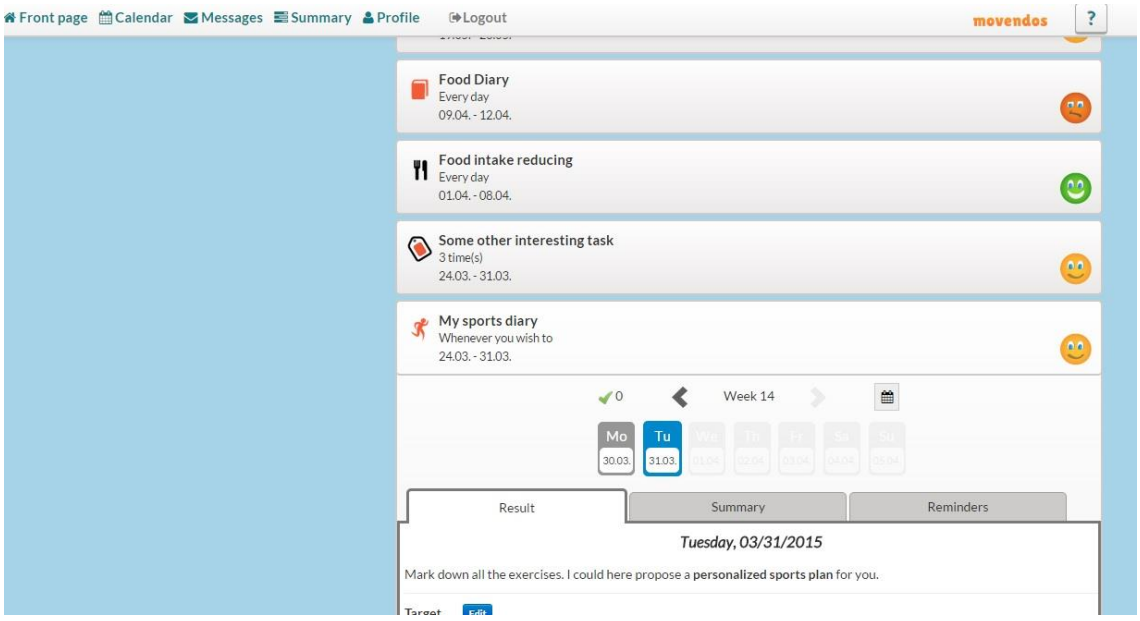


Figure 4.2. *Customer front page view of Movendos system* ***[50]****.*

4.3 System requirements

The requirements for the Progress data component are divided into functional and non-functional requirements. The functional requirements are functions with which the user interacts directly. The non-functional requirements are those relating to proper system performance which the user does not interact with directly, such as usability, safety, security, and supportability.

The functional requirements are:

- The system shall show the tasks given in the coaching plan and which have been completed or are to be completed;
- The system shall show the title, the start date and the end date for each task;
- The system shall show the scheduling type of the tasks, e.g. daily, N times per week, on specific days, whenever you want;
- The system shall group the tasks depending on their type;
- The system shall show adherence to the coaching program by calculating and displaying the user's overall progress scores for each task, and weekly scores, when applicable. This means the average of the client's results of performing the tasks – if the task was completed or not and if it was completed according to the set frequency for the task – during a specific period;
- The system shall allow the user to access more details for each tasks, e.g. more information on what is included in the task or a web-link for further information on the task;
- The system shall allow the user to flexibly navigate in the time axis, e.g. zooming the time axis to have more or less number of days, weeks or months displayed;
- The system shall allow the user to select specific date to view his/her health status in that specific moment in time;
- The system shall allow the user to select two specific dates to compare his/her health status between those specific moments in time.

Regarding the non-functional requirements in the Progress data component, the focus was on usability and supportability, as the component was to be integrated to other systems within the solution. The usability requirement necessitates measuring parameters such as the usefulness and likability of the component, simplicity and ease of use, and quality of the information and the interface. These parameters cannot be implemented directly, but rather measured after implementation. Supportability requires the component to be easy to maintain and modify. It should also be possible to integrate and adapt it into other systems. Another operational requirement was that the component should be compatible to be used with the most famous and popular web browsers.

4.4 System architecture

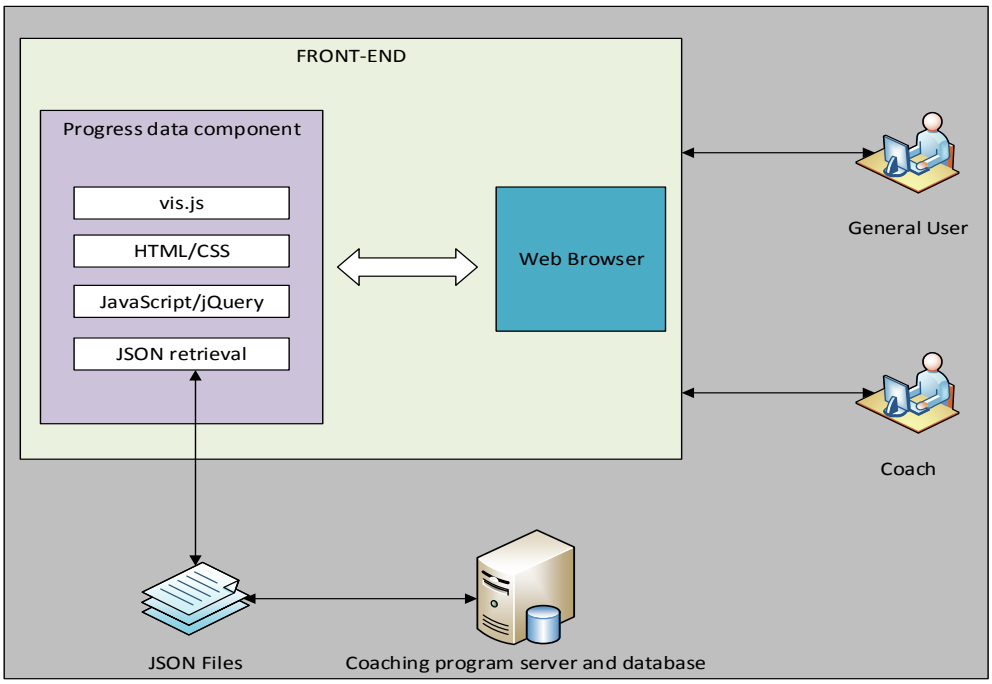


Figure 4.3. *Progress data component architecture.*

The Progress data component is a web based tool to visualize the coaching program plan and user results and progress in this plan. As shown in Figure 4.3, the component retrieves the required data from the coaching program system by sending asynchronous JavaScript requests (AJAX) to the server. The retrieved data is in JSON files format. JavaScript Object Notation (JSON) was used as exchange language between front-end and back-end of the system.

In the front-end of this component, different techniques and programming languages were used to develop the interface and the functionality of the system. HTML is a standard markup language which is interpreted by web browsers. HTML elements form the building blocks of the website. Cascading Style Sheets (CSS) were used to shape and manage the layout and the look of all the HTML elements and their content. It is a powerful tool to implement and improve the user interface and user experience. JavaScript and jQuery code were used to develop the functionality of the component and to display confirmation messages to the user after the user performs a specific function. Vis.js was used to implement the different interactive visualizations. Vis.js is an open source library to implement a dynamic web based visualization that allows to create a fully customizable interactive timeline [51]. The users are able to access the Progress data component from any device with a web browser.

4.5 Design process

The design of the Progress data component followed a user-centered approach, with early focus on the users and the tasks. This approach also included iterative design, with cycles of design, test, measure, and redesign.

The Progress data component design followed the results of the requirement analysis. This analysis provided information on what kind of tasks were needed in the system.

The first stage of prototyping was the low-fidelity prototype, a black and white version, which combined design ideas into one prototype. This prototyping phase was made by using a whiteboard, a pencil and paper to decide the functionality of the system in the prototype and to design an initial user interface. The low-fidelity prototype concentrated on the initial layout and the content patterns of the user interface. This stage involved stakeholders, mainly members of the research group, in order to obtain rapid feedback on the design and the planned functionality of the system.

After this, the colors for the user interface were selected to achieve effective color communication in the visualization to help the user to understand the functioning and the basic idea of the system more quickly. In addition, the colors were used to emphasize and de-emphasize the information.

The selection of the colors followed these guidelines: simplicity, consistency, clarity, and language of color [52]. Gestalt principles of visual perception were applied to organize the information and patterns and to give the user useful insights into them, group them together, and separate the data, or make the data more distinguishable from the rest [53].

After this, the high-quality prototype of the system was implemented as an interactive web-based prototype with all the functionalities required. This was followed by testing the prototype with the members of the research group to quickly analyse if the implemented prototype needed some modifications.

After the implementation of modifications, identified in the initial testing, the high-quality prototype was tested on other users from outside the research group in order to see with potential users the usability of the system and their satisfaction towards the system. In addition, positive and negative feedback was collected on issues which were successfully implemented, as well as those still needing further development. The testing was carried out with eight users, three of whom were experts in the field of usability and user experience. The testing resulted in the identification of new requirements which necessitated the redesign of parts of the system and the inclusion of additional functionalities.

4.6 User interface

In this section, the user interface of the Progress data component is explained. There are two main versions of the user interface. The first version of the user interface was implemented before conducting the evaluation study of the Progress data component, and the second version contained the modifications that were needed on the previous version. These modifications were obtained from feedback from the users and the results of the evaluation study. The results of this evaluation study can be seen in chapter 6.

4.6.1 First version

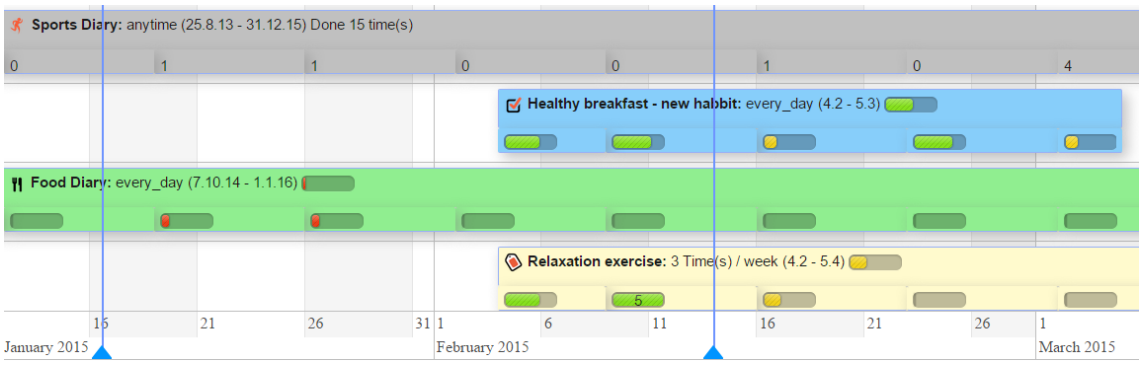


Figure 4.4. *The first version of the Progress data component user interface*

It can be seen from the Figure 4.4 that the layout of the user interface was designed using a timeline shape to allow the users to navigate and view the tasks and interventions given in the coaching plan – both completed or to be completed – and client performance on these tasks. Users can navigate on the time axis by clicking on the timeline and dragging to the left or right, depending on which dates the user wants to view.

The system also allows the users to zoom in or out of the timeline to have more or less number of days, weeks or months displayed. Zooming is done by scrolling using a mouse.

The blue vertical bars were implemented to allow the users to select two different moments of time in order to view the health status of the client, and to compare the health status in the selected moments. This function was implemented in order for the Progress data component to be linked to the other components in the integrated system. The user can interact with this function by dragging the vertical bars on the timeline to the desired date.

The tasks or the interventions are placed in the timeline in groups, depending on the type of the task given by the coach. In addition, each group of tasks is displayed in different color to help the user to distinguish between them. Each group has its own logo icon. These icons are the same used in the mCoach coaching program developed by Movendos company. Same icons were used because the users are familiar with them

from the planning of the coaching plan or recording the result in the coaching program system.

Each task inside the user interface is displayed as a box which includes the required information or parameters in a consistent way: First the logo of the task type and the title of this task, followed by the scheduling type and the period of the task. After that the overall progress of the task is displayed. Moreover, weekly progresses for the whole period of the tasks or the interventions are displayed below the parameters of each task.

The user performance on tasks is presented in different ways depending on the scheduling type of the task. A progress bar is used in the tasks that have ‘every day’, ‘N times per week’, and ‘N times’ scheduling type to display the overall and the weekly progress.

Inside these progress bars, in addition to the length of the bar, three colors were used to display the user performance percentage during a specific period, namely red, yellow, and green. The red color indicates the user performance percentage of under 25%, the yellow indicates the percentage from 25% to 49%, while the green color indicates the percentage of 50% and above.

In the tasks that have ‘N time’ or ‘N times per week’ scheduling types, if the user performs the task more than is required from him or her, the total number of completed tasks will appear in the middle of the progress bar. For example, the ‘Relaxation exercise’ task in Figure 4.4 required the client to do the task 3 times a week, but in the second week of this task the client did it 5 times. This number will help both types of users to see if the task was overperformed, as overperformance is not always a positive thing.

The second way to present the user performance of the task is showing the number of times the client performed the task in a specified period. This way is used in the task with ‘anytime’ scheduling type which allows the user to perform the task as much as he or she likes and whenever they want.

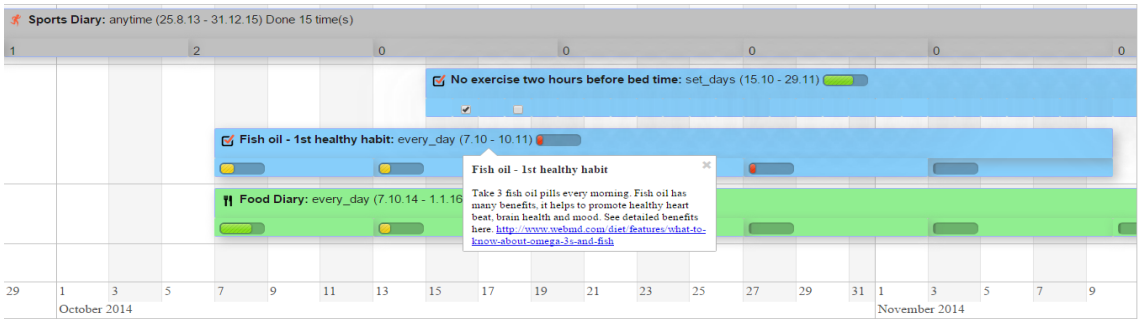


***Figure 4.5**. Task description message, and task with ‘set days’ scheduling type example*

The overall user performance in the task that has ‘set day’ or ‘on specific day’ scheduling type is displayed as a progress bar. The progress bar shows the percentage of how many times the client did the task in these specific dates. Check box objects are used to

show if the user completed this task or not in the specified days. If the check box object is checked, it means that the task was completed in this date and vice versa. See Figure 4.5.

The user interface allows the users to access more details for each task, e.g. more information on what is included in the task or a web-link for further information on the task. The task description can be displayed by clicking on the parameters of the task; a small massage window will appear containing this information.

4.6.2 Second version

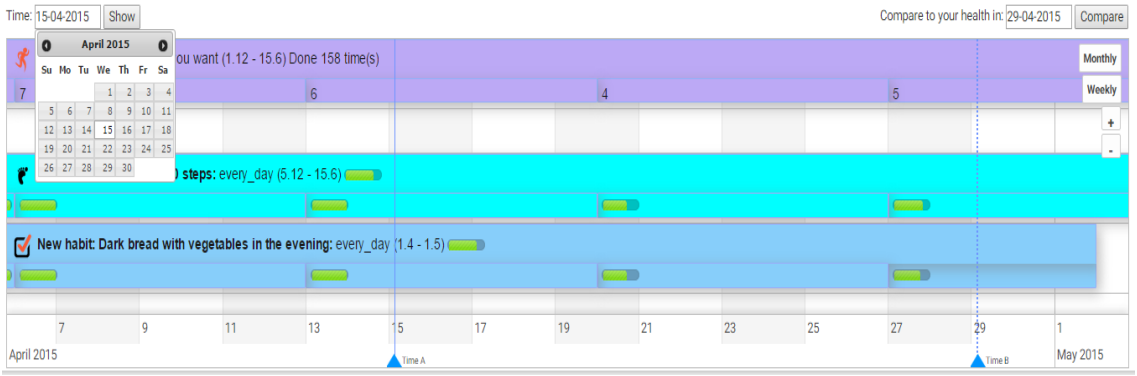


Figure 4.6. *The second version of the Progress data component user interface*

The second version of the Progress data component was implemented after conducting the evaluation study of the first version of the component. The new user interface contained the modifications that were needed to improve the visualization of the component in order to enhance the functionality of the component by implementing additional methods giving the users an opportunity to perform the tasks in an easy way. The evaluation methodology is described in Chapter 5, and the results of the evaluation are detailed in Chapter 6.

As shown in Figure 4.6, on the right side of the timeline four buttons were added to give the user additional methods to zoom in or out of the timeline directly. ‘Monthly’ and ‘weekly’ buttons allow the user to change the view of timeline window to a weekly or monthly view without scrolling. The ‘-‘and ‘+’ buttons allow the user to zoom in and out of the timeline window, with certain limitations (min 1 week – max 3 months).

‘Time’ field and ‘Show’ button on the top left side of the user interface allow the user to choose a specific date that he or she wants to see in the timeline. In addition, when the user chooses the dates, the blue solid vertical bar in the timeline will go directly to the chosen date to show the overall health status in that moment of time. Changing dates does not affect the zooming scale, meaning, for example, if the user had a weekly view in the timeline and selects a different date, the weekly view will remain even with the

new date. The dates are chosen by the user from a calendar view to prevent any mistakes when inputting the date and to provide better interaction with the component.

The ‘Compare to your health in’ field and ‘Compare’ button on the top right side of the timeline allow the user to choose a second specific date for comparing his or her health status with . It also has the calendar view. When the user chooses the dates, the blue dotted vertical bar in the timeline will go directly to the chosen date.

In addition, if the user drags and drops any of the vertical bars in the timeline, the data will be displayed to the user in a specific text box object. This eliminates the need to memorize the dates. Moreover, some modifications were implemented for these two bars to help the user to distinguish between the chosen dates. The first bar is a solid line bar and with a label ‘Time A’, while the second bar is a dotted line bar and with a label ‘Time B’.

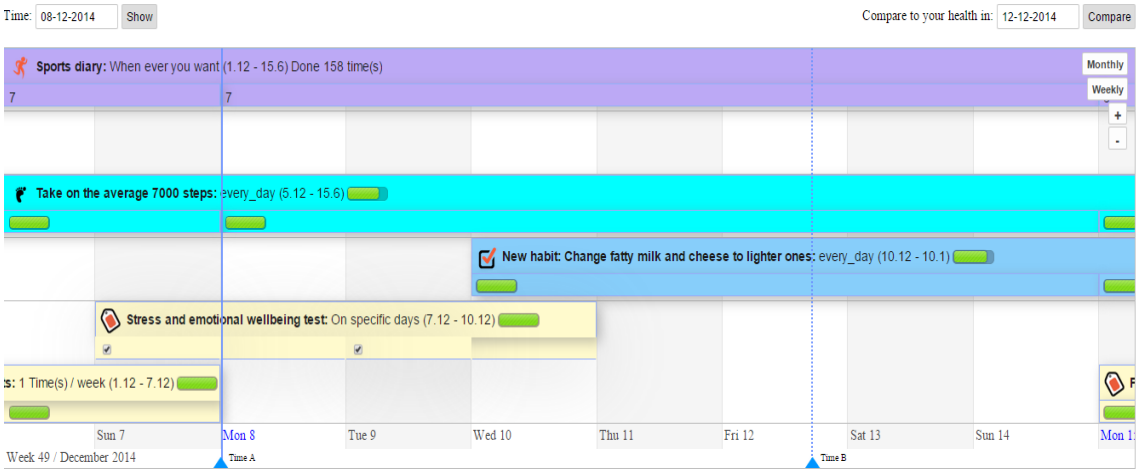


Figure 4.7. *Second view of the second version of the Progress data component interface*

In this version, the weekly progress period of each task was emphasized by making the borders of each week more visible to the user. In addition, the ‘anytime’ and ‘set days’ scheduling type labels changed to ‘Whenever you want’ and ‘On specific days’, respectively. These changes were implemented to enhance the users’ understanding of these scheduling types, see Figure 4.7.

New explanation messages were implemented also to give the user information about the different functions in the system. These messages are displayed when the user clicks on a functionality, e.g. on the weekly progress bar.

4.7 System integration

After finishing the implementation of the Progress data component, this component was integrated with two other components to implement the Health and wellness overview solution. In this section, the two other components are explained, and the integration

process of the solution is clarified. Furthermore, the reasons behind using these three components for the Health and wellness overview solution are explained.

4.7.1 hFigures and Curves components

The two components were developed and implemented by the main author of hFigures [54]. The hFigures component was developed by modifying an open source system to visualize personal health parameters or measurements which allows the users to holistically assess their health or their clients' health, and to increase awareness of the factors that can affect one's overall health [55]. This component gives the user a good assessment of the overall health status, as well as of different areas of health [4].

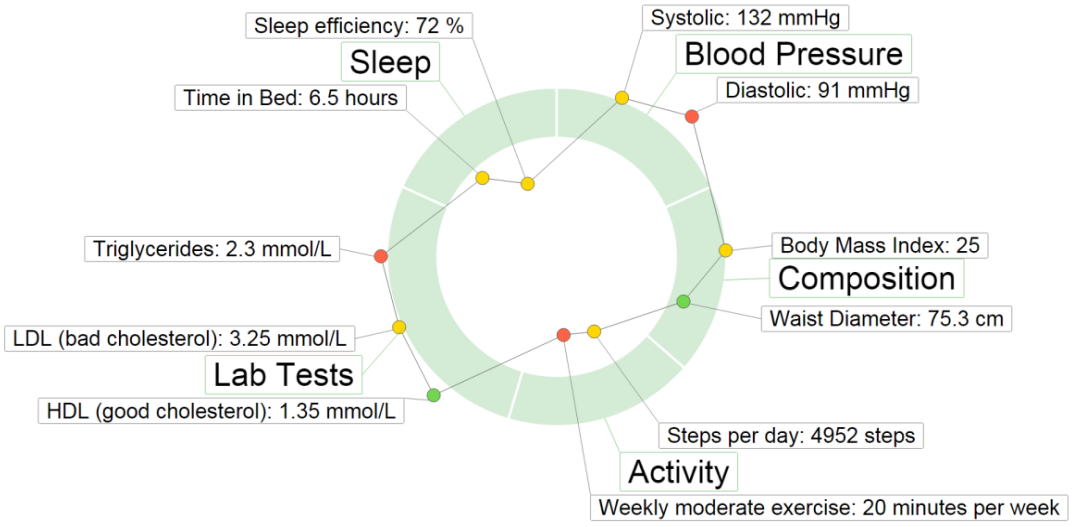


Figure 4.8. *hFigures component to show the overall health status*

As illustrated in Figure 4.8, the hFigures component shows the recommended values for all the parameters as a donut shaped circle. The parameters are shown as small circles. The color and the location of these parameters shows the level of health compared with the recommended value. The red color indicates that the measurement is far from the recommended scale for this parameter, and needs to be addressed urgently. The yellow color shows that the measurement is close to the recommended value, but still outside of it, and merits attention. Green indicates that this parameters falls within the recommended value, or can be considered 'normal'. Parameters inside the donut shaped circle are lower than the recommended value, while those outside the donut shaped circle are higher than recommended. The user of the hFigures library can freely set the borderline values for the green, yellow and red indicators. [54]

The second system is the curve component. This component presents the health parameters of the client over a period of time, with each colored dot representing the measurement. This makes it easy to follow the progress in the health status. The colored horizontal line represents the recommended value. Measurements are color-coded in the

same way as in the hFigures, and measurements above the horizontal line are higher than recommended, and those below the line are lower than recommended, as shown in Figure 4.9.

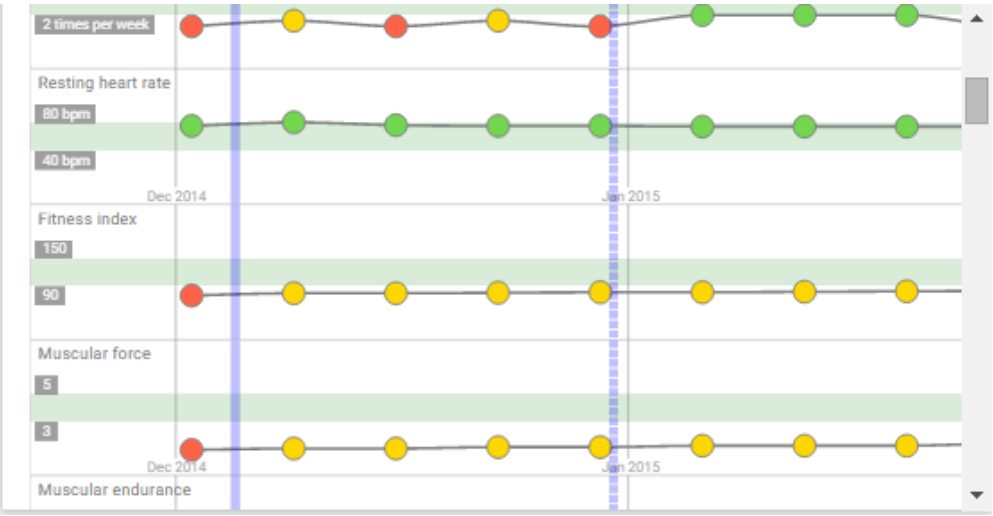


Figure 4.9. *Curves component*

4.7.2 Health and wellness overview solution

The three components mentioned above, namely the Progress data component, the hFigures, and the Curves component, were integrated together to form a Health and wellness overview solution. The aim of this integration was to obtain a holistic visualization of a vast amount of health and wellness data from different sources in order to plan, follow up, and monitor the health and wellness of a client, and to help professionals in decision-making concerning the client's health and wellness.

The three components were chosen for the following reasons. The Progress data component illustrates the health and wellness plan of a client, the performance, and the progress over a period a time. The hFigures shows the health status in specific moments of time to provide an easy way to understand the overall health status of an individual. The Curves component provides the users an opportunity to examine individual health and wellness measurement over a period time to see possible progress and to identify issues of concern over time. All three components give the user the opportunity to compare the health and wellness status in different specific times to monitor any developments.

By integrating the three components, a comprehensive system was achieved, which is easy to understand by both general users and coaches. The layout and positioning on the screen of the three components is based on feedback from the first user evaluation study, as detailed in chapter 6. See Figure 4.10.

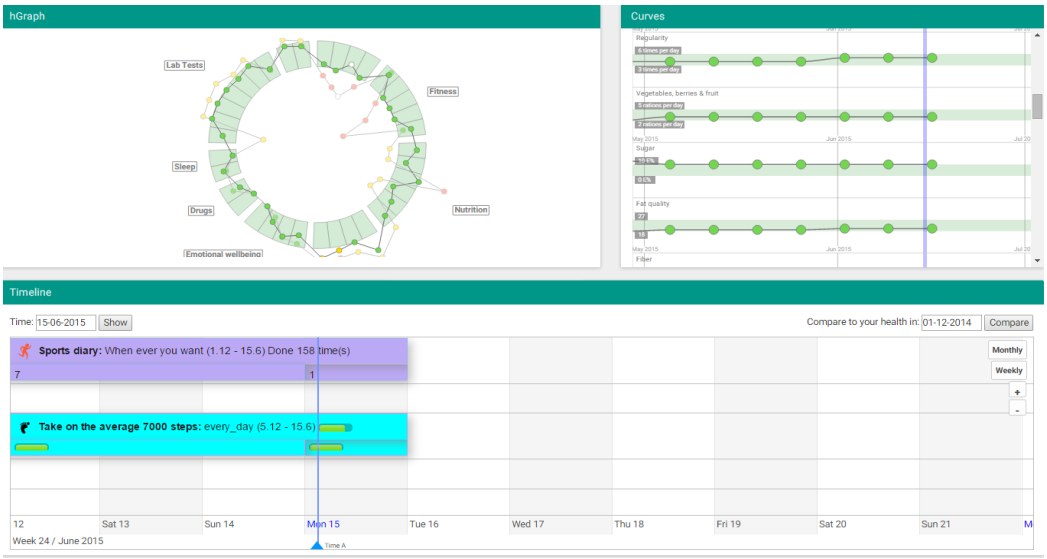


Figure 4.10. *Integrated Health and wellness overview solution*

The different components retrieve the data by sending requests to the servers or devices. This data is passed to each of the components using JSON files format independently from each other. The three components are integrated using one web page divided into three frames scaled to fit the suitable visualization for the solution. See Figure 4.11.

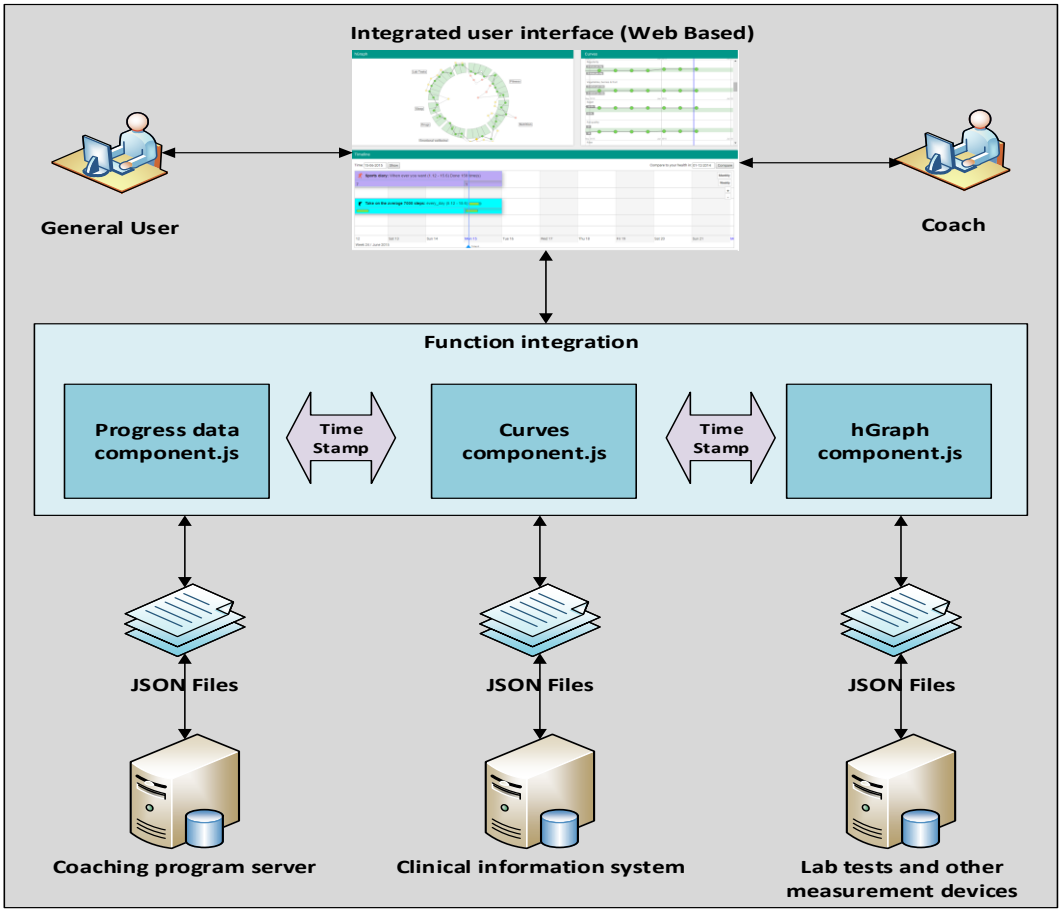


Figure 4.11. *Health and wellness overview solution – architecture of the system*

The integration required time interaction between the different components so that all components refer to the same moment or period of time. This is done by exchanging time stamps between the components. When a moment or period of time is selected on the timeline, the other components show health parameters in the same moment or period.

5. EVALUATION STUDY METHODOLOGIES

During the development of the Progress data component in health and wellness coaching, and the integration of the Health and wellness overview solution, a user-centric design process was used. Therefore, user testing and evaluation studies were an integral part of the process. This chapter describes the framework of the evaluation and the methods and tools which were used, the goals, the ethical issues, the preparation of the evaluation environment, and the scenarios and tasks which were given to the participants during the evaluation studies. Furthermore, the process of the evaluation studies is explained.

5.1 Evaluation framework

The evaluation procedure commences by determining clear goals, suitable questions and tasks to meet the research objectives. The following steps present the main activities of this framework or procedure, in order to perform user testing and to obtain a reliable outcome for the evaluation:

1. Determine and form clear evaluation goals which are linked to the research objectives;
2. Choose the evaluation methods and techniques;
3. Find a way to address the ethical issues;
4. Prepare the practical issues;
5. Create an evaluation plan;
6. Evaluate, analyze and present the data.

5.2 Evaluation goals

Well-planned evaluations are driven by clear goals and questions [56]. The evaluation goals are formed to achieve the research goals. This section will highlight the main goals of the performed user evaluation for both the Progress data component in health and wellness coaching and the integrated health and wellness overview solution.

5.2.1 Progress data component in health and wellness coaching

After developing and implementing the Progress data component in health and wellness coaching, the user evaluation was performed to test the component in order to achieve the following overall goals:

1. Identify any usability issues so that they can be addressed as a part of the iterative design process, namely: System Usefulness, Information Quality, Interface Quality, User Satisfaction, Ease of Use, Ease of Learning, Effectiveness, and Efficiency;
2. Check user performance and identify the tasks and functions which present challenges to the user;
3. Obtain suggestions or alternatives to improve the user interface design of this component;
4. Identify the positive and the negative points in the visualization and interaction;
5. Identify further development areas for the component;
6. Examine different alternative integrated user interface designs to find the most suitable user interface for the health and wellness overview solution before starting the integration;
7. Compare the overall user satisfaction towards the system by using different self-supported metrics methods, and assess the performance of the methods.

5.2.2 Health and wellness overview solution

After integrating the Progress data component in health and wellness coaching with the health and wellness monitor components, the user evaluation was performed to test the integrated solution in order to achieve the following overall goals:

1. Identify any usability issues, namely: System Usefulness, Information Quality, Interface Quality, User Satisfaction, Ease of Use, Ease of Learning, Effectiveness, and Efficiency;
2. Check user performance on the different parts of the integrated solution, as well as the entire solution;
3. Check the improvements in the design of the Progress data component in health and wellness coaching;
4. Identify the tasks and functions which present challenges to the user;
5. Identify further development areas for the integrated solution:
6. Identify the positive and the negative points in the visualization and interaction;
7. Assess if the graphical presentations of the integrated system are easy to understand and simple;

8. Compare the overall user satisfaction towards the solution by using different self-supported metrics methods, and assess the performance of the methods.

5.3 Evaluation methods, techniques and participants

For both user evaluation studies, the researcher selected different usability methods and techniques which were applied to obtain the required information and to achieve the evaluation goals. In addition, different types of participants were involved, namely general users and experts. The following are the descriptions of the testing methods and techniques, and how they were used, with information of the suitable type of participants for each of them.

1. **Predictive/Heuristic method:** this method was used with individuals experienced in human cognition and interface design rules. The aim was to identify usability problems in the user interface and to obtain suggestions for corrective action. The Walk-through technique and the Heuristic questionnaire were used as techniques for this method. In this method, the expert 'test-drove' the component or solution, and answered ten heuristic questions to help address any usability issues which might not be clear to a normal user. In both evaluations, there were three experts who participated in the evaluation study.
2. **Survey method:** this method was used with experts and general users. It was employed to obtain the users' opinions towards the component or solution and to understand their performance on the tasks and functions. Two techniques were used for this method, namely interview and questionnaires. The following three standard usability questionnaires were selected and used in this method to collect the data and to measure different usability factors:
   - After-Scenario Questionnaire (ASQ) was used to measure the effectiveness and efficiency of the system, and user satisfaction. This was done by giving the participants scenarios and tasks to perform before answering the questionnaire;
   - Computer System Usability Questionnaire (CSUQ) was used to measure the usefulness, information quality, and interface quality of the system, and user satisfaction towards the system;
   - USE Questionnaire was used to measure the usefulness, user satisfaction, and ease of use.

   In addition to the standard usability questionnaires, the researcher asked the participants additional questions to obtain background information of the participants.

3. **Observation method:** this method was also used with experts and general users. It was used to collect data to provide information about how the participants interact with the system, and how long they spend to perform different tasks. The

techniques used in this method were direct observation in a controlled environment by the moderator, and note-taking and video recording for later analysis. All the participants were observed by one moderator, namely the researcher.

The number of participants in the first evaluation, for the second and third methods, was 8, and in the second evaluation, also for these methods, was 14. Only one participant in the second evaluation study also participated in the first one. The other 13 were new participants.

In the first evaluation study, two of the expert participants were male, both aged 23, and one female, aged 39. Of the general users, one was male and the other four were female, with the ages ranging from 22 to 27. All eight participants had university degrees. Half of all participants had used a health and wellness application prior to the evaluation study. The participants were of five different nationalities, namely Chinese, Colombian, Finnish, Greek, and Iranian.

In the second study with 14 participants, two of the three experts were also male, aged 23 and 33, and one 30-year old female. The gender division of the general users was six males and five females, with ten of them in their 20s and one in his 40s. All participants had university degrees or had studied at a university. Roughly one third, or five participants, had used a health and wellness application before, while 9 had not. The participants represented eight nationalities, namely American, Chinese, Colombian, Czech, Finnish, French, Iranian, and Italian.

The relationship between the different usability methods, techniques, and participant types and numbers in the two evaluation studies respectively are detailed in Table 5.1.

Table 5.1 *Usability test methods, Techniques, Participants and the number of participants for each evaluation.*

Methods	**Techniques**	**Type of Participant**	**Number of Participants, first evaluation**	**Number of Participants, second evaluation**
Predictive/Heuristic	Walk-through Questionnaire	Expert	3	3
Survey	Interview Questionnaires	Expert/General users	8	14
Observation	Direct Observation Notes and video recording	Expert/General users	8	14

5.4 Ethical issues

Ensuring ethical implementation of an evaluation study is of utmost importance. Participants allocate their time, and give their trust, to the evaluator when they agree to participate in an evaluation study. This should be respected. Furthermore, the rights of the participants need to be protected.

In both of the evaluation studies, an informed consent form adapted to each study was provided to each participant. All the participants were required to read and sign this form prior to starting the evaluation study.

The informed consent form provided to the participants explained the purpose and goals of the evaluation study, and promised that the participants' personal information will be kept confidential and anonymous, meaning that the names of the participants will not be revealed, nor will the answers they provide be linked to their identities.

The form also explains the procedures of the evaluation study. These include using a computer, performing specific tasks, and being recorded on video in some parts of the evaluation study. Moreover, the form informs the participants of the time required to complete the evaluation study, and of the reward, if any, given to the participant after completion. The form also informs the participants of their right to terminate their participation in the study at any time without any consequence to them.

The informed consent forms used for these evaluation studies are attached to this thesis as appendix A.

5.5 Testing environment and equipment

Both evaluation studies were conducted in an office room at Tampere University of Technology. Only one participant at a time and the moderator were present in the room during the test. In order to provide the participants with their own comfortable space during the test, they were seated behind a U-shaped office desk in front of a laptop computer with an attached large screen, being recorded with a video camera from the side. The computer was equipped with a program to collect the participants' replies through online questionnaires without any personal information on the participant. The evaluator was seated on the other side of the desk in a position allowing him to observe the participants without disturbing them in their private space, taking notes on a notepad. Coffee, tea and refreshments were made available to the participants before the evaluation study. The Figure 5.1 illustrates the part of the room used for the evaluation study, with its set-up.

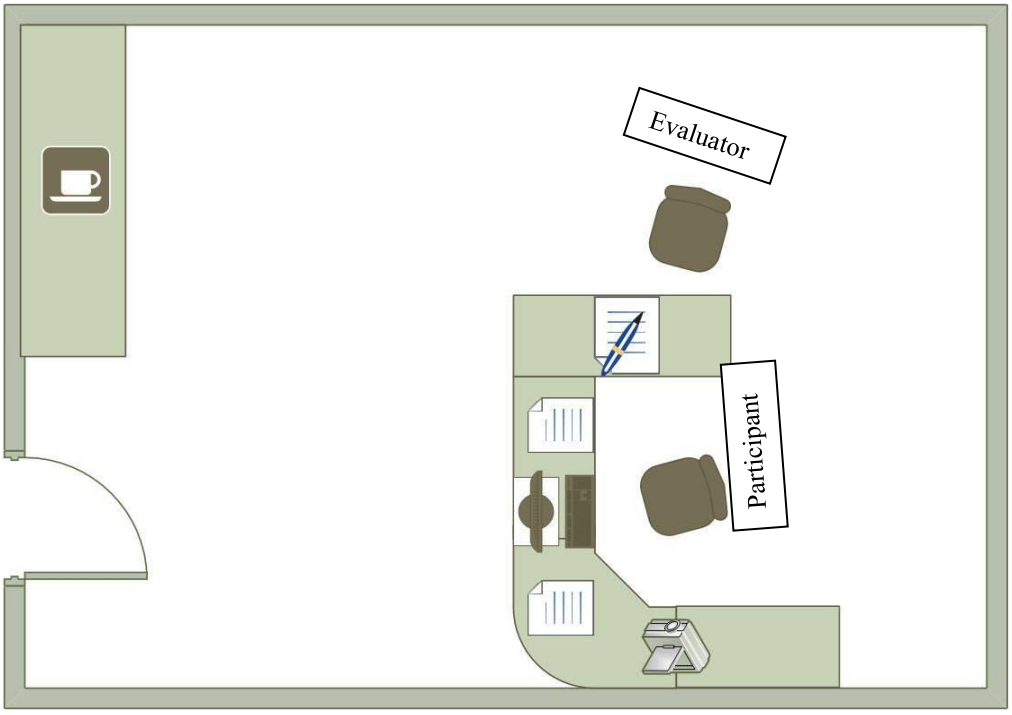


Figure 5.1. Evaluation study environment layout.

5.6 Evaluation study tasks/scenarios

For each evaluation study, interaction visualization scenarios were prepared and used. In each of these scenarios, a set of tasks or questions were implemented to test different interactive functions of the system, and to check user understanding toward a wide range of visualizations. The tasks and question were designed in a way that the participant in the evaluation study performed the tasks from the simple one to the more complicated ones.

In this section, the interaction visualization scenarios and their tasks for both evaluation studies are explained.

5.6.1 Progress data component in health and wellness coaching

Two interactive visualization scenarios were designed for this user evaluation study. The first scenario was for the Progress data component interface interactions and visualization. The second scenario was to understand how the users will interact with the Progress data component to check the health status and to compare the health status in two different moments of time. For the second scenario a paper prototype was provided to the users which contained the Progress component and the graphs that show the overall health status, see Figure 5.2. Simple graphs which showed only the overall health status, and not the individual measurements, were used in the paper prototype. This was done

as the evaluation study concentrated on the Progress data component and user interaction with it to reflect the result on the graphs.

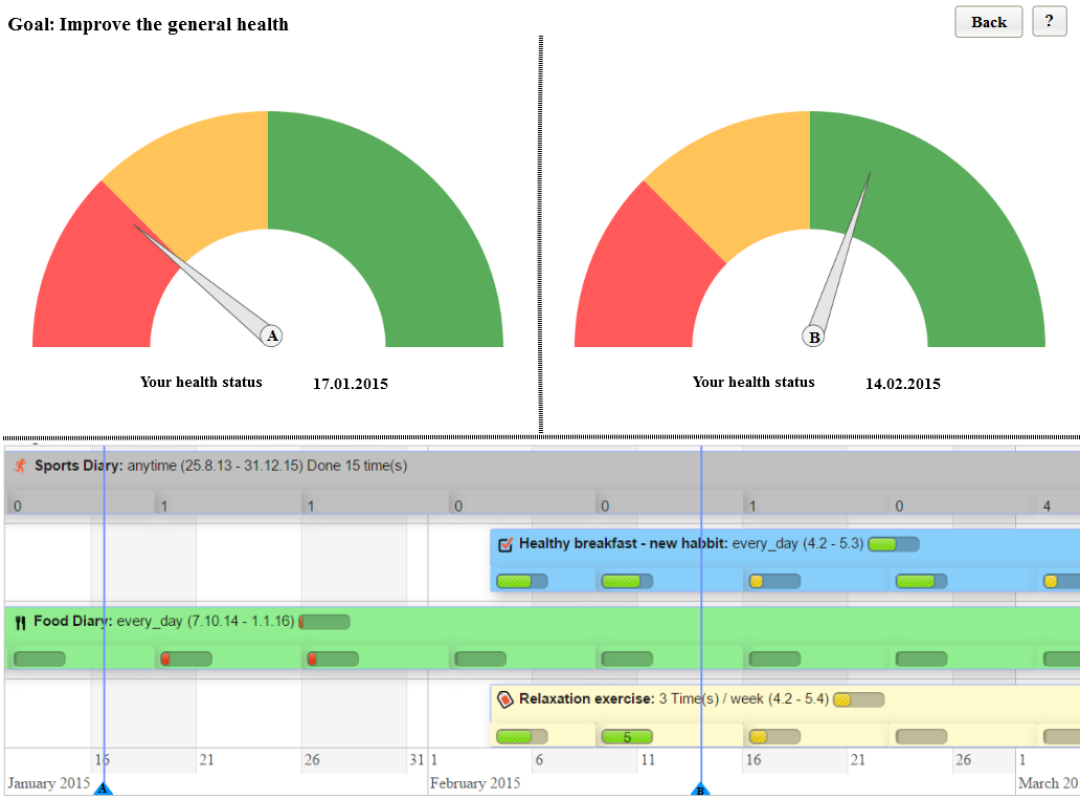


Figure 5.2 *The paper prototype used in the second scenario*

Scenario1: Progress data component interface

"*You visited a coach or a medical professional and received a set of tasks to achieve your specific goals to improve your health. Each task has a specific frequency, length of each task, and length of the program for the task. The frequency can vary as follows: any time, n times per week, every day, specific days. You will be able to see the weekly progress in each of the task, as well as the overall progress in each task over the whole program period.*"

Below are the tasks for this scenario:

1. How many tasks are currently displayed in the coaching program?
2. Point to the current time on the timeline
3. Point to the overall progress bars of one of the tasks
4. Point to the weekly progress of one of the tasks
5. Point to the schedule type (repetition of the task) for the task 'Sport diary and relax exercises'
6. Explain the task period of 'Sport diary' task
7. Find out how to display the task description to get more detail about the task you are performing.

8. Show me your tasks that you needed to make last February.
9. Try to zoom in/out to modify the timeline window.
10. What does ‘Anytime’ schedule type of the task mean to you?
11. Explain the task with ‘Specific days’ schedule type
12. Explain the code colors that are used in these progress bars. What do they show to you?
13. What does the number mean inside the progress bar?
14. In N-time task, estimate the result in the progress bar?
15. Point to the start of the week

Scenario2: Progress data component interface with comparison
In addition to Scenario1, Through the Progress data component interface you can select a specific moment of time and see your health status in the graph for this moment. In addition, you will be able to see a graph containing your overall health status at specific moments in time. You can compare your health status in two different moments in time and see if there is any improvement. The tasks as shown below:

1. Display your health parameters at a specific moment of time.
2. Compare your health parameters for two different specific moment

5.6.2 Health and wellness overview solution

In this evaluation study, three scenarios were designed. The main purposes of the first scenario were to make the user understand the main goals of the Progress data component and to perform the tasks which were challenge for the users in the previous evaluation study. The second scenario was for the health and wellness measurements in the hFigures component interface interactions and visualization. The last scenario was for using the integrated system to compare the health and wellness status in two different moments of time. The scenarios and their tasks as shown below:

Scenario1: Progress data component interface
You visited a coach or a medical professional and received a set of tasks to achieve your specific goals to improve your health. Each task has a specific frequency, length of each task, and length of the program for the task. The frequency can vary as follows: any time, n times per week, every day, specific days. You will be able to see the weekly progress in each of the task, as well as the overall progress in each task over the whole program period.

Through the Progress data component interface you can select a specific moment of time and see your health parameters in the graph for this moment. See Appendix D for an example. Below are the tasks for this scenario:

1. How many tasks are currently displayed in the coaching program?
2. Discovering the meaning of the overall progress bar of the task

3. Discovering the meaning of the weekly progress bar of the task
4. Find out how to display the task description to get more detail about the task you are performing.
5. Move to another specific moment of time
6. Zoom in/out to modify the timeline
7. Understanding ‘Anytime’ schedule type of the task
8. Select specific time in the timeline by using the ‘Input’ box
9. Select specific time in the timeline from the timeline itself

Scenario2: Health and wellness measurements in the hFigures
In addition to Scenario1, you will be able to see a graph containing your health parameters at specific moments in time (e.g. sleeping efficiency, blood pressure, or body mass index). An illustration of this can be seen in Appendix D. This is done by selecting the preferred moment in time from the timeline of Progress data component. The tasks as shown below:

1. How many areas of health are displayed in the hFigures?
2. Choose one of these areas and point to its measurements
3. Identify one measurement inside the recommended values and another one outside
4. Identify the measurement that is the furthest from the recommended values
5. What does the green, yellow and red circles mean?
6. Has the overall health improved after coaching?
7. Which area of health has improved the most after health coaching?
8. Which measurements show the biggest improvement?
9. Explain the difference between the points inside and outside the hFigures

Scenario3: the integrated system with comparison
You can compare your health status in two different moments in time and see if there is any improvement. Appendix D shows an example of the comparison. The task for this scenario was:

1. Compare your health parameters for two different specific moment

5.7 Evaluation study process

The evaluation study process was divided into three stages: preparation stage, evaluation session, and analysis and result stage.

In this research, the preparation stage involved preparing the participants for the test, and scheduling a test session for each of them. In addition, in this stage, all the necessary equipment and materials (such as scenarios, test tasks, questionnaires, etc.) were prepared. Moreover, the evaluation study location and room were selected and configured in this stage.

During each evaluation session, the following steps were implemented, in the following order:

1. The moderator gave an introduction to the participant about the evaluation session procedures, and asked the participant if they had any questions;
2. The participant was asked to read and sign the informed consent form prior to starting the test. In addition, the moderator gave a copy of the form to the participant;
3. The moderator collected the participant's personal information;
4. The moderator gave the participant basic information about the system and its purpose;
5. The moderator asked the participant to spend five minutes to explore the system and think aloud during this time. The moderator observed the participant and took notes while recording the participant on video;
6. The moderator read the scenario aloud and gave it to the participant to read, in order for the participant to be able to perform the prepared tasks;
7. The participant performed the tasks of the read scenario. The moderator observed the participant during the tasks, and took notes while recording the participant on video;
8. After finishing the tasks of each scenario, the participant was requested to answer the 'After-Scenario Questionnaire (ASQ)';
9. In the evaluation study on the Progress data component in health and wellness coaching, the moderator showed the participant alternative prototypes of the integrated user interface design and took the participant's opinion with the help of an Additional questions sheet;
10. Participant answered the 'Computer System Usability Questionnaire (CSUQ)', and 'USE Questionnaire';
11. For the expert participant, the moderator asked the expert user to walk through the system and answer the 'Heuristic' questionnaire in addition to the three questionnaires mentioned above.

During the evaluation sessions, the participants were able to ask the moderator any question at any time.

The last stage in the evaluation process was to analyze the data. This was done in order to find the required result, as defined in the goals of the evaluation study. In this stage, the analysis took place after the data were collected and combined. The results of both of the evaluation studies are presented in the next chapters.

6. EVALUATION STUDY RESULTS FOR THE PROGRESS DATA COMPONENT

This chapter explains the results of the evaluation study with regard to the Progress data component of the system. It aims to illustrate the results, and their linkage to the goals mentioned in chapter 5, with explanations about the areas of positive feedback, and those needing further attention, based on the feedback from the participants on the questionnaires. Recommendations for improvement are also included in this chapter, also derived from participant feedback.

6.1 Tasks/Scenarios results

All but three of the 17 tasks were completed successfully by all participants, within or outside the benchmark time, and the successful completion rate was high also in the remaining tasks. The following tasks were completed successfully by all participants:

- 1 (How many tasks are currently displayed in the coaching program)
- 2 (Point to the current time on the timeline)
- 3 (Discovering the meaning of the overall progress bar of the task)
- 4 (Discovering the meaning of the weekly progress bar of the task)
- 5 (Explain the schedule type of the indicated task)
- 6 (Understanding the task period)
- 7 (Show the task description)
- 8 (Move to another specific moment of time)
- 11 (Explain the task with ‘Specific days’ schedule type)
- 12 (Understanding the colors of the progress bar)
- 13 (Understanding the number inside the progress bar)
- 15 (In N-time task, estimate the result in the progress bar)
- 16 (Point to the start of the week)

Task 9 (Zoom in/out to modify the timeline) was completed successfully by 6 out of 8 participants (75%), while the successful completion rate for tasks 10 (Understanding ‘Anytime’ schedule type of the task), 14 (Select specific time in the timeline), and 17 (Compare two different specific moments of time) was 7 out of 8 (87.5%). Task completion rates are detailed in Table 6.1.

Table 6.1 *Task completion rates*

Tasks	P1	P2	P3	P4	P5	P6	P7	P 8	%
Task 1	√	√	√	√	√	√	√	√	100
Task 2	√	√	√	√	√	√	√	√	100
Task 3	√	√	√	√	√	√	√	√	100
Task 4	√	√	√	√	√	√	√	√	100
Task 5	√	√	√	√	√	√	√	√	100
Task 6	√	√	√	√	√	√	√	√	100
Task 7	√	√	√	√	√	√	√	√	100
Task 8	√	√	√	√	√	√	√	√	100
Task 9	√	√	√	√	-	-	√	√	75
Task 10	√	-	√	√	√	√	√	√	87.5
Task 11	√	√	√	√	√	√	√	√	100
Task 12	√	√	√	√	√	√	√	√	100
Task 13	√	√	√	√	√	√	√	√	100
Task 14	√	-	√	√	√	√	√	√	87.5
Task 15	√	√	√	√	√	√	√	√	100
Task 16	√	√	√	√	√	√	√	√	100
Task 17	√	-	√	√	√	√	√	√	87.5

Benchmark times were developed by estimating the kinds of answers expected for the tasks based on an estimated maximum average time to complete the tasks. When tasks required simple and quick interaction with the system, a benchmark time of 10 seconds was selected. A 15-second benchmark time was chosen for one task which involved explaining the meaning of three colors. The longest benchmark, 60 seconds, was selected for a task which needed more complicated reasoning from the users, and they needed to explain the task in a lengthy way.

Most of the tasks – 13 out of 17 – were completed within benchmark time by all, or all but one, participants. The average benchmark time was exceeded only in 3 tasks, and even in those only slightly. The standard deviation was notably high in four tasks, namely: task 8 (Move to another specific moment of time), task 9 (Zoom in/out to modify the timeline), task 10 (Understanding ‘Anytime’ schedule type of task), and task 11 (Explain the task with ‘Specific days’ schedule type).

For tasks 8 and 9, it seems some participants had difficulties to interact with the system, or did not find the easiest way to complete the task timely. For task 10, some participants found it difficult to understand the word ‘Anytime’ as a schedule type, whereas for task 11 the high standard deviation can be explained by the fact that the task involved explanation of colors used in the progress bar, and the way of explaining differs from individual to individual, and can be short or lengthy. Summaries are illustrated in Table 6.2. Individual task performance results are in appendix B.

Table 6.2 *Performance score summaries in seconds (N=8)*

Tasks	Percentage of participants performing within benchmark	Average time on task (Benchmark)	Standard deviation
Task 1	87.5	5.1 (10)	4.9
Task 2	100	3.0 (10)	1.4
Task 3	87.5	7.4 (10)	5.6
Task 4	87.5	6.8 (10)	4.0
Task 5	100	3.4 (10)	1.1
Task 6	87.5	5.3 (10)	7.6
Task 7	100	4.8 (10)	2.4
Task 8	62.5	10.9 (10)	12.1
Task 9	50	11.1 (10)	10.3
Task 10	62.5	13.9 (10)	17.7
Task 11	100	36.3 (60)	14.3
Task 12	100	10 (15)	3.3
Task 13	100	5.9 (10)	2.7
Task 14	75	8.3 (10)	3.8
Task 15	100	6.5 (10)	2.5
Task 16	100	3.0 (10)	1.7
Task 17	87.5	5.9 (10)	2.9

The analysis of the evaluation study also showed the non-crucial errors committed by the participants. These errors did not prevent the participants from completing the task given to them. The errors committed by those who did not complete a task were not included in these figures.

More than half of the tasks – 9 out of 17 – were completed without non-crucial errors. The task with most errors was task 8 (Move to another specific moment of time) with four errors. Tasks 4 (Discovering the meaning of the weekly progress bar of the task) and 7 (Show the task description) had three errors respectively, while tasks 1 (How many tasks are currently displayed in the coaching program) and 10 (Understanding 'Anytime' schedule type of the task) had two errors each. The tasks with one error were task 3 (Discovering the meaning of the overall progress bar of the task) and 9 (Zoom in/out to modify the timeline).

From the summary in Table 6.3, issues of further development can be seen with ease. The summary combines the Task Completion, Errors made by participants when completing the task, Average time on tasks, and Standard deviation. This combination shows clearly the tasks which the participants had problems with.

Nine of the tasks need further attention, namely 1 (How many tasks are currently displayed in the coaching program), 3 (Discovering the meaning of the overall progress bar of the task), 4 (Discovering the meaning of the weekly progress bar of the task), 7 (Show the task description), 8 (Move to another specific moment of time), 9 (Zoom

in/out to modify the timeline), 10 (Understanding 'Anytime' schedule type of the task), 14 (Select specific time in the timeline), and 17 (Compare two different specific moments of time).

Table 6.3 *Summary of completion, errors, average time on task, and standard deviation*

Tasks	Task Completion	Errors	Average time on task (Benchmark)	Standard deviation
Task 1	8	2	5.1(10)	4.9
Task 2	8	0	3.0(10)	1.4
Task 3	8	1	7.4(10)	5.6
Task 4	8	3	6.8(10)	4.0
Task 5	8	0	3.4(10)	1.1
Task 6	8	2	5.3(10)	7.6
Task 7	8	3	4.8(10)	2.4
Task 8	8	4	10.9(10)	12.1
Task 9	6	1	11.1(10)	10.3
Task 10	7	2	13.9(10)	17.7
Task 11	8	0	36.3(60)	14.3
Task 12	8	0	10.0(15)	3.3
Task 13	8	0	5.9(10)	2.7
Task 14	7	0	8.3(10)	3.8
Task 15	8	0	6.5(10)	2.5
Task 16	8	0	3.0(10)	1.7
Task 17	7	0	5.9(10)	2.9

User satisfaction was measured after each scenario by using an After-Scenario Questionnaire. Overall user satisfaction was high in both scenarios, and both with the ease of completing the tasks, and with the amount of time it took to complete the tasks. The ease of completing the tasks – on the scale of 1 to 7 – was rated at 5.63 for Scenario 1 and 6.75 for Scenario 2, and the satisfaction with the amount of time to complete the tasks was rated at 6.25 and 6.38 respectively. The average of the score for Overall satisfaction of the system was 6.20, with 7 out of 8 participants, or 87.5%, saying they agree or strongly agree on the statements mentioned in Table 6.4. In the total in the said table, the effectiveness metric of the system using this method is rated at 6.19, and efficiency at 6.31.

Table 6.4 *Overall user satisfaction obtained through After-Scenario Questionnaire*

Scenario Number		**Overall, I am satisfied with the ease of completing the tasks in this scenario**	**Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario**	**Overall Satisfaction**
Scenario No.1	Mean	5.63	6.25	
	Std. Deviation	1.30	.707	
Scenario No.2	Mean	6.75	6.38	
	Std. Deviation	.463	1.18	
Total	Mean	6.19	6.31	**6.20**
	Std. Deviation	1.109	.946	1.002
	Percent Agree	87.5%	87.5%	87.5%

6.2 Post-questionnaire results

In this section, the result of the three standard post-questionnaires, namely Computer System Usability Questionnaire (CSUQ), USE Questionnaire, and Nielsen Heuristic evaluation Questionnaire, are presented regarding the evaluation study for the Progress data component solution. Through these questionnaires the rest of the internal metrics of the usability of the said solution can be found, and the overall user satisfaction can be compared.

6.2.1 Computer System Usability Questionnaire (CSUQ) results

System Usefulness, Information Quality and Interface Quality are the main three metrics that can be obtained by examining the CSUQ questionnaire. The first eight items on the CSUQ assess the participant satisfaction score on the usefulness of the system. The results are shown in Table 6.5. The average of the score for overall satisfaction with system usefulness was 5.98 (on the 7-point Likert scale, with 7 meaning 'strongly agree') with a standard deviation of .789. This indicates a high level of satisfaction toward the usefulness of the system. The overall score of all the items regarding the Usefulness of the system was a positive one, as the average response on all the items was on the positive end of the scale. All the participants agreed that the system was easy to use and simple, and easy to learn. 25% of participants did not feel that they were able to complete their work quickly and to become productive quickly using the system, while the majority of the participants did. A total of 7 out of 8 participants felt comfortable while using the Progress data component of the system.

Table 6.5 *Results referring to System Usefulness metric, for items 1- 8 on the CSUQ*

Questions	**Percent Agree**	**Average Score**	**Standard deviation**
Overall, I am satisfied with how easy it is to use this system	100%	5.88	.835
It was simple to use this system	100%	6.13	.835
I can effectively complete my work using this system	100%	6.13	.641
I am able to complete my work quickly using this system	75%	5.38	1.41
I am able to efficiently complete my work using this system	100%	6.00	.756
I feel comfortable using this system	87.5%	6.00	1.07
It was easy to learn to use this system	100%	6.38	.744
I believe I became productive quickly using this system	75%	6.00	1.31
System Usefulness		**5.98**	**.789**

The second metric of the CSUQ is Information Quality. The result of this metric was obtained by the items 9 – 15 of the said questionnaire. The results are shown in Table 6.6. The overall satisfaction with the quality of the information associated with the system was positive, with an average response score of 6.0 out of 7, and a standard deviation of .646. All the participants stated that the information was easy to understand and that it helped them to complete the given tasks and scenarios. With 87.5% of the participants agreed that the provided information was easy to find, well organized on the screen, and that recovery from errors was easy and quick. However, handling errors was an aspect which received the most negative responses, with only 50% of the participants agreeing that the system provides clear error messages. This indicates the need to potentially improve the feedback functions related to the quality of the information of the system.

Table 6.6 *Results referring to Information Quality metric, for items 9- 15 on the CSUQ*

Questions	**Percent Agree**	**Mean**	**Standard deviation**
The system gives error messages that clearly tell me how to fix problems	50%	4.67	1.15
Whenever I make a mistake using the system, I recover easily and quickly	87.5%	6.00	1.26
The information (such as online help, on-screen messages, and other documentation) provided with this system is clear	87.5%	6.13	.991
It is easy to find the information I needed	87.5%	6.00	1.07
The information provided for the system is easy to understand	100%	6.13	.641
The information is effective in helping me complete the tasks and scenarios	100%	6.38	.518
The organization of information on the system screens is clear	87.5%	6.38	1.06
Information Quality		**6.00**	**.646**

The quality of the interface is the third metric obtained from the CSUQ. Items 16-18 were used to assess the participants' satisfaction toward the Interface Quality of the system. A total of 7 out of 8 participants found the interface pleasant to use and liked using it, but it can be seen also that some participants felt that the system functions and capabilities met with their expectations, with a 75% positive response rate. Summaries are illustrated in Table 6.7. All of the results can be combined to give an average response score of 5.75, with a standard deviation of 1.179. This indicates that the system scored well in relation to the interface.

Table 6.7 *Results referring to Interface Quality metric, for items 16- 18 on the CSUQ*

Questions	Percent Agree	Mean	Standard deviation
The interface of this system is pleasant	87.5%	5.88	1.36
I like using the interface of this system	87.5%	5.88	1.36
This system has all the functions and capabilities I expect it to have	75%	5.50	1.51
Interface Quality		**5.75**	**1.179**

By combining the results of these three metrics of Computer System Usability Questionnaire with an additional question regarding overall satisfaction, the result of the overall user satisfaction score toward the system can be obtained. Summaries are illustrated in Table 6.8. It can be seen that the average response for each metric is a positive one. In addition, the average response to the last item of the CSUQ (Overall, I am satisfied with this system) scored well, namely 6.00 out of 7 points, with a standard deviation of .756. In conclusion, the overall user satisfaction from the CSUQ was 5.93 out of 7, which indicates a positive response and a high level of satisfaction toward the system.

Table 6.8 *Results referring to overall user satisfaction on the CSUQ*

Metrics of the of Computer System Usability Questionnaire	Average response	Standard deviation
System Usefulness	5.98	.789
Information Quality	6.00	.646
Interface Quality	5.75	1.179
Overall, I am satisfied with this system	6.00	.756
Overall user satisfaction	**5.93**	**.842**

6.2.2 USE questionnaire results

The four internal metrics or subscales of the USE Questionnaire, referring to System Usefulness, Ease of Use, Ease of Learning, and User Satisfaction are assessed in this section for the Progress data component solution.

The first metric obtained from the USE questionnaire provides a score of System Usefulness, by assessing the first eight items of the said questionnaire. The results are shown in Table 6.9. The average of the score for overall satisfaction with system usefulness was 5.72 (on the 7-point Likert scale, with 7 meaning ‘strongly agree’), with a standard deviation of .749. This shows a high level of satisfaction toward the usefulness of the system. The overall result of all the items regarding the usefulness of the system is on the positive end of the scale.

All the participants agreed that the system was useful and helped them to be more effective, with average scores of 6.50 and 6.13, respectively. The majority of the participants

agreed that the system met their needs and helped them to be more productive and to accomplish things in an easy way. While 2 out of 8 participants disagreed with the statement that the system saves time, 75% of the participants agreed with the statement.

Table 6.9 *Results referring to System Usefulness metric, for items 1- 8 on the USE*

Questions	Percent Agree	Average response	Standard deviation
It helps me be more effective.	100%	6.13	.641
It helps me be more productive.	87.5%	5.63	1.06
It is useful.	100%	6.50	.535
It gives me more control over the activities in my life.	75%	5.88	1.25
It makes the things I want to accomplish easier to get done.	87.5%	5.75	1.39
It saves me time when I use it.	75%	4.38	1.19
It meets my needs.	87.5%	5.75	1.06
It does everything I would expect it to do.	75%	5.75	1.58
System Usefulness		**5.72**	**.749**

The second metric of the USE is Ease of Use. The result of this metric was obtained by assessing the items 9 – 19 of the USE questionnaire. The results are shown in Table 6.10. The overall satisfaction score with the ease of use associated with the system reflects a positive result, with an average score of 5.52 out of 7, with a standard deviation of .813. The average responses for all the items inside this subject are positioned at the positive end of the scale, but it can be seen also that one of the test-subjects did not agree with the ease of use of the current system.

Table 6.10 *Results referring to Ease of Use metric, for items 9-19 on the USE*

Questions	Percent Agree	Average response	Standard deviation
It is easy to use.	100%	6.13	.991
It is simple to use.	75%	5.63	1.18
It is user friendly.	87.5%	5.38	1.18
It requires the fewest steps possible to accomplish what I want to do with it.	87.5%	5.38	1.59
It is flexible.	87.5%	5.13	1.17
Using it is effortless.	75%	5.00	1.06
I can use it without written instructions.	75%	5.13	1.24
I don't notice any inconsistencies as I use it.	87.5%	6.00	1.06
Both occasional and regular users would like it.	75%	5.25	1.28
I can recover from mistakes quickly and easily.	75%	6.00	.632
I can use it successfully every time.	87.5%	5.75	1.39
Ease of Use		**5.52**	**.813**

All the participants found the Progress data component solution easy to use, and most of them agreed that the system was user-friendly, flexible, consistent, and required few steps in order for the participants to accomplish what they wanted to do, with guaran-

teed success every time. A total of 6 out of 8 participants, or 75%, said they agreed or strongly agreed on the related statements in Table 6.10.

The third metric of the USE is the Ease of Learning. The result of this metric was obtained by assessing the items 20 – 23 of the USE questionnaire, as indicated in Table 6.11. The average response score from the participants for this metric is 6.41 out of 7, with a standard deviation of .743, which shows a very high level of satisfaction toward the ease of leaning of the system. A full 100% stated that they agreed or strongly agreed with the statement that they could learn and memorize the use of the system easily, and 7 out of 8 participants agreed that they could become skillful with the system quickly.

Table 6.11 *Result referring to Ease of Learning metric, for items 20-23 on the USE*

Questions	Percent Agree	Average response	Standard deviation
I learned to use it quickly.	100%	6.38	.916
I easily remember how to use it.	100%	6.63	.518
It is easy to learn to use it.	100%	6.50	.756
I quickly became skillful with it.	87.5%	6.13	.991
Ease of learning		**6.41**	**.743**

The last metric of the USE is User Satisfaction toward the system. The result of this metric was obtained by assessing the items 24 – 30 of the USE questionnaire, see Table 6.12. For this metric, the participants were positively satisfied with the Progress data component solution. The user satisfaction average response score is 5.64 out of 7, with a standard deviation of .854. All the participants found the system pleasant to use, and most of the participants were satisfied with the system, agreeing that it worked as they wanted. They would also recommended it to a friend. However, 2 out of 8 participants felt that they had no need for the system, and did not find it 'fun to use'. This said, the overall satisfaction is still scores well.

Table 6.12 *Results referring to Satisfaction metric, for items 24-30 on the USE*

Questions	Percent Agree	Average response	Standard deviation
I am satisfied with it.	87.5%	5.75	.886
I would recommend it to a friend.	87.5%	5.75	.886
It is fun to use.	75%	5.50	1.19
It works the way I want it to work.	87.5%	6.00	1.41
It is wonderful.	87.5%	5.63	1.19
I feel I need to have it.	62.5%	5.13	1.73
It is pleasant to use.	100%	5.75	.886
Satisfaction		**5.64**	**.854**

To sum up the result from the USE Questionnaire, all the four metrics indicate a high level of satisfaction toward different aspect of the system. Some minor future development issues need to be considered. Enhancing the functionality of the system to make it

faster to use is one of the key issues to address. By combining the average of the metrics of the USE Questionnaire, the overall user satisfaction score of the system usability is 5.82 out of 7.

6.2.3 Nielsen heuristic evaluation questionnaire results

This Questionnaire was answered by the three expert participants in the evaluation study to mainly identify the possible problems in the user interface of the system and to obtain their feedback. It can be seen from Table 6.13 that all the three experts agreed or strongly agreed that the Progress data component interface contains familiar words, phrases and concepts to the user, and that the presented information was relevant and simple to understand. In addition, all three experts agreed or strongly agreed that the solution did not require extensive memorizing, and that it was consistent.

One of the three experts wanted easier exit options, better error messages, and less options to make errors. More importantly, two out of the three experts found that the system lacks sufficient shortcuts to navigate within or interact with the system. This said, the overall satisfaction with the system, as rated by the experts, was 5.77 out of 7, which can be considered as a reasonably high score.

Table 6.13 *Results of the Heuristic questionnaire*

Questions	**Percent Agree**	**Average response**	**Standard deviation**
Simple and Natural Dialogue	100%	5.67	1.15
Speak the Users' Language	100%	7.00	.000
Minimize User Memory Load	100%	7.00	.000
Consistency	100%	6.33	.577
Feedback	100%	6.00	.000
Clearly Marked Exits	66.6%	5.33	1.52
Shortcuts	33.3%	3.67	1.52
Good Error Messages	66.6%	5.00	1.00
Prevent Errors	66.6%	6.00	.000
Help and Documentation	100%	5.70	.200
Satisfaction		**5.77**	**.596**

6.3 Questionnaire result summary

Summarizing all four questionnaires regarding the Progress data component of the system, it can be seen that satisfaction with the usability of this component was positive in all the metrics measured. Summaries are illustrated in Table 6.14. The satisfaction rate was highest, above 6 out of 7 in the Likert scale, with ease of learning (6.41), efficiency (6.31) and effectiveness (6.19). Further development of the system is needed in the spheres of ease of use and interface quality, which scored 5.52 and 5.75 respectively, by

addressing the issues which the participants disliked in the system, as indicated in section 6.4 below.

Table 6.14 *Usability metric summary for the Progress data component solution*

Metric	Average response	Standard deviation
System Usefulness	5.98	.789
Information Quality	6.00	.646
Interface Quality	5.75	1.179
Ease of Use	5.52	.813
Ease of Learning	6.41	.743
Effectiveness	6.19	1.109
Efficiency	6.31	.946

When comparing overall user satisfaction results obtained by utilizing different self-reported metrics methods, it can be seen that the results are relatively uniform, with little dispersion between them, and a relatively low standard deviation rate, see Table 6.15. This indicates high reliability of the results obtained from the participants, and the performance of the different questionnaires was similar.

Table 6.15 *Comparison of the overall user satisfaction results of the questionnaires*

Questionnaire Type	Average response	Standard deviation
After-Scenario Questionnaire (ASQ)	6.20	1.00
Computer System Usability (CSUQ)	5.93	.842
USE Questionnaire	5.82	.790
Nielsen heuristic evaluation	5.77	.596

6.4 Likes, dislikes, issues and recommendations

The evaluation study highlighted issues and system functionalities which they liked or disliked, and recommendations were retrieved from the feedback from the participants.

The participants liked most the possibility to compare indicators between two moments in time, and the use of bars to indicate how much of the different task was completed, thus giving them the knowledge of their own performance of the tasks required for their health and wellness. The participants also liked the choice of colors which were easily understandable and distinguishable at a glance.

The participants were shown prototypes of the integrated system. A simple graph was used for the overall health status instead of the hFigures, as the purpose of the exercise was to concentrate on the layout of the solution rather than the individual components. The most preferred one was the prototype featured in Figure 6.1.

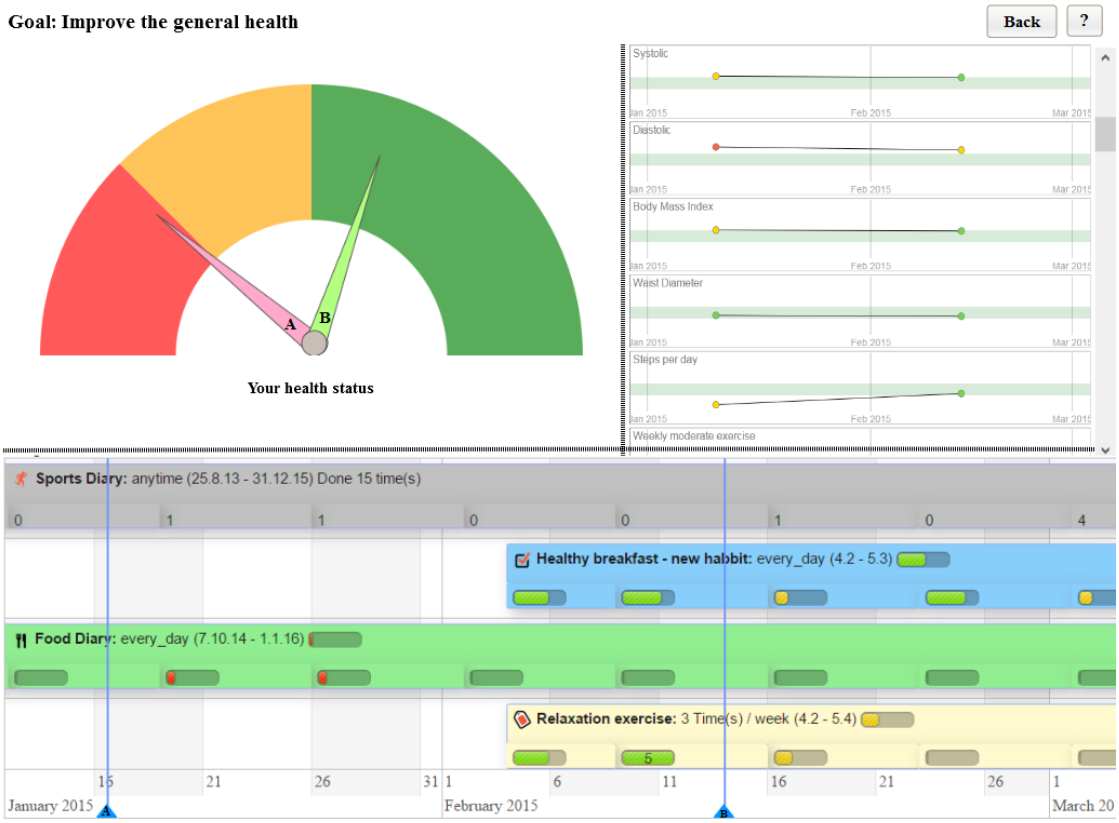


Figure 6.1. *The most preferred prototype for the integrated health and wellness overview solution.*

The least liked feature in the system, as derived from the feedback from the participants, was related to moving within the timeline of the system by scrolling. Participants found it difficult to move over extensive periods of time by scrolling.

After obtaining all the results from the evaluation study, issues that need to be considered for future work to improve the Progress data component before implementing the integrated health and wellness solution could be identified, and the recommendations to correct these issues could be drawn up. The issues were ranked in priority: low, medium, and high. The five high priority issues to be addressed, as shown in Table 6.16, need to be solved to improve user interaction with the system and to increase the users' ability to complete their tasks expediently using the system. Other issues, those with medium and low priority, need to be addressed as well, in order to enhance the users' understanding about the visualization of the data in the system interface.

Table 6.16 *Issues of concern and recommendations for future development of the Progress data component of the system*

Issue#	Issue Priority	Issue	Recommendation
1	High	Comparing two specific moments inside Progress data component timeline easily was time-consuming	Provide an additional method to compare directly the two specific moments. This also could be done by making the user choose the two dates from a calendar tool
2	High	The possibility to zoom in/out to modify the timeline was not recognized	Provide additional methods to show the weekly and monthly views of the Progress data component, and another one to zoom in and out in different scales. These methods could be done by adding buttons for these tasks
3	High	'Anytime' word as schedule type was not clear	Change it to something more clear to the user, e.g. 'Whenever you want'
4	High	Moving easily to another specific moment of time inside the Progress data component timeline was difficult	Provide an additional method for moving directly to a specific moment. This could be done by making the user choose the date from a calendar tool
5	High	Selecting specific moment to show the health status by only dragging the customs bar was not efficient for some of the participants	Provide an additional method to select directly a specific moment. This could be done by making the user choose the date from a calendar tool
6	Medium	Distinguishing the weekly progress from the overall progress bar was difficult	Add messages to show the user that this is the weekly progress
7	Medium	Figuring out the period of the weekly progress bar was difficult	Make clear borders to the weekly period
8	Low	It was not easy to find the task description. Participants were clicking on other task-related information to find it	Make the task descriptions available by clicking on any place of the task, not only the title
9	Low	Using gray color for tasks makes the users feel inactive in these task	Change the color to another one

7. RESULTS OF EVALUATION STUDY FOR THE HEALTH AND WELLNESS OVERVIEW SOLUTION

This chapter explains the results of the evaluation study with regard to the Integrated health and wellness overview solution. It aims to illustrate the results, and their linkage to the goals mentioned in chapter 5, with explanations about the areas of positive feedback, and those needing further attention, based on the feedback from the participants on the questionnaires. It also includes a comparison of the results of the two evaluation studies. Recommendations for improvement are also included in this chapter, also derived from participant feedback.

7.1 Tasks/scenarios results

The evaluation study for the integrated solution was carried out after the first evaluation study for the Progress data component of the solution, and after some modifications and improvements were made to the said component following findings and recommendations obtained through the first evaluation study.

The ten tasks related to the Progress data component in this evaluation study were:

1. How many tasks are currently displayed in the coaching program?
2. Discovering the meaning of the overall progress bar of the task
3. Discovering the meaning of the weekly progress bar of the task
4. Show the task description
5. Move to another specific moment of time
6. Zoom in/out to modify the timeline
7. Understanding ‘Anytime’ schedule type of the task
8. Select specific time in the timeline by using the ‘Input’ box
9. Select specific time in the timeline from the timeline itself
10. Compare two different specific moments of time

All 14 participants completed all the tasks successfully, with only a few errors in total, and with most of the tasks completed within benchmark time. Benchmark times were, again, selected based on estimated average completion time, and the required level of interaction with the system. The summary in Table 7.1 illustrates the successful completion rate, non-crucial errors committed by participants while completing the tasks, per-

centage of performance within benchmark, average time to complete the tasks, and standard deviation. Individual task performance results are in appendix B.

Table 7.1 *Summary of completion, errors, average time on task, and standard deviation of the Progress data component*

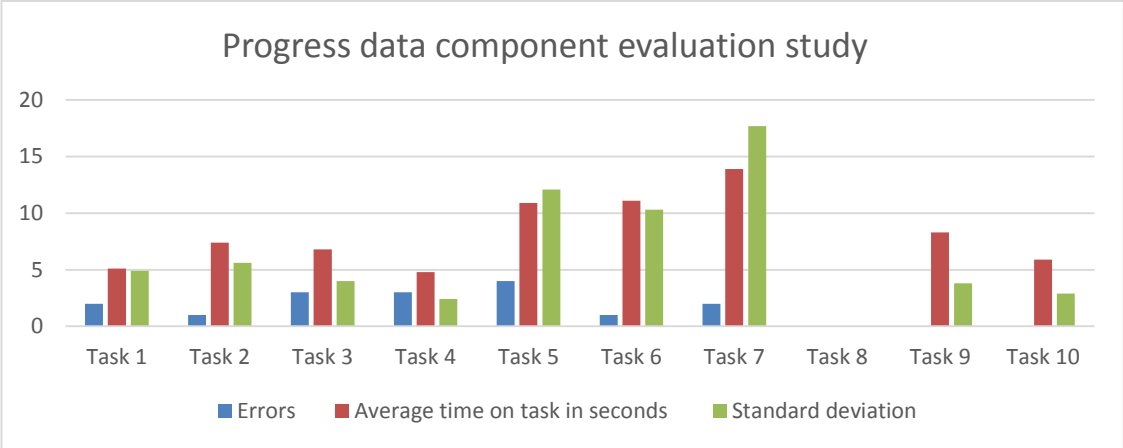
Tasks	Task Completion	Errors	Percentage of participants performing within benchmark	Average time on task (Benchmark)	Standard deviation
Task 1	14	1	100	4.1 (10)	2.6
Task 2	14	0	100	4.0 (10)	1.7
Task 3	14	1	92.9	6.5 (10)	2.9
Task 4	14	1	100	3.1 (10)	1.1
Task 5	14	0	100	5.4 (10)	2.2
Task 6	14	0	100	3.9 (10)	0.9
Task 7	14	0	92.9	7.4 (10)	2.1
Task 8	14	0	100	7.3 (15)	2.8
Task 9	14	0	100	6.4 (10)	2.7
Task 10	14	0	100	30.0 (60)	9.8

Comparing the evaluation studies for the Integrated solution and the earlier one for the Progress data component, it can be clearly seen that the modifications and improvements of the system following the first evaluation study have resulted in fewer non-crucial errors in all tasks, faster completion of the tasks, and a drastically decreased standard deviation. This indicates that the interactive visualization for the user interface of the Progress data component had improved significantly by focusing on the user during the design process, and following the iterative design approach.

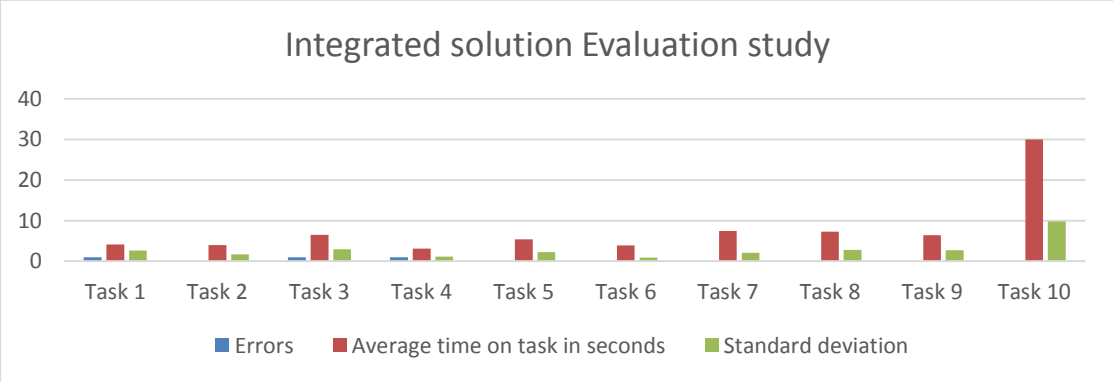
The numbering of the tasks in Table 7.2 and in Figure 7.1 refer to the ones used for the evaluation study for the Integrated solution, and the tasks in the evaluation study for the Progress data component have been matched with those of the evaluation study for the Integrated solution. For task 8 in the Integrated solution evaluation study, there is no corresponding task in Progress data component evaluation study, as this task relates to a modification in the system which was implemented after the first evaluation study. For task 10, the participant was required only to answer a question and implement one interaction with a paper model in the Progress data component evaluation study, while in the Integrated solution evaluation study the task required several interactions with the solution on the computer. Hence the difference in the benchmark time and average time on task.

Table 7.2 *Comparison of the results of the evaluation studies for the Integrated solution and the Progress data component*

	Integrated solution Evaluation study			Progress data component evaluation study		
Tasks	**Errors**	**Average time on task (Benchmark)**	**Standard deviation**	**Errors**	**Average time on task (Benchmark)**	**Standard deviation**
Task 1	1	4.1 (10)	2.6	2	5.1(10)	4.9
Task 2	0	4.0 (10)	1.7	1	7.4(10)	5.6
Task 3	1	6.5 (10)	2.9	3	6.8(10)	4.0
Task 4	1	3.1 (10)	1.1	3	4.8(10)	2.4
Task 5	0	5.4 (10)	2.2	4	10.9(10)	12.1
Task 6	0	3.9 (10)	0.9	1	11.1(10)	10.3
Task 7	0	7.4 (10)	2.1	2	13.9(10)	17.7
Task 8	0	7.3 (15)	2.8			
Task 9	0	6.4 (10)	2.7	0	8.3(10)	3.8
Task 10	0	30.0 (60)	9.8	0	5.9(10)	2.9



A) Errors, average time on task, and standard deviation of the Progress data component



B) Errors, average time on task, and standard deviation of the Integrated solution

Figure 7.1. *Comparison of the results of the evaluation studies for the Integrated solution and the Progress data component*

The second scenario in the evaluation study of the Integrated solution focused on the hFigures component of the system.

The nine tasks related to the hFigures component in this evaluation study were:

1. How many areas of health are displayed in the hFigures?
2. Choose one of these areas and point to its measurements
3. Identify one measurement inside the recommended values and another one outside
4. Identify the measurement that is the furthest from the recommended values
5. What does the green, yellow and red circles mean?
6. Has the overall health improved after coaching?
7. Which area of health has improved the most after health coaching?
8. Which measurements show the biggest improvement?
9. Understand the difference between the points inside and outside the hFigures

As Table 7.3 illustrates, a total of 7 out of the 9 tasks were successfully completed by all 14 participants. Finding the measurements in the area of health (Task 2) proved the most difficult one for the participants, with 3 out of the 14 not completing the task, while one participant had difficulties understanding the difference between the points inside and outside the hFigures (Task 9).

Table 7.3 *Task completion rates of the hFigures wellness overview*

Tasks	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	%
Task 1	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 2	√	-	√	√	√	√	-	√	√	√	√	√	√	-	78.6
Task 3	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 4	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 5	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 6	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 7	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 8	√	√	√	√	√	√	√	√	√	√	√	√	√	√	100
Task 9	√	√	√	√	√	√	√	√	-	√	√	√	√	√	92.9

The analysis of the evaluation study also showed the non-crucial errors committed by the participants. These errors did not prevent the participants from completing the task given to them. The errors committed by those who did not complete a task were not included in these figures.

Only 3 out of 9 tasks were completed without non-crucial errors. The task with most errors was task 1 (How many areas of health are displayed in the hFigures?) with four errors. Tasks 4 (Identify the measurement that is the furthest from the recommended values) and 6 (Has the overall health improved after coaching?) had two errors respec-

tively, while tasks 3 (Identify one measurement inside the recommended values and another one outside), 8 (Which measurements show the biggest improvement?), and 9 (Understand the difference between the points inside and outside the hFigures) had one error each. Summaries are illustrated in Table 7.4.

More than 70% of the participants were able to complete most of the tasks within benchmark time. The required level of interaction with the hFigures was the basis of the selection of these benchmark times. Longer 15-second times were chosen for tasks requiring two-part answers, and a 30-second time was chosen when a user was requested to explain more than two parts.

The average benchmark time was exceeded only in 3 tasks, and even in two of them only slightly. The standard deviation was notably high in three tasks, namely: task 1 (How many areas of health are displayed in the hFigures?), task 2 (Choose one of these areas and point to its measurements), and task 6 (Has the overall health improved after coaching?). Individual task performance results are in appendix B.

For tasks 1 and 2, it seems some of the participants had difficulties to interact with the hFigures component in terms of zooming in or out. For task 6, some participants faced difficulty to distinguish between the two specific moments of time between which they chose to compare the health status.

From the summary in Table 7.4, issues of further development can be seen with ease. The summary combines the Task completion, Errors made by participants when completing the task, Average time on tasks, and Standard deviation. This combination shows clearly the tasks which the participants had problems with.

During the further development, the most urgent modifications need to be done on tasks 1, 2 and 6 to enhance the interactive visualization of the hFigures.

Table 7.4 *Summary of completion, errors, average time on task, and standard deviation of the hFigures wellness overview*

Tasks	Task Completion	Errors	Percentage of participants performing within benchmark	Average time on task (Benchmark)	Standard deviation
Task 1	14	4	78.6	12.2 (10)	12.6
Task 2	11	0	71.4	10.0 (10)	12.4
Task 3	14	1	85.7	10.8 (15)	5.4
Task 4	14	2	85.7	6.8 (10)	5.0
Task 5	14	0	100	17.5 (30)	6.6
Task 6	14	2	50.0	16.1 (10)	16.5
Task 7	14	0	92.9	6.2 (10)	5.6
Task 8	14	1	85.7	7.9 (10)	5.9
Task 9	13	1	78.6	9.2 (15)	4.7

User satisfaction was measured after each scenario by using an After-Scenario Questionnaire. Overall user satisfaction was positively high in the three scenarios, and both with the ease of completing the tasks, and with the amount of time it took to complete the tasks. The ease of completing the tasks – on the scale of 1 to 7 – was rated at 6.36 for Scenario 1, and 6.64 for each of the Scenarios 2 and 3, and the satisfaction with the amount of time to complete the tasks was rated at 6.43, 6.64 and 6.71 respectively. The average of the score for Overall user satisfaction of the Integrated system was 6.46, with a standard deviation of .531.

All the participants agreed or strongly agreed on the statement 'Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario', and 13 out of 14 participants agreed or strongly agreed with the ease of completing the tasks in the provided scenarios. The effectiveness metric of the system using this method was rated at 6.55, and efficiency at 6.60.

Table 7.5 *Overall user satisfaction obtained through After-Scenario Questionnaire*

Scenario Number		**Overall, I am satisfied with the ease of completing the tasks in this scenario**	**Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario**	**Overall Satisfaction of the system**
Progress data component Scenario No.1	Mean	6.36	6.43	
	Std. Deviation	.745	.646	
hFigures Scenario No.2	Mean	6.64	6.64	
	Std. Deviation	.842	.497	
Comparison Scenario No.3	Mean	6.64	6.71	
	Std. Deviation	6.71	.611	
Total	Mean	6.55	6.60	**6.46**
	Std. Deviation	.739	.587	**.531**
	Percent Agree	92.9%	100%	

7.2 Post-questionnaire results

In this section, the result of the three standard post-questionnaires, namely; Computer System Usability Questionnaire (CSUQ), USE Questionnaire, and Nielsen Heuristic evaluation Questionnaire are presented for the evaluation study for the integrated health and wellness overview solution. Finding the internal metrics of the usability of the said system, and comparing the overall user satisfaction which are obtained from the different usability tools.

7.2.1 Computer System Usability Questionnaire (CSUQ) results

System Usefulness, Information Quality and Interface Quality are the main three metrics that can be obtained by examining the CSUQ questionnaire. The first eight items on the CSUQ assess participant satisfaction with the usefulness of the system. The results are shown in Table 7.6. The average of the score for overall satisfaction with system usefulness was 6.13 (on the 7-point Likert scale, with 7 meaning 'strongly agree'), with a standard deviation of .930. This indicates a high level of satisfaction toward the usefulness of the system. The overall evaluation of all the items regarding usefulness of the system is a positive one, as the average response for all the items was on the positive end of the scale. The vast majority of participants, 13 out of 14 participants, agreed that the system was easy to use and simple, and felt that they were able to complete their work effectively and efficiently using the system. Also, ease of learning was rated high by all the participants, which indicates that the system is easy to learn. However, only 78.6% of the participants were able to complete their work quickly. This issue needs to be considered when planning future work on the system.

Table 7.6 *Results referring to System Usefulness metric, for items 1- 8 on the CSUQ*

Questions	**Percent Agree**	**Average Response**	**Standard deviation**
Overall, I am satisfied with how easy it is to use this system	92.9%	6.29	.994
It was simple to use this system	92.9%	6.07	1.20
I can effectively complete my work using this system	92.9%	6.07	1.07
I am able to complete my work quickly using this system	78.6%	5.86	1.40
I am able to efficiently complete my work using this system	92.9%	6.21	.893
I feel comfortable using this system	92.9%	6.21	.975
It was easy to learn to use this system	100%	6.43	.852
I believe I became productive quickly using this system	85.7%	5.93	1.26
System Usefulness		**6.13**	**.930**

The second metric of the CSUQ is Information Quality. The results for this metric were obtained by the items 9 – 15 of the said questionnaire. The results are shown in Table 7.7. The overall satisfaction with the quality of the information associated with the system is positive, with an average score of 5.66 out of 7, with a standard deviation of 1.20. The majority of participants found the information was easy to understand and helped them to complete the given tasks and scenarios.

A total of 85.7% of the participants agreed that the provided information was easy to find and well organized on the screen, and that they could recover easily and quickly from errors. However, handling errors was an aspect which received the most negative response, with only 10 out of 14 participants agreeing that the system gives clear error

messages. This points to the need to potentially improve the feedback related to the quality of the information of the system.

Table 7.7 *Results referring to Information Quality metric, for items 9- 15 on the CSUQ*

Questions	Percent Agree	Average Response	Standard deviation
The system gives error messages that clearly tell me how to fix problems	71.4%	4.50	2.44
Whenever I make a mistake using the system, I recover easily and quickly	85.7%	5.43	1.95
The information (such as online help, on-screen messages, and other documentation) provided with this system is clear	78.6%	5.29	1.90
It is easy to find the information I needed	85.7%	6.07	1.27
The information provided for the system is easy to understand	92.9%	5.93	1.39
The information is effective in helping me complete the tasks and scenarios	92.9%	6.14	1.17
The organization of information on the system screens is clear	85.7%	6.29	1.14
Information Quality		**5.66**	**1.20**

The quality of the interface is the third metric obtained from the CSUQ. Items 16-18 were used to assess the participants' satisfaction toward Interface Quality of the system. Almost all the participants, 13 out of 14 participants, found the interface pleasant to use and liked using it. Also, 85.7% of the participants felt that the system functions and capabilities fulfilled their expectations. Summaries are illustrated in Table 7.8. Combining all the results gives an average response score of 6.24 with a standard deviation of .999. This is an excellent score and indicates that participants were overwhelmingly satisfied with the interface.

Table 7.8 *Results referring to Interface Quality metric, for items 16-18 on the CSUQ*

Questions	Percent Agree	Average Response	Standard deviation
The interface of this system is pleasant	92.9%	6.36	1.00
I like using the interface of this system	92.9%	6.36	.929
This system has all the functions and capabilities I expect it to have	85.7%	6.00	1.18
Interface Quality		**6.24**	**.999**

The result of the overall user satisfaction score toward the system was obtained by combining the results of the above-mentioned three metrics of the Computer System Usability Questionnaire with an additional question regarding overall satisfaction. Summaries are illustrated in Table 7.9. It can be seen that the average response for each metric is a highly positive one. In addition, the average response to the last item of the CSUQ, 'Overall I am satisfied with this system', scored well, 6.07 out of 7 points. From all these results, the complete user satisfaction from the CSUQ is 6.02 out of 7, which

indicates that the participants found using the health and wellness overview solution to be a satisfactory experience.

Table 7.9 *Results referring to overall user satisfaction on the CSUQ*

Metrics of the of Computer System Usability Questionnaire	**Average response**	**Standard deviation**
System Usefulness	6.13	.930
Information Quality	5.66	1.20
Interface Quality	6.24	.999
Overall, I am satisfied with this system	6.07	1.07
Overall user satisfaction	**6.02**	**1.04**

7.2.2 USE questionnaire results

The four internal metrics or subscales of the USE Questionnaire, referring to System Usefulness, Ease of Use, Ease of Learning, and User Satisfaction are assessed in this section for the Integrated health and wellness overview solution.

The first metric obtained from the USE questionnaire provides a score of System Usefulness, by assessing the first eight items of the questionnaire. The results are shown in Table 7.10. The average of the score for overall satisfaction with system usefulness was 6.13 (on the 7-point Likert scale, with 7 meaning 'strongly agree'), with a standard deviation of .611. This shows a very high level of satisfaction toward the usefulness of the system. The overall result of all the items regarding the usefulness of the system is on the positive end of the scale.

Table 7.10 *Results referring to System Usefulness metric, for items 1- 8 on the USE*

Questions	**Percent Agree**	**Mean**	**Standard deviation**
It helps me be more effective.	100%	6.21	.802
It helps me be more productive.	100%	6.29	.726
It is useful.	100%	6.79	.426
It gives me more control over the activities in my life.	92.9%	6.00	.961
It makes the things I want to accomplish easier to get done.	100%	6.07	.917
It saves me time when I use it.	78.6%	5.71	1.33
It meets my needs.	85.7%	6.07	1.21
It does everything I would expect it to do.	92.9%	5.93	1.21
System Usefulness		**6.13**	**.611**

All the participants considered that the system was useful and helped them to be more effective and productive, and that the system allowed them to complete their work in an easy way. The majority of the participants agreed that the system met their needs and they received what they expected from the system. While 3 out of 14 participants disa-

greed with the statement that the system saved time, 78.6% of the participants said that the system saved time when they used it.

The second metric of the USE is Ease of Use. The result of this metric was obtained by assessing the items 9 to 19 of the USE questionnaire. The results are shown in Table 7.11. The overall satisfaction score with the ease of use associated with the system reflect a positive result, with an average response of 5.94 out of 7, with a standard deviation of 1.05. The average responses for all the items inside this subject are positioned at the positive end of the scale.

A total of 13 out of 14 participants agreed or strongly agreed that the health and wellness overview solution was easy to use, and user friendly, and that they could use it without additional efforts. They also felt it easy and quick to recover from mistakes when performing the tasks. In addition, most of the participants found the system simple to use and required only few steps to accomplish what they wanted to do, with an average response of 6.07. The flexibility and the consistency of the system were rated high among the participants, with an average response of 5.5 and 5.79 out of 7, respectively. While the majority of the participants said that different kind of users would like to use the system, only 64.3% agreed that they did not need a written instructions to use the system. This issue needs to be considered in the further development of the system.

Table 7.11 *Results referring to Ease of Use metric, for items 9-19 on the USE*

Questions	**Percent Agree**	**Mean**	**Standard deviation**
It is easy to use.	92.9%	6.21	1.19
It is simple to use.	85.7%	6.07	1.49
It is user friendly.	92.9%	5.93	1.26
It requires the fewest steps possible to accomplish what I want to do with it.	85.7%	6.07	.997
It is flexible.	85.7%	5.50	1.23
Using it is effortless.	92.9%	5.71	.994
I can use it without written instructions.	64.3%	5.71	1.38
I don't notice any inconsistencies as I use it.	85.7%	5.79	1.48
Both occasional and regular users would like it.	85.7%	5.86	1.56
I can recover from mistakes quickly and easily.	92.9%	6.21	1.05
I can use it successfully every time.	85.7%	6.29	1.07
Ease of Use		**5.94**	**1.05**

The third metric of the USE is the Ease of Learning. The result of this metric was obtained by assessing the items 20 to 23 of the USE questionnaire, as illustrated in Table 7.12. The average response from the participants for this metric was 6.50 out of 7, with a standard deviation of .620, which shows a very high level of satisfaction toward the ease of leaning of the system. All 100% of the participants agreed or strongly agreed with the statement that they learned and could easily memorize the use of the system.

Moreover, all but one participant agreed that they could become skillful with the system quickly.

Table 7.12 *Results referring to Ease of Learning metric, for items 20-23 on the USE*

Questions	Percent Agree	Mean	Standard deviation
I learned to use it quickly.	100%	6.57	.756
I easily remember how to use it.	100%	6.71	.611
It is easy to learn to use it.	92.9%	6.43	.938
I quickly became skillful with it.	92.9%	6.29	.914
Ease of learning		**6.50**	**.620**

The last metric of the USE is the User Satisfaction toward the system. The result of this metric was obtained by assessing the items 24 to 30 of the USE questionnaire, see Table 7.13. The results show a high satisfaction rate with the health and wellness overview solution. The user satisfaction average response was 5.88 out of 7, with a standard deviation of .983. Most of the participants were satisfied with the system, and found the system pleasant to use and working as they expected. They would also recommend the system to a friend. While 4 out of 14 participants felt that they had no need for the system, still the majority of the participants found the system fun to use and wonderful.

Table 7.13 *Results referring to Satisfaction metric, for items 24-30 on the USE*

Questions	Percent Agree	Mean	Standard deviation
I am satisfied with it.	92.9%	6.21	.802
I would recommend it to a friend.	92.9%	6.36	.842
It is fun to use.	85.7%	5.86	1.23
It works the way I want it to work.	92.9%	5.86	1.10
It is wonderful.	78.6%	5.64	1.28
I feel I need to have it.	71.4%	5.43	1.65
It is pleasant to use.	92.9%	5.79	1.12
Satisfaction		**5.88**	**.983**

By combining the average of the metrics of the USE questionnaire, the overall user satisfaction scores for the complete questionnaire is 6.11 with a standard deviation of .816. This indicates that the participants were greatly satisfied with the health and wellness overview solution.

7.2.3 Nielsen heuristic evaluation questionnaire results

This Questionnaire was answered by the three expert participants in the evaluation study with the objective of obtaining their feedback in identifying the possible problems in the user interface of the system. As Table 7.14 shows, all three experts agreed or

strongly agreed on all but one of the indicators. One of the three found the system to require extensive use of his memory. According to the feedback, this expert needed to spend time to distinguish which lines in the hFigures component corresponded to the specific times in the timeline, which loaded the expert's memory.

The experts rated their overall satisfaction with the system at 6.3 out of 7, which is a very high score, with a standard deviation of .562 on the average.

Table 7.14 *Results of the Heuristic questionnaire*

Questions	Percent Agree	Average response	Standard deviation
Simple and Natural Dialogue	100%	7.00	.000
Speak the Users' Language	100%	6.33	.577
Minimize User Memory Load	66.7%	4.67	.577
Consistency	100%	6.67	.577
Feedback	100%	6.00	1.00
Clearly Marked Exits	100%	6.33	.577
Shortcuts	100%	6.67	.577
Good Error Messages	100%	6.33	.577
Prevent Errors	100%	6.33	.577
Help and Documentation	100%	6.67	.577
Satisfaction		**6.3**	**.562**

7.3 Questionnaire result summary

Summarizing all four questionnaires regarding the health and wellness overview solution, it can be seen that satisfaction with the usability of this solution was positive in all the metrics measured. As Table 7.15 shows, the satisfaction rate was highest, above 6 out of 7 in the Likert scale, with efficiency (6.60) and effectiveness (6.55), ease of learning (6.50), interface quality (6.24), and system usefulness (6.13). Further development of the system is needed in the spheres of ease of use and information quality, which scored 5.94 and 5.66 respectively, by addressing the issues which the participants disliked in the system, as indicated in section 7.4 below.

Table 7.15 *Usability metrics summary for the solution*

Metric	Average response	Standard deviation
System Usefulness	6.13	.930
Information Quality	5.66	1.20
Interface Quality	6.24	.999
Ease of Use	5.94	1.05
Ease of Learning	6.50	.620
Effectiveness	6.55	.739
Efficiency	6.60	.587

While user satisfaction with information quality was decreased from the previous evaluation study, most of the usability metrics were slightly increased from the previous evaluation study as shown in Chapter 6.

When comparing the overall user satisfaction results obtained by utilizing different self-reported metrics methods, it can be seen that the results are relatively uniform, with little dispersion between them, and a relatively low standard deviation rate, see Table 7.16. This indicates high reliability of the results obtained from the participants.

When comparing overall user satisfaction results of this evaluation study with the previous evaluation study in Chapter 6, it can be also seen that the results improved in all the usability questionnaires toward a higher level of satisfaction. The different tools also produced similar results.

Table 7.16 *Compare the overall user satisfaction result of the questionnaires*

Questionnaire Type	**Average response**	**Standard deviation**
After-Scenario Questionnaire (ASQ)	6.46	.531
Computer System Usability (CSUQ)	6.02	1.04
USE Questionnaire	6.11	.816
Nielsen heuristic evaluation	6.30	.562

7.4 Likes, dislikes, recommendations

The most positive feedback from the participants regarding the system was related to the extensive amount of information at a time, providing the user with very useful and motivating data about their health, ease of learning and operating with a user-friendly and pleasant interface, and the possibility to see the progress in the health status through the parameters.

Negative feedback was obtained from the participants regarding some functionalities of the system, such as showing the measurements in the hFigures, and problems with some methods of interaction with the system.

The results from the evaluation study highlighted issues that need to be considered for future work to improve the integrated health and wellness solution, and the recommendations to correct these issues could be formulated. The issues were ranked in priority: high, medium, and low. The four high priority issues, as shown in Table 33, need to be solved to improve user interaction with the system and to increase the users' ability to complete their tasks expediently using the system without excessive load on the memory. Issues with medium priority should be also considered in the redesign or modification stage, in order to enhance the users' understanding about the visualization of the data in the system interface. The low priority issues are not urgent, and they are

mainly ‘nice to have’. However, as the recommended solution for them is simple to implement, they could be addressed easily.

Table 7.17 *Issues of concern and recommendations for future development of the health and wellness overview solution*

Issue#	Issue Priority	Issue	Recommendation
1	High	In the hFigures, people want to see all the graph and the titles of the areas of health inside hFigures window.	Increase the area of the hFigures in the integrated system to show all the graph
2	High	In the hFigures, people are not able to see the title of the measurement inside areas of health	Make titles of the measurements appear when you click on them
3	High	In the hFigures, people face difficulty to distinguish between the two specific moments of time between which they choose to compare the health status	Add legends, or labels, and make the style of the two lines different
4	High	People need a tutorial or help document	Implement a help document to explain what the purpose of each part in the integrated system is
5	Medium	In the hFigures, people want to see both the ‘before’ and ‘after’ values of the measurements	Add the ‘before’ values
6	Medium	In the progress data component, people wanted error messages to be displayed when people choose incorrect dates	Add error messages to both date input boxes to inform the user about the incorrect date
7	Medium	In the curves, people want to see the same parameter that they are viewing in the hFigures, without searching them by scrolling	Add new interaction between the hFigures and the curves to show the measurements that the user is viewing in both the hFigures and the curves
8	Medium	In the hFigures, people do not understand the measurement values	Clarify the value range, e.g. 5 out of 7
9	Low	In the hFigures, people find it difficult to distinguish between the ‘before’ and ‘after’ indicators of measurements	Make the line between the ‘before’ and ‘after’ values of measurements in different color and bold to make it easier to distinguish when the user interacts with them
10	Low	In the progress data component (Timeline), people want to move the custom bar to a specific date more easily	Add new interaction where a double click on the desired date will bring the custom bar to this date
11	Low	In the hFigures, people want explanation to some of the measurements to help them understand this measurement	Show measurement descriptions by right click on the measurements

8. DISCUSSION AND CONCLUSION

This thesis focused on development and user testing of a solution for visualizing the health status of individuals and their progress during health and wellness coaching, in order to achieve highest possible usability and user satisfaction, and good user performance in their interaction with solution.

In order to reach this goal, a progress data component was developed and integrated into the other components of the health and wellness solution, namely the hFigures and curves that show the health measurements of the client. The Progress data component includes tasks or interventions given to the client by the coach. These are placed on a timeline with the frequency of the task or intervention in order to reach a commonly agreed goal. It also shows the user's results on these tasks.

Implementation and design of the progress data component followed a user-centered approach, with early focus on the users and the tasks. This approach also included iterative design, with cycles of design, test, measure, and redesign.

The first stages of the design were implemented using paper prototypes and a white board and involved stakeholders, mainly members of the research group, in order to obtain rapid feedback on the design and the functionality of the system. After this, the high-fidelity prototype of the system was implemented as a web-based prototype with all the functionalities required. This was followed by a user evaluation study in order to see with potential users the usability of the system and their satisfaction towards the system. In addition, positive and negative feedback was collected on issues which were successfully implemented, as well as those needing further development. The evaluation study was carried out with eight users, three of whom were experts in the field of usability and user experience.

Three different methods were used during the evaluation study. The first method was heuristic. It was used on the three experts, only, utilizing the walk-through technique and full heuristic questionnaires to identify possible problems which non-expert users might not find. The second method was used on all 8 participants, and consisted of a survey with interviews and questionnaires. The third method, also used on all eight participants, was direct observation, in which users were given tasks and scenarios which they were required to fulfil with the system. This process was observed directly by the researcher, who took notes and recorded the participants on video.

Four standard usability questionnaires were used, namely After-Scenario Questionnaire (ASQ), Computer System Usability (CSUQ), USE Questionnaire, and Nielsen heuristic evaluation, to obtain information on different usability metrics, i.e. System Usefulness, Information Quality, Interface Quality, User Satisfaction, Ease of Use, Ease of Learning, Effectiveness, and Efficiency. The questionnaires were also used to compare information received on the overall user satisfaction and to obtain reliable evaluation data.

The evaluation framework began by determining evaluation goals to match with the research objectives. Evaluation methods and techniques were then chosen, and an informed consent form was created to address ethical issues. Practical issues were then prepared, such as identifying locations and equipment needs, and an evaluation plan was drawn up. The evaluation process ended with analysis and presentation of the data. The analysis stage included gathering the data on the rate of task completion, the number of non-crucial errors which did not prevent the participants from completing the tasks, and the time required to perform the tasks.

This information, combined with other feedback from the participants, showed some areas or functionalities which needed modifications in order for the users to utilize the system more easily and speedily. The results of the usability metrics were, in general, positive, with an overall score of more than 5 out of 7, with 1 meaning 'strongly disagree' and 7 'strongly agree'. The main functionality which prompted negative feedback was related to moving within the timeline of the progress data component, and zooming in and out of the timeline.

This was followed by a redesign process, during which additional functionalities were added to address the issues prompting negative feedback, and to make interaction with the system easier.

After the redesign process, the progress data component was integrated with the hFigures and curves components which had been developed by the main author of hFigures [54]. The aim of this integration was to obtain a health and wellness overview solution. The integration required time interaction between the different components so that all components refer to the same moment or period of time. When a moment of period of time is selected on the timeline, the other components show health parameters in this selected moment or period.

The integration process was followed by another evaluation study, this time with 14 participants, three of whom were experts in the field of usability and user experience. The goals of the evaluation study were to check the usability of the solution, and the participants' understanding of the visualization and functionalities. The same methods and framework as in the first evaluation study were used, but with new tasks and scenarios. Tasks for the progress data component concentrated on the issues which had caused the most problems in the first evaluation study.

The results of the second evaluation study show that the modifications of the progress data component improved user performance clearly in terms of less errors, no task completion failure, and significantly reduced time spent on completing the tasks. In addition, the results indicate that, in the hFigures component, some functionalities still need to be developed further, mainly those related to finding the measurements more easily, and to identifying the correct moment in time when comparing data from two different times.

The results for the usability metrics, obtained from the four standard questionnaires, indicated high rates of satisfaction, with system usefulness scoring, on the average, 6.13 in the scale from 1 to 7, information quality 5.66, interface quality 6.24, ease of use 5.94, ease of learning 6.50, effectiveness 6.55, and efficiency 6.60. The average score for overall user satisfaction toward the solution varied between 6.02 and 6.46, depending on the questionnaire, which shows high user satisfaction and reliable results.

The most important strength of this research was the fact that several different usability and evaluation methods and questionnaires were used. Using different methods to evaluate usability and user satisfaction, both with experts and general users, helped us obtain different kinds of information to enable us to measure the required metrics and to reach the goals of the study. The methods used in the study allowed us to obtain also direct feedback from the participants, including their reactions and interaction with the system. I believe using different post-test questionnaires, which address the same issues from different angles, e.g. positive statements or negative statements, and analyzing and comparing the results, increases the reliability of the results. In the case of this study, the results from the questionnaires were similar, which indicates high reliability of the results as well as the questionnaires themselves.

The overall goals of the research were to implement the Progress data component, to integrate it with the other components, and to evaluate the Progress data component and the Integrated health and wellness solution. These goals were met. The goals for the evaluation studies were also met, but only with a certain type of user demographic.

As the evaluation studies were conducted on people with a university level education, the results illustrate the understanding of data visualization of this particular demographic. It would be beneficial for future work to conduct an evaluation study with small groups of individuals representing different levels of education and computer literacy in order to obtain a wider understanding of how different kinds of people understand the data visualization of the system, and what kind of usability issues they encounter.

The evaluation studies were conducted by the same researcher throughout the process, which may present an issue of bias. It might be beneficial to have at least two observers

and analysts to observe the participants and to analyze the data in order to prevent presumptions or loss of data, and to obtain critical peer assessment.

The system should also be tested with a different client data set, for example a large number of different tasks and measurements. This would provide information on the performance of the system with different amounts of data.

Additionally, some aspects of the system need to be developed further, by improving user interaction with the system, mainly in order to reduce memory load on the user and to provide more information for the user through Help functions, for example. In addition, other minor modifications are needed in the hFigures as mentioned above, and additional interaction is needed between the hFigures and curves.

Other further work could include evaluating the design of the integrated interface on devices with different screen sizes, such as tablets and smart phones. For tablets, the system could be evaluated in the near future, as they generally have a reasonably large screen. However, the applications interaction through touch screen technology should be carefully assessed. For smart phones, a new interface, designed for smaller screens, should be designed, implemented, and evaluated, putting emphasis on the context of use with smaller devices.

In conclusion, users demonstrated high satisfaction with the usability of the system, which indicates that the information visualization techniques used in the system were successful, and that the user-centered approach is a viable one in order to reach high levels of usability and user satisfaction. Moreover, this research strongly indicates that the use of different methods and standardized questionnaires in the evaluation phase increases the reliability of the results. In addition, the different tools produced similar results, which suggests that the tools perform in a similar way. The results also show that successful visualization can assist individuals to better understand their holistic health and wellness data.

REFERENCES

[1] C. Soomlek, An Agent-Based Wellness Visualization System, dissertation, University of Regina, Regina, 2013, Available: http://hdl.handle.net/10294/3848.

[2] E. Mattila, I. Korhonen, R. Lappalainen, A. Ahtinen, L. Hopsu and T. Leino, Nuadu Concept for Personal Management of Lifestyle Related Health Risks, Proceedings of the 30th Annual International IEEE EMBS Conference Engineering in Medicine and Biology Society, Vancouver, Canada, 20-25 Aug, 2008, pp. 5846 - 5850.

[3] JA-CHRODIS, Health Promotion and Primary Prevention in 14 European countries: a comparative overview of key policies, approaches, gaps and needs, Brussels, 2015, 36 p. Available: http://www.chrodis.eu/wp-content/uploads/2015/07/FinalFinalSummaryofWP5CountryReports.pdf.

[4] A. Ledesma, H. Nieminen, P. Valve, M. Ermes, H. Jimison and M. Pave, The Shape of Health: A Comparison of Five Alternative Ways of Visualizing Personal Health and Wellbeing, Proceedings of the 37th Annual International Conference of the *IEEE* Engineering in Medicine and Biology Society (EMBS2015), Milan, Italy, Aug, 2015.

[5] J. Viitanen, H. Hyppönen, T. Lääveri, J. Vänskä, J. Reponen and I. Winblad, National questionnaire study on clinical ICT systems proofs: Physicians suffer from poor usability, International Journal of Medical Informatics, Vol. 80, No. 10, 2011, pp. 708-725.

[6] M. Khan and S. S. Khan, Data and Information Visualization Methods, and Interactive Mechanisms: A Survey, International Journal of Computer Applications, Vol. 34, No. 1, 2011, pp. 1-14.

[7] H. Nieminen, S. Baggström, H. Lehtonen, A. Leppisaari, H. Mikkola and I. Korhonen, Mobile Solution for Increasing the Efficiency of Health Coaching for Preventative Health Care and Chronic Disease Management, Proceedings of the 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC2013), Osaka, Japan, 2013, 生体医工学, Vol. 51, No.

Supplementpp, pp. M-153.

[8] J. W. Miller, Wellness: The History and Development of a Concept, Spektrum Freizeit, Vol. 1, 2005, pp. 84-102.

[9] H. Dunn, High-level Wellness for Man and Society, American Journal of Public Health and the National's Health, Vol. 49, No. 6, 1959, pp. 786-792.

[10] WHO, Official Records of the World Health Organization, in International Health Conference, New York, No. 2, 19–22 June, 1946, 100 p.

[11] B. J. Smith, K. C. Tang and D. Nutbeam, WHO Health Promotion Glossary: new terms, Health Promotion International Advance Access, vol. 21, 2006, pp. 340-345.

[12] B. Hettler, "The Six Dimensions of Wellness Model," National Wellness Institute, Inc., 1976. Available (accessed on 15.9.2015): http://www.nationalwellness.org/?page=AboutWellness.

[13] M. Swarbrick, A wellness approach, Psychiatric Rehabilitation Journal, Vol. 29, No. 4, 2006, pp. 3311-3314.

[14] J. M. Montague, w. Piazza, K. Peters, G. Eippert and T. Poggiali, The Wellness Solution, Journal of Active Aging, Vol. March April, 2002. pp. 17-20.

[15] A. A. Murphy, M. Zechner, A. B. Spagnolo and K. J. Gill, "Wellness Coaching: A New Role for Peers, Psychiatric Rehabilitation Journal, Vol. 34, No. 4, 2011, pp. 328–331.

[16] J. Desch, What is a Wellness Coach?, sick and happy, 4 August, 2008. Available (accessed on 16.9.2015): http://www.sickandhappy.com/what-is-a-wellness-coach/.

[17] ProWellness Health Coaching System, Information System for Health Coaching, ProWellness UK Ltd, 1 November 2007. Available (accessed on 16.9.2015): http://www.prowellness.com//?s=news&id=19.

[18] M. de Ridder, et al., A Web-Based Medical Multimedia Visualisation Interface for Personal Health Records, Proceedings of the 26th International Symposium on Computer-Based Medical Systems (CBMS) in IEEE, Porto, 20-22 June, 2013, pp.191-196.

[19] L. Chittaro, Information visualization and its application to medicine, Artificial Intelligence in Medicine, Vol. 22, 2001, pp. 81-88.

[20] J. J. Thomas and K. A. Cook, A Visual Analytics Agenda, IEEE Transactions on Computer Graphics and Applications, Vol. 26, No. 1, 2006, pp. 12-19.

[21] M. Bärtschi, Health Data Visualization - A review, Seminar Collaborative Data Visualization, Fribourg, Switzerland, 2011, 4 p. Available (accessed on 16.9.2015): https://diuf.unifr.ch/main/diva/.../Health_Information_Visualization.pdf.

[22] T. Le, K. Wilamowska, G. Demiris and H. Thompson, Integrated data visualisation: an approach to capture older adults' wellness, International Journal of Electronic Healthcare, Vol. 7, No. 2, 2012, pp. 89-104.

[23] A. Cabarcos, T. Sanchez, J. A. Seoane, V. Aguiar-Pulido, A. Freire, J. Dorado and A. Pazos, Retrieval and management of medical information from heterogeneous sources, for its integration in a medical record visualisation tool, International Journal of Electronic Healthcare, vol. 5, no. 4, 2010, pp. 371-385.

[24] A. Bui and W. Hsu, "Chapter 4," in *Medical Data Visualization: Toward Integrated Clinical Workstations*, Springer US, Los Angeles, USA, 2009, pp. 139-193.

[25] F. S. Roque, L. Slaughter and A. Tkatsenko, A Comparison of Several Key Information Visualization Systems for Secondary Use of Electronic Health Record Content, Proceedings of the NAACL HLT 2010 Second Louhi Workshop on Text and Data Mining of Health Documents, Los Angeles, 2010, pp. 76-83.

[26] A. Bui, D. R. Aberle and H. Kangarloo, TimeLine: Visualizing Integrated Patient Records, IEEE Transaction on Information Technology in Biomedicine, Vol. 11, No. 4, 2007, pp. 462-473.

[27] Fitbit Inc, Mobile App + Dashboard, Fitbit Inc, 2015. Available (accessed 18.9.2015): https://www.fitbit.com/app.

[28] NexJ Health, Nexj Health Coach, NexJ Health, 2015. Available (accessed 18.9.2015): http://www.nexjhealth.com/solutions/nexj-health-coach/.

[29] B. v. Niman, T. Sund, A. Rodriguez-Ascaso, S. Brown and P. Garner, User Experience Design Guidelines for Telecare Services, Proceedings of the 8th conference on Human-computer interaction with mobile devices and services, ACM, 2006, pp. 279-280.

[30] J. Gulliksen, B. Göransson, I. Boivie, S. Blomkvist, J. Persson and A. Cajander, Key Principles for User-Centred System Design, Behaviour and Information

Technology, Vol. 22, No. 6, 2003, pp. 397-409.

[31] K. Rekha Devi, A. M Sen and K. Hemachandran, A working Framework for the User-Centered Design Approach and a Survey of the available Methods, International Journal of Scientific and Research Publications, Vol. 2, No. 4, 2012, ISSN 2250-3153.

[32] S. Venkataramesh and S. Veerabhadraiah, Effective Usability Testing – Knowledge of User Centered Design is a Key Requirement, International Journal of Emerging Technology and Advanced Engineering, Vol. 3, No. 1, 2013, pp. 627-635.

[33] J. Preece, Y. Rogers and H. Sharp, Interaction design: Beyond human-computer interaction, New York: John Wiley and Sons, 2002, 519 p.

[34] J. D. GOULD and C. LEWIS, Designing for usability: key principles and what designers think, Communications of the ACM , Vol. 28, No. 3, 1985, pp. 300–311.

[35] J. D. Gould, Human-computer interaction. chapter How to design usable systems, Morgan Kaufmann Publishers Inc. San Francisco, CA, USA, 1995, pp. 93–121.

[36] R. M. Baecker, Readings in Human-Computer Interaction: Toward the Year 2000, Morgan Kaufmann, San Francisco, USA, 2014, 900 p.

[37] ISO, ISO 13407: Human centred design processes for interactive systems, International Standard Association, 1999, 32 p.

[38] S. Riihiaho, Experiences with usability evaluation methods, Licentiate thesis, Helsinki University of Technology, Laboratory of Information Processing Science, Helsinki, 2000, 113 p.

[39] S. R. Humayoun, Incorporating Usability Evaluation in Software Development Environments, KI-Künstliche Intelligenz, Vol. 26, No. 2, 2012, pp.197-200.

[40] Usability Consulting Services, Indiana University, User Centered Design Methods, 2002. Available (accessed on 12.9.2015): http://www.indiana.edu/~usable/presentations/ucd_methods.pdf.

[41] J. Viitanen and M. Nieminen, Usability Evaluation of Digital Dictation Procedure - An Interaction Analysis Approach, Proceedings of the 7th conference on Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society: information Quality in e-Health, Springer-Verlag,

Graz, 2011, pp.133-149.

[42] ISO 9241-210, International Standard: Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems. First edition 2010-03-15. Reference number ISO 9241-210:2010(E), 2010, 32 p.

[43] J. Nielsen, Usability Engineering, Elsevier, 1994, 362 p.

[44] J. Rubin and D. Chisnell, Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests, 2 ed., Indianapolis, Indiana: Wiley Publishing, Inc, 2008, 384 p.

[45] C. M. Johnson, D. Johnston, P. K. Crowley, H. Culbertson, H. E. Rippen, D. J. Damico and C. Plaisant, EHR Usability Toolkit: A Background Report on Usability and Electronic Health Records, (Prepared by Westat under Contract No. HHSA 290-2009-00023I). AHRQ Publication No. 11-0084-EF. Rockville, MD: Agency for Healthcare Research and Quality, Rockville, 2011, 63 p.

[46] J. R. Lewis, IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use, IBM, Indianapolis, 1993.

[47] J. R. Lewis, IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use, International Journal of Human-Computer Interaction, Vol. 7, No. 1, 1995, pp. 57-78.

[48] J. R. Lewis, PSYCHOMETRIC EVALUATION OF AN AFTER-SCENARIO QUESTIONNAIRE FOR COMPUTER USABILITY STUDIES : THE ASQ, SIGCHI Bulletin, Vol. 23, No. 1, 1991, pp. 78-81.

[49] A. Lund, *Measuring usability with the USE questionnaire,* STC Usability SIG Newsletter, 2008, Available (accessed on 30.4.2015): http://garyperlman.com/quest/quest.cgi?form=USE.

[50] A. Leppisaari , "Movendos Oy," 2013. Available (accessed on 30.4.2015): www.movendos.com.

[51] B. Almende, "Vis org," Almende B.V, 2015. Available (accessed on 15.3.2015): http://visjs.org/.

[52] W. Peggy, M.-W. Diane and W. Bruce, Techniques & Tools for Using Color In Computer Interface Design, Crossroads, Vol. 3, No. 3, 1997, pp. 3-6.

[53] S. Few, Information Dashboard Design: The Effective Visual Communication of

Data, 1st ed., O'Reilly Media, Incorporated, 2006, 211 p.

[54] A. Ledesma and H. Nieminen, hFigures, Tampere University of Technology, Signal Processing, Personal Health Informatics, 2015. Available (accessed on 15.8.2015) : https://gitlab.com/ledancs/hFigures.

[55] F. Jonathan and J. Sonin, "hGraph: An Open System for Visualizing Personal Health Metrics," Involution Studios, Massachuestts, 2015, 10 p. Available (accessed on 8.4.2015) : http://www.hgraph.org/docs/hGraph_Whitepaper.pdf.

[56] V. BASILI, G. CALDIERA and D. ROMBACH, The Goal Question Metric Paradigm: Encyclopedia of Software Engineering, New York: John Wiley & Sons, 1994.

APPENDIX A: INFORMED CONSENT FORMS

The informed consent form used for the Progress data component evaluation studies:

Informed Consent Form

I volunteer to participate in a research project conducted by research assistant Mohammed Al-Musawi from Tampere University of Technology.

The purpose of the research is to assess the usability of wellness data visualization solution, and evaluate the user satisfaction toward this solution.

Wellness data visualization solution is a website to allow the user to follow the progress in their wellness by showing their health parameters in a specific moment of time, and the tasks which are provided by a coach or a medical professional.

The procedures involve using the website and also a paper prototype. I will be asked to perform specific tasks, I will be asked questions about the solution and my experience using it. In addition, I will be recorded during some part of the experiment.

All the data that we obtain will be kept confidential and anonymous, and the researcher will not identify me by name in any report. I understand that free to ask question or to stop participating in this experiment at any time without penalty. I also understand that I will not be paid for my participation.

The Experiment will take about 40 minutes to complete.

I, _____, understand the nature of the experiment and I agree to participant. I give the researcher permission to use my data as part of his experimental study.

_____ _____

Signature of Participant Date

The informed consent form used for the health and wellness overview evaluation studies:

Informed Consent Form

I volunteer to participate in a research project conducted by research assistant Mohammed Al-Musawi from Tampere University of Technology.

The purpose of the research is to assess the usability of wellness data visualization solution, and evaluate the user satisfaction toward this solution.

Wellness data visualization solution is a website allowing the user to follow the progress in their wellness by showing their health parameters in a specific moment of time, and the tasks which are provided by a coach or a medical professional.

The procedures involve using the website and also a paper prototype. I will be asked to perform specific tasks, I will be asked questions about the solution and my experience using it. In addition, I will be recorded during some part of the experiment.

All the data that is obtained will be kept confidential and anonymous, and the researcher will not identify me by name in any report. I understand that I am free to ask questions or to stop participating in this experiment at any time without penalty. I also understand that I will not be paid for my participation. **The only compensation for my participation will be one ticket to the cinema.**

The Experiment will take about 60 to 80 minutes to complete.

Copy should be given to the participant.

I, _____, understand the nature of the experiment and I agree to participate. I give the researcher permission to use my data as part of his experimental study.

_____ _____

Signature of Participant Date

APPENDIX B: INDIVIDUAL TASK PERFORMANCE RESULTS

Table 1 *Individual task performance results for the Progress data component evaluation study*

Tasks	P1	P2	P3	P4	P5	P6	P7	P8	Benchmark In Seconds	Average time on task	Standard deviation
Task 1	10	2	2	2	15	2	3	5	10	5.1	4.9
Task 2	4	2	5	2	2	2	2	5	10	3.0	1.4
Task 3	3	**20**	5	4	6	4	10	7	10	7.4	5.6
Task 4	3	5	7	**15**	4	10	4	6	10	6.8	4.0
Task 5	5	3	5	3	3	3	2	3	10	3.4	1.1
Task 6	24	3	2	2	3	2	3	3	10	5.3	7.6
Task 7	4	3	2	5	7	8	2	7	10	4.8	2.4
Task 8	15	**36**	3	5	4	20	2	2	10	10.9	12.1
Task 9	30	5	15	10			5	2	10	11.1	10.3
Task 10	4		25	50	4	4	5	5	10	13.9	17.7
Task 11	20	25	30	40	50	50	20	55	60	36.3	14.3
Task 12	10	9	15	7	7	7	10	15	15	10.0	3.3
Task 13	5	8	4	9	3	4	4	10	10	5.9	2.7
Task 14	3		5	15	9	8	8	10	10	8.3	3.8
Task 15	10	6	10	5	4	5	4	8	10	6.5	2.5
Task 16	2	3	2	3	3	2	2	7	10	3.0	1.7
Task 17	6		4	4	10	9	6	2	10	5.9	2.9

Table 2 *Individual task performance results for the integrated health and wellness solution evaluation study (Progress component tasks)*

Tasks	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	M	B	SD
Task 1	2	2	2	5	10	5	8	2	4	4	3	3	6	1	4.1	10	2.6
Task 2	3	4	3	4	4	2	3	3	4	5	4	5	9	3	4.0	10	1.7
Task 3	4	7	3	5	10	6	4	7	10	**12**	4	10	4	5	6.5	10	2.9
Task 4	3	3	3	4	4	2	3	5	3	2	3	5	2	1	3.1	10	1.1
Task 5	10	6	5	7	5	6	5	6	6	3	8	5	2	2	5.4	10	2.2
Task 6	5	4	3	4	3	3	5	4	5	5	4	3	4	2	3.9	10	0.9
Task 7	9	8	5	7	7	6	8	6	**12**	6	9	5	10	5	7.4	10	2.1
Task 8	8	6	9	8	10	5	5	5	15	**6**	6	5	9	5	7.3	15	2.8
Task 9	4	5	10	9	9	4	5	10	4	3	4	9	9	5	6.4	10	2.7
Task10	21	44	17	30	37	24	31	17	45	23	35	40	36	20	30.0	60	9.8

M: Mean **B:** Benchmark In Seconds **SD:** Standard deviation

Table 3 *Individual task performance results for the integrated health and wellness solution evaluation study (hGraph component tasks)*

Tasks	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	M	B	SD
Task 1	5	4	4	6	10	7	8	8	10	**11**	**50**	8	**30**	10	12.2	10	12.6
Task 2	5		6	6	5	9		**47**	6	6	10	5	5		10.0	10	12.4
Task 3	**20**	3	8	15	4	5	6	9	8	**17**	15	15	15	11	10.8	15	5.4
Task 4	5	4	4	7	3	5	4	**20**	**16**	7	7	4	5	4	6.8	10	5.0
Task 5	26	17	25	27	14	10	14	25	6	12	23	14	15	17	17.5	30	6.6
Task 6	**22**	2	2	3	**20**	**25**	**30**	4	**13**	**50**	3	4	**45**	2	16.1	10	16.5
Task 7	**25**	3	4	5	4	9	5	5	4	4	4	6	5	4	6.2	10	5.6
Task 8	8	6	4	4	**15**	5	10	5	**25**	5	5	4	10	4	7.9	10	5.9
Task 9	7	10	**16**	9	6	4	10	**19**		4	15	6	8	6	9.2	15	4.7

M: Mean **B:** Benchmark In Seconds **SD:** Standard deviation

APPENDIX C: USABILITY QUESTIONNAIRES USED IN THE RESEARCH

Below are the links to the three usability questionnaires used in this research.

After-Scenario Questionnaire (ASQ):
http://garyperlman.com/quest/quest.cgi?form=ASQ

Computer System Usability Questionnaire (CSUQ):
http://garyperlman.com/quest/quest.cgi

Usefulness, Satisfaction, and Ease of Use Questionnaire (USE):
http://garyperlman.com/quest/quest.cgi?form=USE

APPENDIX D: SCREENSHOTS OF THE SYSTEM

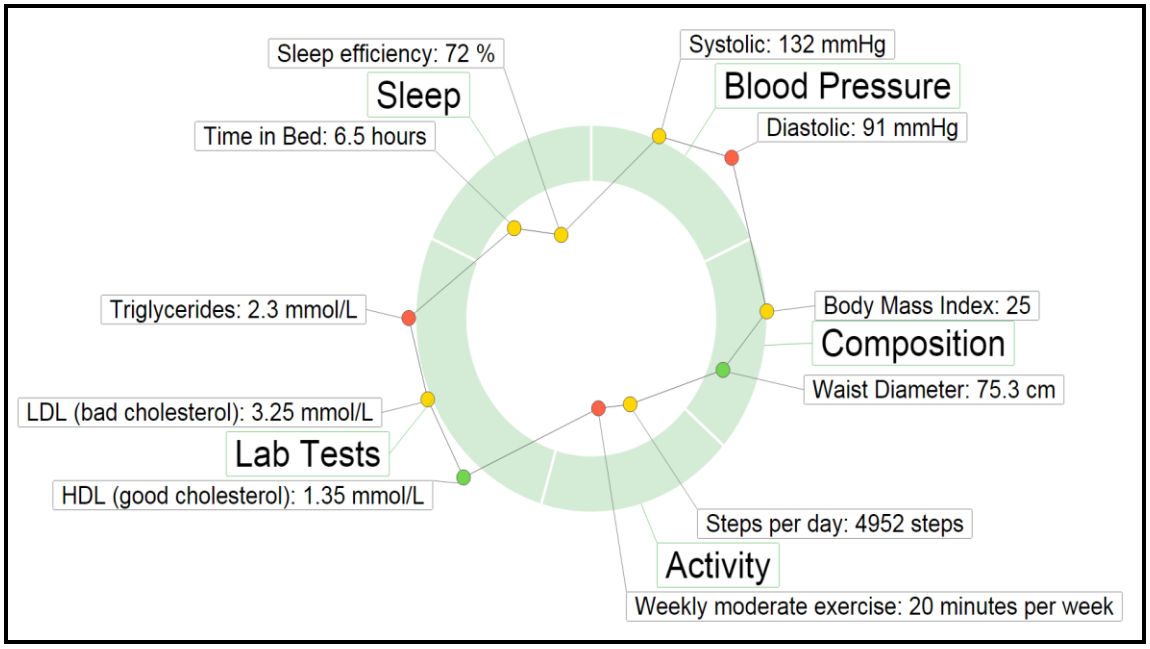


Figure 1. This hFigures graph shows a client's areas of health and their measurements before coaching intervention.

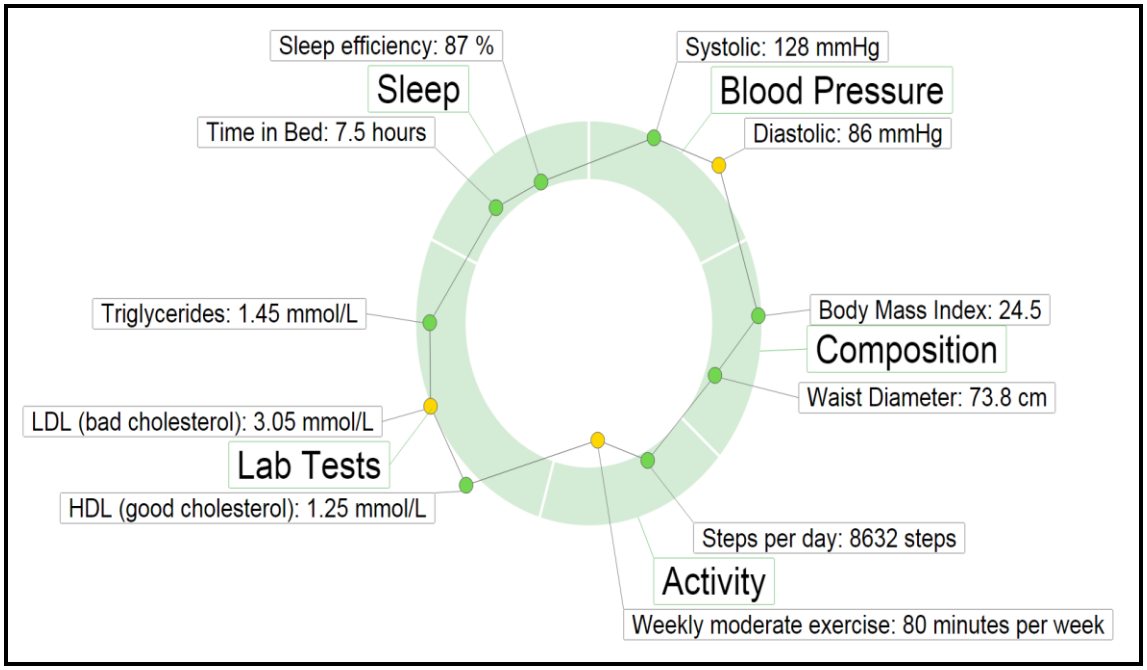


Figure 2. This hFigures graph shows a client's areas of health and their measurements after coaching intervention.

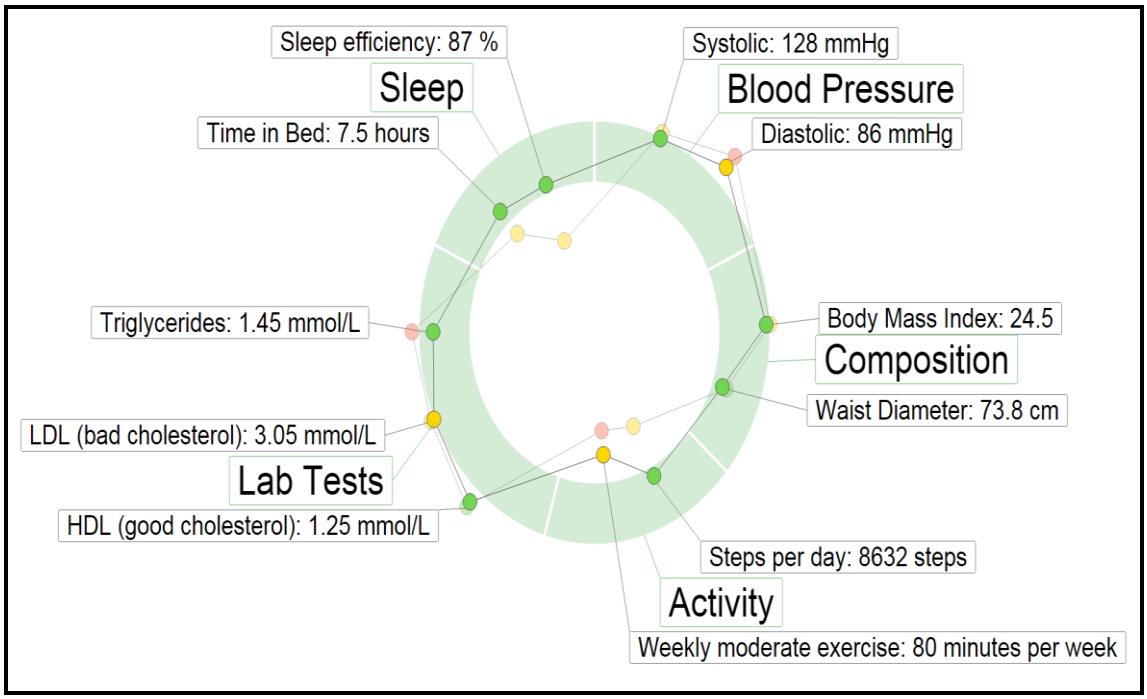


Figure 3. This hFigures graph shows the comparison between the measurements before and after coaching intervention

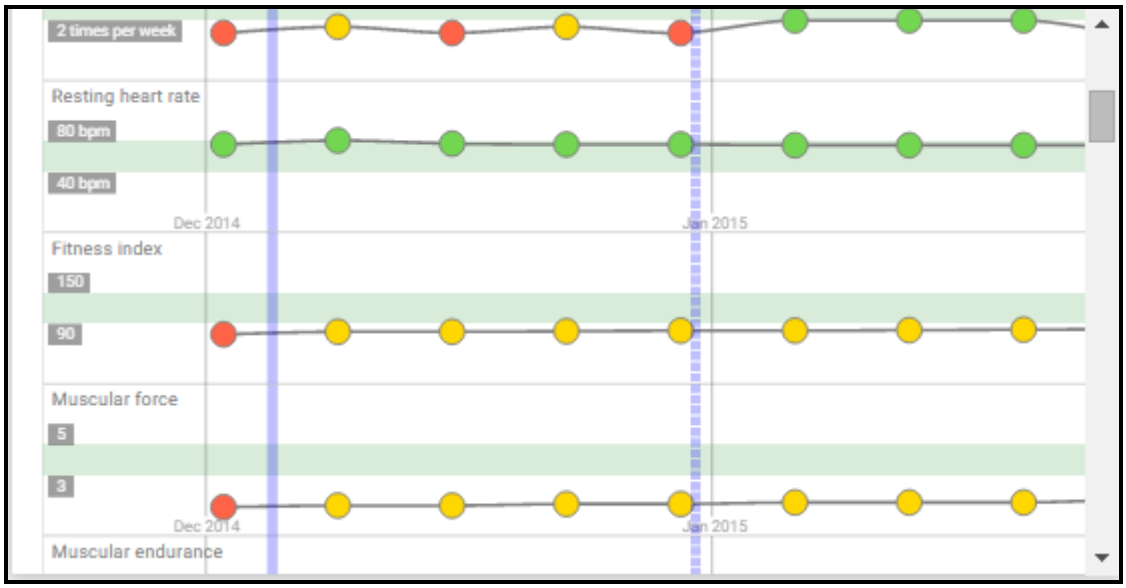


Figure 4. In the curves part the vertical bars represent two specific moments in time.

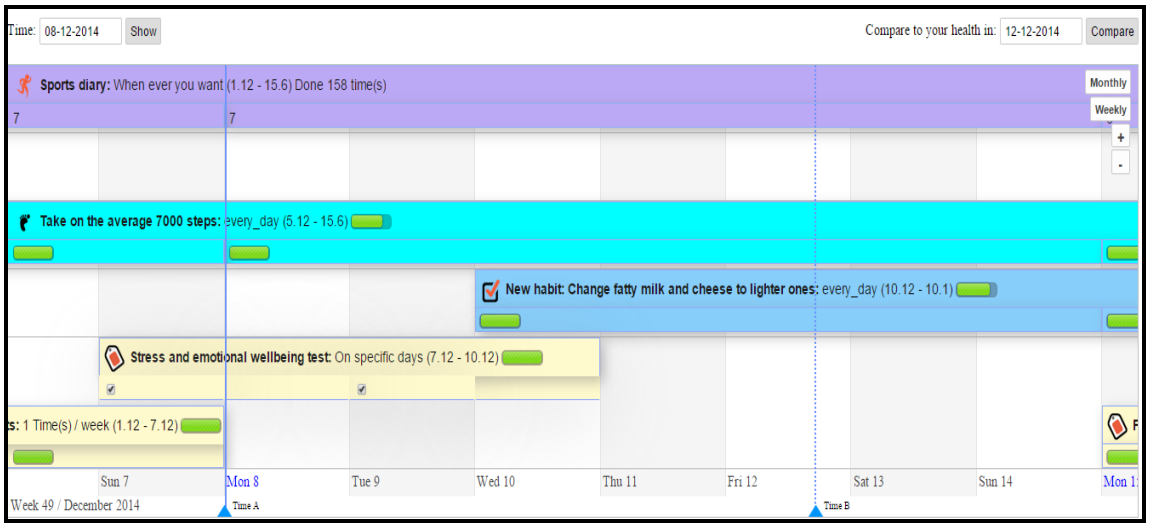


Figure 5. In the progress data component by moving the two vertical bars the clients can compare their health and wellness status between these two moment in time.

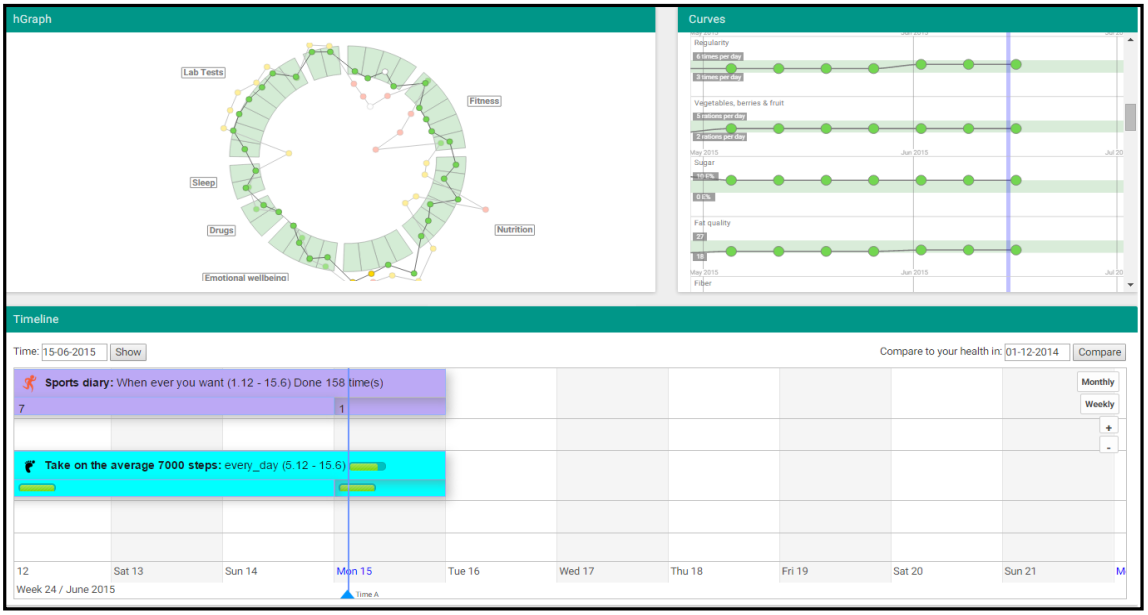


Figure 6. The entire integrated system.