Developing Visual Analytics Capacity of a Clinical Research Project Management System in a Pediatric Heart Institute

Manhar Suharwardy[1,2], Ting Zhang[1], Anirudden Ramesh[1,3], Danny T.Y. Wu, PhD, MSI[1,2,3]

[1]Department of Biostatistics, Health Informatics, and Data Sciences; [2]Medical Sciences Baccalaureate Program, [3]Department of Computer Science, University of Cincinnati, Cincinnati, OH

Introduction

Project management employs principles and approaches to reduce the risk of delays and loss of progress in planning and executing projects. An informatics solution implementing these approaches can be useful for academic hospitals since they serve as centers of extensive research and clinical trials. In our previous study (in review), we developed a clinical research project management system (CRPMS) in a user-centered and workflow-compatible manner. In the present study, we aimed to grow the visual analytics capacity of our CRPMS to increase the value of the CRPMS.

Methods

The CRPMS was developed in a research core of a pediatric heart institute in a leading non-profit children's hospital in midwestern United States. The development followed a hybrid model (**Figure 1**), which incorporated usability testing[1,2], semi-structured interviews, modified Scrum methodology[3–5], and iterative prototype improvements. The hybrid model included four phases. In Phase 0, workflow analysis was conducted to understand the current processes. In Phase 1, designers concurrently developed the project management and budget components of the CRPMS. In Phase 2, the intake pages were created. Usability testing[2] of the prototype included 19 individual sessions (30 to 45 minutes each) in these two phases. The participants of the usability testing completed realistic tasks with a think-aloud protocol and provided feedback through surveys and follow-up questions to assess the accuracy, efficiency, and user-friendliness of the CRPMS. In Phase 3, several visualizations were created to enhance the visual analytics capacity of the CRPMS following the Munzner's Nested Model[6], which provides a structured framework for designing and validating visualizations. The nested model had four hierarchical layers for designing visualizations: 1) characterize the problem domain, 2) abstract into operations on data types, 3) design visual encoding and interaction techniques, and 4) create algorithms to execute techniques efficiently. The different visualization mock-ups were presented to a group of 5-10 users during the weekly meetings. The user feedback included a need for consolidated views of enrollment data to improve clarity and accessibility of data interpretation for users and interactive features such as hover-to view details[7]. These requirements directly informed the creation of the mock-ups accordingly.

Results

Table 1 summarizes the design process of the enrollment data visualization as an example. It was determined to replace the visualization[9] in the enrollment pace section under the Collect Phase—Industrial Milestones and Metrics, where the data was structured to meet client requirements by incorporating two key sets of information. The first set included the total enrollment figures, specifying both the target and actual numbers. The second set focused on the number of new enrollments each month (which is enrollment pace), also detailing both target and actual figures. Target enrollment numbers were initially recorded in the Plan Phase, while the target months to complete enrollment were calculated based on the "Active Years" specified in the earlier section of the graphs. Three distinct visualizations were proposed. The first option (**Figure 2a**) used two separate tables, each with a line chart: one illustrating monthly enrollment totals and the other showing the enrollment pace. This allowed the user to focus on one metric at a time without being overwhelmed. However, users reported potential for misinterpretation when switching between the charts for comparison. The second option (**Figure 2b**) consolidated the data into a single table, with a line chart representing the enrollment pace and a bar chart depicting current enrollment progress as a percentage of the total goal. In this option, the users (project managers and clinical research coordinators) were able to view specific total enrollment numbers by hovering over a particular month, with the detailed information displayed in a hover window. Here, the target enrollment pace was shown as a gray dashed line, while the actual pace was depicted by a solid dark blue line. This concept was guided by the need to consolidate all relevant data into a single view to prevent errors in comparing enrollment pace and totals. Additionally, the use of hover features allowed inclusion of detailed information without overcrowding the interface. The third option (**Figure 2c**) also combined the data into a single table but reversed the chart types: the line chart now illustrated current enrollment progress, while the bar chart represented the enrollment pace. The target enrollment progress was displayed as a straight line, indicating linear growth and reaching 100% by the planned completion month. Meanwhile, the target enrollment pace was shown as a constant value, represented by a light blue dashed line. Similarly, users were able to view specific figures by hovering over the desired month. This concept provided an alternative view for concept 2, however, during the weekly feedback meetings, users favored the second option. This approach aligns better with conventional chart usage—line charts typically convey trends or speed, while bar charts display quantitative values—making it easier for new users to understand and compare the data.

Discussion

We developed and evaluated the CRPMS in an agile and user-centered manner[5]. While similar designs have been applied in developing informatics solutions[10–14], we were the first to apply them in the context of clinical research. The CRPMS was further enhanced in its visual analytics capacity by following the Munzner's Nested Model, which provided a structured way to design visualizations. Using the enrollment data as an example, this abstract described the design process and choices of the visualization. We are following the same methodology to design more visualizations and grow the visual analytics capacity of the

CRPMS with a goal to increase the value of the project management data collected on this platform. Our future work includes conducting usability testing on the prototypes and developing interactive dashboards to support the annual review of the research core performance.

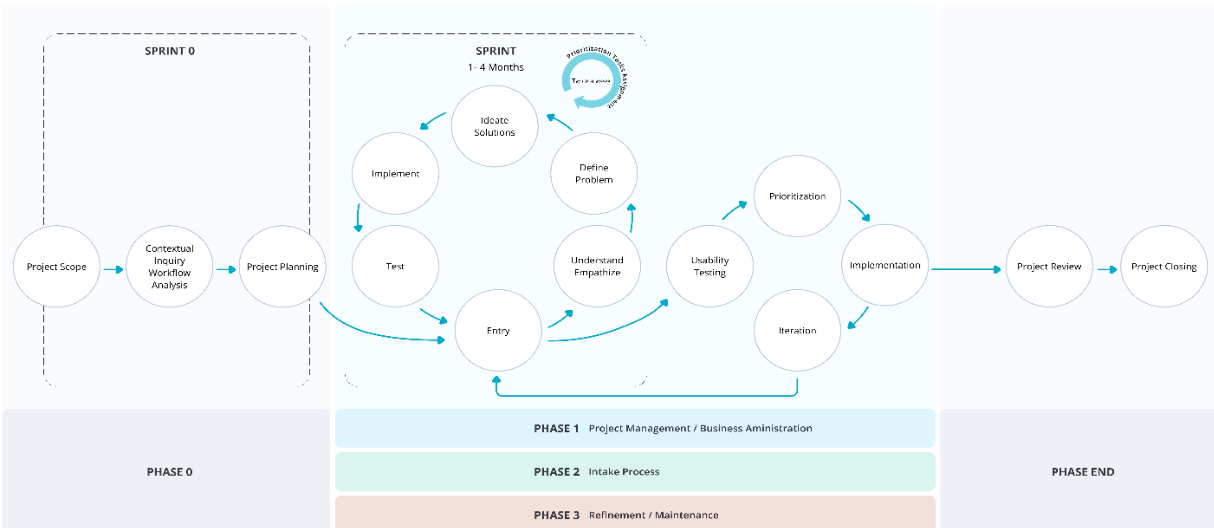

Figure 1. The Overall Study Design Combining Agile Software and User-Centered Design

Table 1: Applying Munzner's Model

Nested Model Layer:	What is it?	How did we apply it?
Domain Problem & Data Characterization	Define what needs to be visualized and the relevant data that will be used.	Interacting with users to define the need for understanding the trends in the enrollment related data.
Operation & Data Type Abstraction	Translate issues into more generic and abstract terms. Convert specific tasks and data into broader categories that can be universally understood in CS and information visualization terms.	Translating the user needs into visualization terms, e.g., form enrollment data as a trend line (time series).
Visual Encoding & Interaction Design	Design how information will be represented and interacted with.	Defining the x- and y-axis and mapping the enrollment data to the figure; creating mock-ups;
Algorithm Design	Developing algorithms that will automatically and efficiently create visualization tools based on the design from the previous level. (creating the code)	Automatically calculating the sum of multiple enrollment data in each time point.

(a) (b) (c)

Figure 2. a) Concept 1: Initial Study Enrollment Visualization. . b) Concept 2: Combined Study Enrollment Visualization with Hover Features. c) Concept 3: Reverse Combined Study Enrollment Visualization with Hover Features.

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