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Resolving complex research data management issues in biomedical laboratories: Qualitative study of an industry–academia collaboration

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ABSTRACT

This paper describes a distributed collaborative effort between industry and academia to systematize data management in an academic biomedical laboratory. Heterogeneous and voluminous nature of research data created in biomedical laboratories make information management difficult and research unproductive. One such collaborative effort was evaluated over a period of four years using data collection methods including ethnographic observations, semi-structured interviews, web-based surveys, progress reports, conference call summaries, and face-to-face group discussions. Data were analyzed using qualitative methods of data analysis to (1) characterize specific problems faced by biomedical researchers with traditional information management practices, (2) identify intervention areas to introduce a new research information management system called Labmatrix, and finally to (3) evaluate and delineate important general collaboration (intervention) characteristics that can optimize outcomes of an implementation process in biomedical laboratories. Results emphasize the importance of end user perseverance, human-centric interoperability evaluation, and demonstration of return on investment of effort and time of laboratory members and industry personnel for success of implementation process. In addition, there is an intrinsic learning component associated with the implementation process of an information management system. Technology transfer experience in a complex environment

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such as the biomedical laboratory can be eased with use of information systems that support human and cognitive interoperability. Such informatics features can also contribute to successful collaboration and hopefully to scientific productivity.

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1. Introduction

Biomedical research when coupled with the high speed processing technologies results in highly detailed datasets. Bioscience laboratories are inherently data intensive which is evident from the publicly accessible immense databases generated by the Human Genome project [1]. The information to be processed in a biomedical laboratory ranges from DNA sequences, mutation analysis, expression arrays, cell and biochemical assays, animal and reagent inventory, to name a few. The challenge to genomic medicine is to analyze and integrate these diverse and voluminous data sources to elucidate normal and abnormal physiology [2–4]. In addition to scientific research, academic biomedical laboratories (labs) are expected to use their data and consequent results to support education, knowledge dissemination through publications, and future research questions. However, current traditional informatics approaches used by these labs have helped them little in performing their daily tasks and in fact, jeopardized their productivity [5,6]. Some of the current lab data management methods include handwritten lab notebooks, paper files, homegrown small databases and spreadsheet files. Problems with heterogeneous data, nonintegrated information retrieval and querying, nonadherence to standards, lack of documented laboratory workflows, and usability issues have been reported as major hindrances to efficient information management and research productivity in bioscience labs. The need for informatics solutions to solve the problems with current information management methods used by academic as well as industrial biomedical labs is well-documented [7–9]. Informatics systems that (a) enable collaborative authoring of lab records, (b) integrate and parse multiple biomedical data types, (c) efficient database architectures, and (d) user-centered data visualization have been developed and evaluated [10–15]. With increase in functional complexity in biomedical research, a single system can no longer support the entire lifecycle of a biomedical research project. Hence it is inevitable for lab researchers to use multiple interoperating systems for their research. Modern information management systems should have a common layer of interoperability while providing a spectrum of options that could be used to support individual researcher needs. Comprehensive, yet nuanced customization of information management systems, therefore may be a solution to address informatics issues in bioscience labs.

In this paper, we describe the attempts of our collaboration to identify and reduce barriers to scientific productivity and satisfaction in a specific translational research-oriented biomedical research lab through direct involvement in evaluating and improving data management in research laboratories. Contrary to the focus of our paper, published literature on similar collaborative efforts have provided insights into technical architecture of bioscience system with minor focus on sociotechnical aspects [16], and summative evaluation of an informatics-driven solution rather than implementation process itself [17]. Majority of reported studies on bioscience information management provide an account of system design and demonstration [18–21]. Our study is data-driven and qualitative in nature. Specific objective of this paper is to present the efforts made by one industry–academia collaboration to improve the data management and integration capabilities of an academic biomedical lab through an iterative design process. The lessons learned from this collaborative implementation effort can inform the scientific, academic, and industrial communities of (a) implementation strategies that can help optimize technology transfer in academic biomedical labs, (b) possible pitfalls to be aware of during intervention with a new data management system, and (c) important characteristics that are pre-requisite for every biomedical research collaboration when implementing new information technology in academic labs. The next sections are organized as follows. Section 2 provides a brief overview of our study context, outlining the industry–academia collaboration with a brief background on the nature of this intervention project as well as of the technology that was used to improve management of biomedical research data. Section 3 describes methodological details of the study, and in the remaining sections of the paper, we summarize the results and limitations of the study while providing relevant discussions and conclusions.

2. Study background

*B*ioscience *R*esearch *I*ntegration *S*oftware *P*latform (*BRISP*) research group is a collaboration between Johns Hopkins School of Medicine, Fraunhofer Center for Experimental Software Engineering, UTHealth-Houston School of Biomedical Informatics, and Biofortis Inc., whose mandate has been to join in the development of a software platform that can help biomedical labs improve their research productivity and satisfaction. Detailed contributions of the four collaborative sites can be seen in Fig. 1. Selection of the test lab was based on several criteria including their responsiveness, motivation of the lab's PI, and the richness of lab environment in terms of its ability to represent the manifold changes of use of information technology. A biomedical research information management system called "Labmatrix" developed by Biofortis was used during the project to resolve data management issues in the test lab. Recent studies show that Labmatrix can improve data management capabilities of basic research

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