Thesis Project Portfolio

DFit: Cloud-Based Service and Business Case

(Technical Report)

Online and Blended Learning: Non-Access Problems

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

John Blair Mitchell III

Spring, 2024

Department of Systems and Information Engineering

Contents of Portfolio

Executive Summary

Advances in technology offer the potential to transform and improve the world, but careful considerations must be made to ensure that technologies are designed to properly support their intended uses. These considerations are not only to be made by those adopting the technology but also by the engineers designing it. Otherwise, engineers and adopters may fall into the hype of new technologies, applying them in places where they are not appropriate. This can result in systems that become less efficient with the inclusion of new technology, which is the opposite of the intended effect. As such, the research presented herein seeks to take the perspective of both the engineer and the adopter of internet technologies, addressing specific problems through flexible frameworks that can be applied elsewhere. From engineers' perspective (the technical project), an internet software was improved to prepare for an upcoming surge in users, its performance was analyzed against competing software to judge how well it supports its intended use, and its demand was probabilistically forecasted to assess how these factors may affect its adoption. From adopters' perspective (the sociotechnical project), educational models that utilize the internet were analyzed to judge how well they meet students' needs, as to understand the appropriateness of their implementation in terms of improving student outcomes equitably.

The technical project aimed to support Distribution Fitter (DFit), a web-based distribution fitting software. Distribution fitting is a crucial part of probabilistic modeling, but real-world data rarely align with common probability distributions. DFit provides a coherent methodology for addressing this problem, where the user is able to fit a large variety of continuous parametric distributions to data, having them ranked by goodness-of-fit to aid in finding the best model. It is provided alongside the book *Probabilistic Forecasts and Optimal Decisions*, to be released in

2024. Three main goals guided the project: (i) improving the scalability and performance of DFit, (ii) evaluating DFit's performance against its competitors, and (iii) forecasting the demand for the book and DFit. The project began with migrating DFit to a cloud-based infrastructure on Amazon Web Services, ensuring scalability for an expected increase in users due to the book's release. Its performance in terms of distribution fitting and usability was compared to that of other distribution fitting software, which demonstrated its superiority in user experience and the MAD (maximum absolute difference) goodness-of-fit metric. Finally, market research was used to prepare judgmental forecasts for the demand for the book and, subsequently, DFit. Overall, DFit was positioned as a comprehensive tool for distribution modeling in academia and industry.

The sociotechnical project investigated non-access problems associated with online and blended learning models, which had been found to be as, if not more, effective when compared to traditional in-person models. Unlike access problems that prevent students from participating in online or blended learning entirely, non-access problems are those that affect students' ability to learn effectively once basic access requirements are met. They were sorted into two primary categories: technological and self-regulatory. Past research has shown that underprivileged students disproportionately face technological challenges, such as difficulty navigating complex online platforms or lacking foundational digital literacy skills. Self-regulatory challenges, such as procrastination, were found to be prevalent across all demographics. Overall, the results suggested that online and blended learning models often fail to provide equitable educational opportunities, particularly for underprivileged students who struggle with technological proficiency. As such, the implementation of these models and the design of the tools they use should align with the capabilities of all of the students who participate in them.

These projects highlight the importance of a thoughtful, comprehensive approach to implementing new technologies. The technical project gave a great example of a software that completes its intended task appropriately by using a coherent methodology not offered by any of its competitors. An analysis of its performance and a forecast of its demand made evident the benefits this approach gave. The sociotechnical project gave an example of a thorough analysis on the appropriateness of internet technologies in education, taking the perspective of the adopter rather than the engineer. This allowed for considerations not only towards adequately designing technology to support its intended use, but also for considerations towards the population that will be using the technology and whether it is appropriate based on their capabilities. Going forward, future research should continue in two directions to provide: (i) methodologies for developing technologies that coherently complete the tasks they will be used for, (ii) frameworks for analyzing the nuances in implementing technologies so that their benefits are felt equitably by all who they will affect.