
The Importance of Critical Thinking Skills to Successful Accounting Data Analytics

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Abstract

The purpose/objective of this study is to emphasize that critical thinking is very important for accounting data analytics, and therefore the skills needed to this should be improved. To this end the authors interviewed managers of small and large accounting firms, industry, and government about the importance of the topic. Their answers are summarized in this article, sharing some of these practical experiences and using the lessons learned from these experiences to describe a framework for using data to solve various accounting problems.

Key words: data analytics; critical thinking; management interviews; accounting; audit;

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1. Introduction

The ability to do quality data analytics has become increasingly important in today's professional accounting world. The rapid increase in computing power in the past twenty years has facilitated demand for big-data and this, in turn, has led to a marked increase in the demand for accounting graduates who can analyze, summarize, and present data and, more importantly, make critical decisions with data (e.g. Richins *et al.*, 2017). Accounting programs at colleges and universities have responded by revamping their curricula to include training in all things data and data analytics (e.g. Richardson and Shan, 2019; Andiola, Masters and Norman, 2020; Losi, Isaacson and Boyle, 2022). Sometimes the focus, however, has been on specific data-analytic exercises such as computing summary statistics and making visually appealing data-summarizing plots and charts (Dow, Jackson and Watson, 2021). While these skills are important, accounting firms and other potential employers want their new hires to be able to use the data ultimately to make decisions and recommendations. This overarching goal of data analytics is not realizable without proper critical thinking skills.

The motivation for our study was to get inside the minds of professionals in accounting, industry and government to understand what specific example problems they face where critical thinking within a data analytics context is imperative. We also wanted to listen to and share their insight regarding how skilled they feel new hires/interns are in terms of critical thinking in a data analytics context at their respective firms. We knew that if we could interview a diverse sample of professionals, then we could synthesize their responses into a framework with which to think about critical thinking in a data analytics context.

Consequently, we interviewed managers of small and large accounting firms, industry, and government about the importance of critical thinking to data analytics. In the following article, we share some of these experiences and use the lessons learned from these experiences to describe a framework for using data to solve various accounting problems.

The primary goal of this paper is to shed light on what real-life professionals have to say regarding the importance of critical thinking, specific examples of where critical thinking is very useful and recommendations regarding how one may improve their critical thinking skills, all within a data analytics context. We believe that our four-step framework for critical thinking regarding data,

along with the four-phrase verbiage that we introduce, will be insightful and memorable to business professionals, educators and students as they seek to better understand the "black-box" of critical thinking.

The rest of this paper proceeds as follows. Section 2 describes our research methodology. Section 3 synthesizes the interviews we conducted into the before-mentioned critical thinking framework for data analyses and the results obtained. Section 4 to conclusion.

2. Research methodology

We interviewed managers of small and large accounting firms, industry, and government. We chose our interviewees based on the firms that they represent, the professional relationships that we have with them and their availability. We knew they would take the interviews seriously and provide useful information. We feel this is an advantage that our study has over a study using survey responses. Interviews elicit more reliable information than survey responses primarily because we can ask follow-up clarification questions regarding the responses we get. The downside to interviews is the number of interviewees is smaller, relative to survey responses and this reduced sample size can limit the generalizability of the results. Despite our small sample size, we feel the variety of people that we interviewed, and the entities that they represent, work in our favor, in terms of being able to generalize what we found to a larger audience. The interviews were conducted either via Zoom or over the phone in the Fall, 2023 semester. We asked each of our interviewees primarily for **specific examples of where critical thinking in a data analytic context is relevant in their business**. We also asked them general questions such as those listed below.

- Can you think of ways in which an organization could foster critical thinking data analytics skills in their accountants?
- What does the term "data analytics" mean for your firm when you look for new hires/interns?
- How important is hiring accounting students with solid data analytics skills for your firm today?

We asked eight managerial professionals for an interview and all eight granted an interview with us. **Table no. 1** displays the information regarding the interviewees. Interviewees generally expressed to remain anonymous and stated that their views do not necessarily represent the views of their respective employers.

Table no. 1. Structure of the interviewees

Domain of Activity	Entity Name	Interviewee	Job Title
Large, global, public accounting firm	Ernst and Young	Anonymous	Managing Director, Technology Risk
Global activewear firm	Fruit of the Loom	Anonymous	Accountant
Government agency	Tennessee State Comptroller	David Cook	Legislative Audit Review Officer for the State of Tennessee, USA
Government agency	Tennessee State Comptroller	Chris Kelly	Manager of Data Analytics
Regional accounting and consulting firm	Forvis LLP	Anonymous	Audit Manager
Global technology firm / subsidiary of Colgate Palmolive	FAMSUN USA / Hills Pet Nutrition NA	Barry Howard	Vice President / Director of Engineering
Mid-sized regional consulting firm	Anonymous	Anonymous	Valuation and Analytics Manager

Source: authors' projection

Our study does not have the traditional, statistically testable hypotheses that come with traditional empirical or experimental studies. Our purpose was to gain insight into how large and influential firms, mid-size regional firms and governmental entities think about critical thinking within data analytics. We had the following expectation going into the interviews and the interview responses, collectively, substantiated our ex ante expectation.

Expectation: Critical thinking, especially in a data analytics context, is hard to teach employees. It is imperative for potential employees (e.g. students and interns) to learn to critically think regarding data analytics, instead of only learning the rudimentary data analytic skills such as computing summary statistics, making charts and diagrams and doing predictive statistical analysis. These critical thinking skills are developed and honed by being exposed to diverse and unstructured problems in which a solution is demanded, within a time constraint.

We synthesized their responses into a four-step critical thinking framework that is helpful for conducting competent data analyses. The critical thinking framework that we describe models data analyses in the following four steps: (1) planning the analyses, (2) data acquisition, (3) data processing and (4) data reporting. The critical thinking phraseology that matches to each of these steps that we would have our readers remember is: (1) know before you go, (2) good conclusions require good information (3) process your data with care, your insights are there (4) you are only as insightful as your audience is able to remember.

3. Results

3.1 Thinking critically begins before beginning your data analyses – “Know before you go”

There is a natural tendency to disregard the planning stage, during which thinking through the data analytics is most decisive, and instead dive straight into the analyses. However, critical thinking is purpose driven. The first and most important step occurs before acquiring or analyzing data. This step involves accurately defining the desired objective. As straightforward as this step might seem, *oftentimes, the primary challenge is not solving a problem, but rather identifying what the correct problem actually is.* Systems are endogenous organisms. The data generated within any component of a system are infused into the data generated in all other parts within the system. The consequence is that the relevant problem is not always what it initially appears to be and(or) may not originate where the problem manifests itself to be.

For example, one company’s accountants noticed concerning patterns in the data that, on the surface, indicated problems with inconsistent quantity usage and sporadic levels of material waste during the company’s production runs.¹ The technical team launched an investigation to uncover where waste was occurring and the cause of the waste. IT staff verified the controls for usage levels in the manufacturing software program,

¹ This example is from the authors’ Interview with Barry Howard, VP, FAMSUN USA and former Director of Engineering for Hill’s Pet Nutrition North America, division of the Colgate Palmolive Company, henceforth, (Howard 2023).

eliminating that concern. During interviews, line personnel insisted that they were following protocols. A couple of the employees speculated that the issue was “faulty equipment”. Over the next few weeks, management found themselves replacing valves, gauges, and other equipment at a significant cost to the company. In fact, the actual source of the problem eventually was traced back to poor inventory management and controls. The way materials inventory were stored made obtaining reliable inventory levels difficult. Recalibrating inventory levels would require temporarily shutting down operations, which the company had not been willing to do. Purchase quantities were not adequately verified. In short, these data problems were circulated throughout the system.

Thinking critically about data analytics also includes preemptive consideration of where problems may likely occur. One of the characteristics that make data analytics for accounting unique is the need to consider the incentives that are infused into the data that will be analyzed.¹ These incentives certainly will vary according to any number of situations and purposes. In planning what to do with the data, it is advisable to consider the incentive to overstate earnings or assets when there are accounting-based compensation packages, or businesses that will be sold, or potentially taken over. Incentives to understate earnings or assets should be considered when data are used for determining taxes, including estate settlement, or data are used during lawsuits and divorce settlements, or anytime there are opportunities for employees or managers to misappropriate assets. These incentives affect considerations regarding the data that will be used across the entire scope of accounting applications including auditing, financial preparation and reporting, internal auditing, business valuation, and tax returns.

During an advising engagement, a firm was retained to determine both the merits and the offer price of a business that the client was hoping to purchase.² What immediately stood out to the firm’s advisors was a dramatic spike in the sales volume of the target company in the most recent periods, which also coincided with COVID shutdown measures. Naturally, there was a concern that the client could significantly overpay for the business based upon

sales that were not sustainable. Thinking critically about the problem, the advisors identified a particular service within the target company’s lines of business that stood to most benefit from the COVID measures. Operating under a strict and tight time-frame window, the advisors developed a plan to collect and analyze individual revenue transaction detail (which had not been provided). The advisors constructed an algorithm using the transaction detail to isolate this service line’s pre-COVID and post-COVID divisional performance. In short, the advisors developed a pre-analysis hypothesis and plan that, when their analyses were finished, led to the determination of a revised offer price within the constrained deadline.

3.2 Critically thinking during data acquisition – “Good conclusions require good information”

Critical thinking skills require accountants to take control of ensuring the quality of the data that will be used to address a given problem statement. Many U S firms employ less common, smaller market, or customized enterprise (ERP) systems. It is also very common when auditing or working with federal agencies to encounter fragmented ERP systems, in which case, the data to solve a given problem must be pulled from multiple sources.¹ Some federal agencies and other organizations still employ mainframe systems. Oftentimes, when auditing or advising small or even medium sized companies, the quality and structure of the data from their systems can present a massive challenge. There are still companies approaching \$100 million in sales using their original entry-level business accounting software packages. In each of these situations, critical thinking would require the accountant to learn what systems are in use, to retrieve documentation and variable definitions, to evaluate who should supply the data, to anticipate all of the tables and fields that will be needed, to develop a plan for how data will be obtained, to consider running some quick analytics to determine areas of risk, and to construct a plan for validating that the dataset that is eventually constructed is both complete and accurate.. As one Big Four firm manager described, “Everybody is so excited to do the brilliant things that they want to do with the data, that they don’t bother to assess whether or not the data are any

¹ Statement from the authors’ personal interview with an Audit Manager at Forvis LLP, September 15, 2023.

² This example is taken from the authors’ personal interview with the Valuation and Analytics Manager at a mid-sized regional consulting firm, September 8, 2023.

¹ Examples in this paragraph are taken from the authors’ interview with a Managing Director at Ernst & Young, August 28, 2023. Henceforth, referred to as Anonymous Director (2023).

good, and you end up with bad conclusions off of bad information” (Anonymous Director, 2023).

For example, for many organizations, travel expenses are both a consistent and substantial cost. The auditors of one organization wanted to use data analytics to isolate the more likely problematic reimbursements for further scrutiny.¹ In thinking through their data processing needs, it became apparent that the auditors would need to visualize how a “problematic reimbursement” appeared in the data, as opposed to how a pattern of legitimate reimbursements of frequent travelers appeared. Rather than simply asking the client to provide total travel disbursements by departmental unit, they first requested disbursement data for the employees who were the top three recipients in each department. From these data, they developed thresholds for numbers of requests, dollar amounts per request, patterns and timing of disbursements, and other critical forensic indicators. They learned through this process that, to best determine whether their client was complying with travel disbursement policies, it was necessary to first critically think about what data should be analyzed and how data should be analyzed (Cook, 2023).

3.3 Critically thinking when analyzing data – “Process your data with care. Your insights are there”

Processing would typically entail how data are formatted, mapped, and brought into a state that allows for something useful to be done with the data. While this is the step that employees most tend to enjoy, there are some important lessons that were learned and are worth considering.

One important lesson, throughout all steps, but particularly during this step, was the necessity of maintaining frequent communications among everyone that is involved in this step. Although accountants have achieved significant progress learning data analytics, often there is a need to involve IT specialists in solving various data challenges. Still, it is the accountants that are subject matter experts on audit standards, and it is the accountants that understand accounting requirements, accounting procedures, and accounting entries (Anonymous Director,

¹ This example is taken from the authors’ interview with David Cook, CPA, Legislative Audit Review Officer, Comptroller of the Treasury, Division of State Audit, State of Tennessee, henceforth, (Cook 2023).

2023). While both groups may be working toward solving a data analytics problem, they often speak different languages with different terminology. These differences are the source of many problems.

To help address this challenge, many organizations began holding formal meetings that included both IT, and accountants at the beginning of each project. One organization concluded each meeting with a drafted memorandum of understanding of what was needed from whom and of precisely what needed to be done.¹ After initially adopting this approach, the organization’s audit teams would find that at the end of the project, what was expected had still not been achieved. They discovered that, while such meetings were necessary, it was also necessary to maintain frequent communications among parties at each step of the process.

Thinking critically about data analytics also requires developing a plan for how to verify the analyses once the data analytics are finished. “There are numerous situations in which people place excessive trust in processes that are a ‘black box’ to them (Anonymous Director, 2023). However, someone has to audit the evidence. Someone must understand what kind of audit evidence is required to meet a particular audit objective.

Adding to this problem, while data analytics has created opportunity for improvement and expanded possibilities, according to Anonymous Director (2023), and Cook (2023) the increased efficiency brought about by data analytics also has created increased compliance expectations for the companies being audited, for public auditors (e.g., with the PCAOB) and for governments (e.g., for peer review).² For these reasons, organizations are discovering the importance of thinking about how to compensate for the trail of documentation that might be sacrificed with automation and efficiency in operations when applying data analytics to a problem (Kelly, 2023).

For example, in calculating the necessary criteria for lease accounting, accountants, historically, would build custom spreadsheets, displaying the data with the calculations that were needed for each lease. Many organizations now have developed programs to allow accountants simply to

¹ This example is taken from the authors’ interview with Chris Kelly, CPA, Manager of Data Analytics, Comptroller of the Treasury, Division of State Audit, State of Tennessee, henceforth, (Kelly 2023).

² Also, statement by an accountant at Fruit of the Loom, subsidiary of Berkshire-Hathaway.

enter data. These programs have automated the determination of the net present values of the various leases and the assessment of other lease reporting criteria, saving tremendous amounts of time. (Similar programs have been developed to assist with other applications as well.) However, a common problem is that these new processes evolved to become too opaque. Lost in the data analytics was adequate critical thought about the documentation, who could sign off on the numbers, or how to accomplish the necessary tasks to test the program.

One organization was progressing toward a more technical, automated approach to their work. During this transition, one ambitious accountant, who had embraced the challenge of learning data analytics, acquired enough coding skills to write a computer program that would automate the physical task of inspecting vouchers to verify that all the necessary internal control and compliance requirements were followed. Clearly, this employee had to possess a sufficient level of both accounting and data analytics knowledge and had to apply critical thinking to that knowledge in order just to write a workable program. When he was finished, he began using the program and was acknowledged by a manager for his contribution. Afterwards, other employees also adopted his program and began using the program in similar situations. Later, an auditor, who was shown the program and how the program was being used, asked, "How do you know that this program is achieving its objectives? How do you know that this program does exactly what you think that it does?" And that question represents the disconnect that occurs. Other employees had not taken the time to understand the program or to critically think through how the program was being used and no one in the department had developed sufficient documentation or had adequately verified the program (Cook, 2023).

3.4 Critically Thinking About How to Report Your Findings – "You are Only as Insightful as Your Audience is Able to Remember"

Reporting involves communicating your findings and analyses in such a manner that you convert the data into intended accomplishments and actionable plans. For example, the management of a European plant of a U S based food company programmed their manufacturing software to systematically use less than the standard quantities of the more expensive product ingredients. They compensated for product weight by programming the

same software to use more of the product's least expensive main ingredient. Management did this because they were compensated based upon lower product costs. Of course, this conduct was fraudulent and violated company policy. However, the managers were careful to program quantity changes to be sufficiently small as to fall within allowable variation and to not be detected by quality control samples taken of only a few products at a time. Despite the small size of the variation, given the operation's high volume of production, over the course of a year, the plant's management had amassed millions of dollars in unauthorized cost savings, which formed the basis for significant bonus payouts to the managers. Despite leaving behind a well-established pattern of anomalies within the data, the scheme was able to be perpetuated for an extended period without detection by the corporate accountants. One of the weaknesses in the monitoring system was the way reports were generated. Reports tended mostly to be a data dump of numbers. The reports only highlighted large and negative variances beyond predetermined thresholds. The reports were also for short periods of time and thus were not suitable for detecting the systematic pattern of smaller and positive variances over an extended period (Howard, 2023).

Many reports and presentations, like the example above, spout numbers, such as "Total expenses were 5.3 million dollars". But what was the story behind this number? Is there a trend or comparison number that needs to be communicated? What happened to cause the increase? Did we identify controllable factors that suggest a plan? Critical thinking includes consideration of how to tell the story of the analyses.

Storytelling is a valuable complementary service to numbers. Most people don't comprehend raw numbers. But stories can give meaning to numbers. One manager of a Big Four firm explained, "Public accounting has largely turned into storytelling. It is increasingly subjective and complicated. It has become a challenge of how you take these analytics and either generate (if you are an advisory side staffer or manager) meaningful actionable improvements for a company or (on the Assurance side) how do you generate audit evidence out of this?" (Anonymous Director, 2023).

To increase effectiveness in this regards, one organization created a position for a dedicated data visualization designer, who would design and format tables and charts, and create diagrams, flowcharts, and visual aids in a manner that could convert heavy text and heavy data into

effective illustrations that might be used to assist in telling a story (Cook, 2023).

Here are two other considerations to address when telling your data analytics story. Tying back to the first step, the story needs to be communicated consistent with the defined objective. Without critical thought about the intended message, and how to convey that message, the result of the data analytics likely will be a collection of random artifacts and curiosity metrics that do not really contribute anything toward fulfilling a purpose. There needs to be a definitive return to the hours that were accumulated in the data analytics exercise (Anonymous Director, 2023).

Also, your data analytics story needs to be tailored to your audience. You want to critically know your audience. If your audience is a jury, then a minimal number of simple, but compelling charts or graphs is optimal. If your intended audience is a bond rating agency, then an entirely different delivery is warranted. Some organizations survey or initiate and maintain communication with their audience to develop improved understanding of the audience's expectations and to refine the purpose of the presentation of data.

4. Conclusion

Regardless of which step of the data analysis process you are performing, critical thinking is of utmost importance. As you plan the analysis, "knowing before you go" is important because it forces you to identify the precise problem to which your data analysis will provide the solution. "Knowing before you go" thus helps you plan to acquire data that will answer said problem. The data

acquisition process is improved from remembering that "good solutions (or conclusions) require good information". Emphasizing the relevance (to the problem identified in the planning stage) and accuracy of the acquired data is therefore important. Remembering to "process your data with care because your insights are there" helps to prevent incomplete, or at worst faulty, analysis which consequently leads to a blurring of insights upon which the data potentially sheds light. Finally, remembering that "you are only as insightful as your audience remembers" helps you to ensure that your graphical and tabular presentations of the results are succinct and precise.

In this paper we have synthesized the responses from our eight-person interview sample of highly professional and experienced individuals into a four-step critical thinking framework that is helpful for conducting competent data analyses. The critical thinking framework that we describe models data analyses in the following four steps: (1) planning the analyses, (2) data acquisition, (3) data processing and (4) data reporting. The critical thinking phraseology that matches to each of these steps that we would have our readers remember is: (1) know before you go, (2) good conclusions require good information (3) process your data with care, your insights are there (4) you are only as insightful as your audience is able to remember.

We believe that our four-step logical framework for critical thinking regarding data, along with the four-phrase verbiage that we have introduced, will be insightful, memorable, and thus applicable, to business professionals, educators and students as they seek to better understand the "black-box" of critical thinking.

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