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Educational Case

Making sense of complex data using interactive data visualization

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ABSTRACT

An important role for accountants today is to provide decision support to senior management by assisting them in the analysis of large, complex data sets. Interactive data visualization (IDV) facilitates this process by allowing users to navigate, select, and display data via an easy-to-use interface often used as a component of data analytics. Given the increasing popularity of IDV as a tool for making sense of complex data, it is important that accountants become familiar with and learn how to use this technology. This case provides a hands-on opportunity to organize complex accounting data to create IDVs for decision makers to use. Further, the case enables students to understand the potential impact of IDVs on preparers and users of accounting information. Students will assume the role of a division controller in a hypothetical company and create an IDV to assist the chief executive officer (CEO) in decision making.
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1. Background

1.1. Introduction

Today, accountants provide essential decision support to senior management, which often involves the analysis of complex data. Indeed, the accountant's role is moving away from an emphasis on transaction processing towards a focus on providing decision support to top management (Beaman & Richardson, 2007). To support management decision making, accountants are often involved in

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business intelligence, or the gathering, processing, and analysis of large, complex data sets (Chaudhuri, Dayal, & Narasayya, 2011; Romney & Steinbart, 2015). Interactive data visualization (IDV) facilitates this process by organizing and visually displaying data in an easy to use interface.

"Interactive data visualization" (IDV) refers both to the above-defined technology and to a specific application of that technology. IDV applications are also commonly referred to as "dashboards" (Tableau Software, 2012; Yigitbasioglu & Velcu, 2012). Unlike existing *static* information visualization technologies, where preparers select information items and their display format for decision makers, IDV allows users a choice of which data to display, how to represent the data, or both (Dilla, Janvrin, & Raschke, 2010). As discussed below, spreadsheet packages such as Microsoft Excel can be used to analyze large data sets via dashboards. However, many organizations are now using interactive visualization software since this technology seamlessly provides navigation, selection, and representation of data. Indeed, recent research reports that 57 percent of business and IT executives are currently implementing IDVs and 31 percent plan to do so in the next few years (Stodder, 2013).

Further, IDVs are one of many techniques used in data analytics, i.e., the processing of massive volumes of data that are too volatile, large, and complex to be handled effectively using current technologies found within most organizations (Livingstone, 2013; Schneider, Dai, Janvrin, Ajayi, & Raschke, 2014). With the recent availability of user-friendly interactive visualization packages for commercial use (SAP, 2012; Stodder, 2013), the exponential growth in data available for analysis (Moffitt & Vasarhelyi, 2013), and the demand for quick responses to changing scenarios, it is likely that this technology will be used increasingly to support management decision making (Chaudhuri et al., 2011; Heer, van Ham, Carpendale, Weaver, & Isenberg, 2008). Therefore, given the availability of IDV packages and the increasing use of IDVs for making sense of complex data, it is important that accountants learn how to use this technology.

As information *preparers*, accountants may be responsible for determining how to visualize and present information to management to support diverse tasks such as evaluating sales trends, monitoring IT network security, and detecting fraudulent transactions (Chaudhuri et al., 2011; Dilla et al., 2010; Yigitbasioglu & Velcu, 2012). Further, accountants may develop IDVs of financial information for investors and other external parties (e.g., BP, 2013; Microsoft, 2013a). The development of IDVs for investors is likely to increase due to the Securities and Exchange Commission (SEC)'s mandate that requires publicly-traded companies to furnish financial statement information in XBRL format (Dilla et al., 2010; SEC, 2009). In addition, given the increasing emphasis on accounting as a decision support role and the availability of IDVs within many ERP systems, accountants often are information *users* and employ IDVs to identify and investigate unusual patterns in complex information sets (Dilla et al., 2010; Yigitbasioglu & Velcu, 2012). Finally, the Pathways Commission (2012, p. 72) report sponsored by the American Accounting Association (AAA) and American Institute of Certified Public Accountants (AICPA) recently recommended that instructors "transform learning experiences to reflect current and emerging technologies." Further, the AICPA notes that enabling decision support and analytics is a top technology concern for accountants (AICPA, 2013). It is therefore important that accountants understand how to both *prepare* and *use* IDV applications.

This case introduces IDVs to students by requiring them to create a simple interactive application to support pricing and product-line strategy decisions. The case exposes students to the advantages of interactive visualization, as compared to the static graphical representations of accounting information that they might have prepared in introductory information systems or accounting courses. Similar to real-world applications, the data set does not generate a pre-determined optimal pricing and product-line strategy. The case can be implemented using a spreadsheet program such as Excel or one of several interactive visualization software packages currently available for instructional use.

2. The case

In this case, students assume the role of the division controller assigned the task of developing an IDV to support the parent company chief executive officer (CEO)'s decision. Specifically, this assignment involves creating an IDV for the CEO to use when making pricing and product-line strategy decisions for an office supply retailer. Students will complete the following tasks:

1. Review scenario information about the company and the need to organize complex sales data for the company's CEO.
2. Study the basic IDV guidelines provided via the appendices and classroom discussion.
3. Learn how to use the assigned interactive visualization software through detailed instructions.[1]
4. Create IDVs from the spreadsheet containing detailed sales information to assist senior management in making pricing and product-line strategy decisions, and write a short memo summarizing how the data analysis may impact senior management's decision making.

2.1. Scenario

The Fletcher Company is a fictitious conglomerate with divisions in the retailing, manufacturing, and insurance industries. The retailing division consists of a chain of office supply stores known as Super Depot. Each student should assume the role of the divisional controller of SuperDepot. Pricing and product-line strategy decisions at SuperDepot are made by the CEO with input from the Vice President of Marketing. Fletcher's Vice President of Marketing has just resigned and the CEO wants to re-evaluate the pricing and product-line strategy decisions for each division. Fletcher's CFO is out on an extended medical leave and has asked the divisional controller to complete this assignment for SuperDepot without her assistance. For the purpose of making a decision about pricing and product line strategy at SuperDepot, provide Fletcher's CEO with an interactive report presenting the sales and profits of SuperDepot for the last four years.

2.2. Guidance notes

2.2.1. Learning to use interactive visualization software

Your instructor will provide instructions on how to use the required interactive visualization software. For Tableau users, a 10-minute video is available from your instructor.

2.2.2. Deliverables

Use the interactive visualization software to produce one or more IDVs of the sales information contained in the SuperDepotSales.xlsx workbook provided by your instructor. After completing the IDV(s), prepare a one-page memo describing the data and how the IDV may be used to assist management in making pricing and product line strategy decisions.

Save the IDV in a packaged workbook file for use by Fletcher's CEO. Please submit the workbook file and the memo by the assignment due date. Include your name in the workbook file and memo file names.

3. Teaching notes

3.1. Learning objectives

A recent review of Accounting Information Systems (AIS) instructional resources encourages educators to develop instructional cases that emphasize best practices so that students can stay abreast of rapid changes in technology (Apostolou, Dorminey, Hassell, & Rebele, 2014). This case allows students to stay informed about new data visualization technology by providing students with an understanding of how IDVs may be used to evaluate complex accounting information and by providing them with hands-on experience creating IDVs. Specific learning objectives include providing students with the opportunity to:

- Organize complex accounting data
- Learn about and apply guidelines for interactive data presentation

[1] In addition, each interactive visualization software has 'getting started' videos available for student use.

Table 1
Case alignment to AICPA Core Competency Framework.

Competency addressed	Level addressed	Why effective
Functional: leverage technology	Level 1: Identifies problems, potential solution approaches, and related uncertainties.	Students analyze multivariate data and provide information to senior management regarding pricing and product line strategy.
Functional: leverage technology	Level 3: Links data, knowledge, and insights together for decision-making purposes.	Students evaluate sales trend data, analyze the data using interactive data visualization, and summarize their analyses in a written memo.
Personal: communication	Level 3**:** Organizes and effectively displays information so that it is meaningful to the receiving party.	Students design interactive data visualization(s) for management decision making.
Personal: leverage technology	Level 4: Explores new technologies and their application to business and accounting scenarios.	Students are provided with an opportunity to understand how interactive data visualization software works and can be applied to accounting situations.

- Create IDV(s) from a complex data set for decision makers to use

Extensions to the basic case described in Section 3.3 provide students with the opportunity to:

- Evaluate complex accounting data using IDVs
- Learn how IDVs may bias decision making

The case addresses four competencies described in the AICPA Core Competency Framework (AICPA, 2011; Bonner, 2011), as shown in Table 1. Under the functional category "decision modeling," the case focuses on competencies regarding identifying problems, potential solution approaches, and related uncertainties (Level 1) and linking data, knowledge, and insights together for decision making purposes (Level 3). In addition, the case addresses the personal category "communication competency" by organizing and effectively displaying information so that it is meaningful to the receiving party (Level 3) and the "technology competency" by exploring new technologies and their application to business and accounting scenarios (Level 4).

3.2. Course use and student prerequisites

The case can be implemented using an interactive visualization software package or spreadsheet software such as Excel. Some instructors may want to use a spreadsheet program (e.g., see Lehman, Lehman, & Feazell, 2011) due to the inability to acquire or support interactive visualization software. In addition, instructors may ask students to create IDVs using both types of software to allow them to compare the capabilities of interactive visualization vs. spreadsheet software.[2]

The current case explicitly directs students to create an IDV presenting sales and profit information to the CEO to make pricing and product-line strategy decisions. Students receive guidance in the

[2] In this case, the third task in the instructions to students should be worded as: Learn how to use the assigned interactive visualization software by viewing the short tutorial provided and review how to create dashboards using Excel. The deliverables (section 2.2.2.) should read: Use both the interactive visualization software and Excel to produce IDVs of the sales information contained in the SuperDepotSales.xlsx workbook provided by your instructor. After completing these IDVs, prepare a one-page memo describing the data and how the IDVs may be used in decision making. Save the IDVs in a packaged interactive visualization software workbook file and in Excel for use by Fletcher's CEO. Please email the workbook file, the Excel file, and the memo to your instructor by the assignment due date. Include your name in all file names.

video and appendix materials about which variables to include, and must make decisions about data dimensions and presentation formats to be made available in each individual information view. It is helpful to remind students that similar to real-life situations, the data set is not designed to reach an optimal pricing or product-line strategy solution.

This case was implemented in an advanced accounting information systems (AIS) course four times at two public universities. The case was also tested once in an upper-level managerial accounting course and five times in an introductory AIS course at one public university. In the advanced AIS courses, the case followed coverage of general ledger reporting concepts in Simkin and Norman (2012)'s Chapter 8 at one institution and coverage of business intelligence concepts at the second. In the managerial accounting course, the case was presented while covering product costing concepts. Finally, the case in the introductory AIS course followed coverage of the general ledger process (e.g., Chapter 16 in Romney and Steinbart (2015)). The average age of the participants in the undergraduate courses was 20.5 years and the average age for the advanced AIS participants was 23.5 years. Fifty-two percent of participants were female. Most participants were able to complete the case requirements in two hours or less.

The only prerequisite for this case is basic competency in using spreadsheet graphing functions. Therefore, it can readily be used at several points in the curriculum. Given the decision making context of the case, it can be used in managerial accounting courses at any point from the introductory through advanced levels. With appropriate modifications the case might also be used in an auditing or fraud examination course in an analytical procedures context.[3]

3.3. Case extensions

This section describes four possible case extensions. First, the scope of the case scenario can be broadened to provide students with a less structured task. For example, students could be informed that the CEO is considering a new product line and needs information to assist her in pricing and product-line strategy decisions. In this scenario, students would choose not only data dimensions and presentation formats, as in the original case, but also which variables (i.e., sales, costs, market data, etc.) would be useful to the CEO.[4]

Second, instructors may wish to inform students how preparers may elect to emphasize or highlight certain information using multidimensional charts, artistic embellishments or other gratuitous display elements to influence decision makers (Bateman et al., 2010; Lurie & Mason, 2007; Tractinsky & Meyer, 1999). For example, Bateman et al. (2010) includes several interesting examples of gratuitous displays. The instructor can then discuss with students how gratuitous display elements contained in IDVs might be used by preparers to influence decision makers.[5]

Third, an instructor may wish to provide students with experience in terms of both preparing and using IDVs. This can be accomplished by having students peer review IDVs. Specifically, each student would create an IDV, trade it with another student, and then act as the CEO to make a decision using the partner's IDV. Finally, the 'CEO' provides feedback on how useful the IDV was for decision making. This activity meets the learning objective of providing students with the opportunity to evaluate complex accounting data using IDVs.

Finally, students could work across applications. Specifically, the instructor could provide a sales database in either Access or Excel to students, then require students to query the database to extract the data to be imported to the interactive visualization software.[6]

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[3] For example, students might explore how IDVs can be used to detect anomalies suggestive of fraudulent activity, using purchases data such as in the Albrecht, Albrecht, Albrecht, and Zimbelman (2012, 196) Chapter 6, Case Study 2.

[4] We thank an anonymous reviewer for this suggestion.

[5] This extension would be best implemented as a second (or later) assignment in a module on IDVs. Interactive visualization software typically provides users with a set of simple default display options. Additional training may be necessary to access the more elaborate display options used to embellish display elements.

[6] We thank an anonymous reviewer for the last two suggestions.

3.4. Implementation guidance

The case begins with basic instruction on IDV guidelines. Even though the functions of IDVs extend beyond basic static data representation to include allowing users to select both the information they deem appropriate and the format of that information, IDV guidelines may start with basic graph techniques. Since only a few accounting information systems textbooks describe basic graph design techniques (e.g., Hall, 2011, pp. 647–652; Romney and Steinbart, 2015, p. 489–490), there are limited resources to inform students of guidelines for IDVs. Therefore, we developed a set of basic IDV guidelines based on static representation best practices described in Tufte (1997) and Hill and Milner (2003) (see Appendix A) and provided these to students. We also prepared slides to illustrate examples of these IDV concepts (available from the first author upon request).

Most general-purpose interactive visualization software packages are fairly easy to learn how to use. We developed a 10-minute video on how to use interactive visualization software. Students view this video before attempting to complete the project (see Appendix C for overview of video content). Students are then given the case scenario and provided with a spreadsheet containing detailed sales data (see Table 2).[7] The file contains four years of detailed store sales and profit data with multiple data dimensions such as product category, product sub-category, and sales region. Students are then asked to use this information to develop IDVs to support management decision making. Students are also asked to write a one-page memo describing how the data analysis may impact senior management's decision making.

3.5. Obtaining access to interactive visualization software

Several interactive visualization products are available for educational use (see Table 3). We used Tableau Software in the courses where this case was taught. Tableau offers site licenses for educational use (see http://www.tableausoftware.com/academic/teaching). Alternatively, students can obtain a 14-day free trial license directly from the company (see www.tableausoftware.com). Similar to other interactive visualization software, Tableau has two components: an interactive data visualization creator and interactive data visualization reader. Students used the interactive data visualization creator to select the data variables, dimensions, and representations and prepare their interactive data visualizations. Students completing the third case extension (peer review of IDVs) would use the reader to select and view the items made available by the preparer.[8]

We developed instructions for using the case with four other interactive visualization software packages: AnalystX Office, Centrifuge, SpotFire, and Visual Mining, as well as Excel dashboards. Table 3 summarizes differences between these interactive visualization software packages and Excel Dashboards. Table 4 provides an overview of how to use each package.[9]

3.6. Scoring rubric and sample solution

The scoring rubric for the case (available from the first author upon request) assigns 15 points to the IDV task and 15 points to the creation of the memo. Since the functions of IDVs extend beyond basic static representation, each IDV is evaluated on basic graph concepts such as number of graphs presented, whether appropriate formats were used in the construction of each graph, the presence of stacked bars, number of dimensions and variables used, appropriate use of color, additional appropriate embellishment, and ability to view detailed data by highlighting graph dimensions. In addition, each IDV is evaluated on how well it allows a decision maker to select the information

[7] We asked three graduate students to learn each package during case development. They reported that the interactive visualization software packages were fairly easy to use. The most common hurdle noted by these students was learning how to add numeric labels to bar charts.

[8] One can view examples of interactive reader applications at http://www.tableausoftware.com/solutions.

[9] Detailed instructions for each interactive visualization software package and Excel can be obtained by contacting the first author.

Table 2
Data attributes of Super Depot sales file.

Order ID	Order date	Order quantity	Sales	Profit	Unit price	Customer name	Customer state	Zip code	Region	Product category	Product sub-category
3	10/13/2012	6	272.58	215.74	38.94	Muhammed MacIntyre	New Jersey	7514	East	Office supplies	Storage & organization
6	2/20/2014	2	6.24	5.98	2.08	Ruben Dartt	New York	10457	East	Office supplies	Scissors, rulers and trimmers
32	7/15/2013	15	143.82	56.00	8.46	Liz Pelletier	Ohio	44197	Central	Technology	Computer peripherals
32	7/15/2013	24	1772.25	–481.61	70.89	Liz Pelletier	Ohio	44197	Central	Furniture	Tables
32	7/15/2013	23	159.8	154.93	7.99	Liz Pelletier	Ohio	44197	Central	Technology	Telephones and communication
32	7/15/2013	26	2795.78	1692.71	107.53	Liz Pelletier	Ohio	44197	Central	Furniture	Office furnishings
35	10/22/2013	30	291.52	137.74	9.11	Julie Creighton	Michigan	49822	Central	Office supplies	Pens & art supplies
35	10/22/2013	14	1871.88	–246.68	155.99	Julie Creighton	Michigan	49822	Central	Technology	Telephones and communication
36	11/2/2013	46	2507.62	–959.79	65.99	Sample Company A	Connecticut	6074	East	Technology	Telephones and communication
65	3/17/2013	32	3821.07	3137.44	115.79	Tamara Dahlen	Delaware	19936	East	Technology	Computer peripherals
66	1/20/2011	41	109.44	–42.04	2.88	Arthur Gainer	North Carolina	27006	South	Office supplies	Pens & art supplies
69	6/4/2011	42	1175.34	624.40	30.93	Jonathan Doherty	Ohio	43567	Central	Furniture	Office furnishings
69	6/4/2011	28	52.08	–20.37	1.68	Jonathan Doherty	Ohio	43567	Central	Office supplies	Pens & art supplies
70	12/17/2012	46	7827.62	–760.93	205.99	Helen Wasserman	North Carolina	27006	South	Technology	Telephones and communication
70	12/17/2012	48	89.28	86.32	1.86	Helen Wasserman	North Carolina	27006	South	Office supplies	Rubber bands
96	4/17/2011	37	4157.67	226.11	125.99	Keith Dawkins	Texas	73301	Central	Technology	Telephones and communication
97	1/29/2012	26	75.14	–2.27	2.89	Craig Yedwab	Arizona	85354	West	Office supplies	Labels
129	11/19/2014	4	32.4	20.97	6.48	Pauline Chand	Connecticut	6439	East	Office supplies	Paper
130	5/8/2014	29	569.1	–256.16	18.97	Roy Collins	Florida	32003	South	Office supplies	Paper
130	5/8/2014	3	452.94	441.04	150.98	Roy Collins	Florida	32003	South	Technology	Office machines
130	5/8/2014	23	233.04	14.46	9.71	Roy Collins	Florida	32003	South	Office supplies	Storage & organization
132	6/10/2012	27	191.76	157.58	7.99	Emily Phan	Maryland	21290	South	Technology	Telephones and Communication
132	6/10/2012	30	4060.38	–28.01	130.98	Emily Phan	Maryland	21290	South	Furniture	Bookcases
134	5/1/2014	11	1151.88	–532.27	95.99	Michael Dominguez	Colorado	81221	West	Office supplies	Storage & organization
135	10/20/2013	25	124.5	–12.51	4.98	Anne Pryor	Ohio	43054	Central	Technology	Computer peripherals
166	9/11/2013	10	593.91	295.36	65.99	Valerie Takahito	Utah	84001	West	Technology	Telephones and communication
193	8/7/2012	14	174.16	–61.50	12.44	Justin Hirsh	Arizona	85231	West	Office supplies	Storage & organization
194	4/5/2014	49	327.6	–74.04	7.28	Maria Zettner	Georgia	30002	South	Furniture	Office furnishings
194	4/5/2014	6	18.84	8.50	3.14	Maria Zettner	Georgia	30002	South	Office supplies	Scissors, rulers and trimmers
195	12/27/2012	34	1315.8	6.09	36.55	Brad Thomas	Connecticut	6074	East	Office supplies	Pens & art supplies
197	4/6/2013	23	311.52	161.86	12.98	Penelope Sewall	Ohio	45999	Central	Office supplies	Scissors, rulers and trimmers
224	6/18/2011	25	184.5	107.22	7.38	Bart Folk	Connecticut	6439	East	Furniture	Office furnishings
224	6/18/2011	33	524.28	–74.71	15.42	Bart Folk	Connecticut	6439	East	Office supplies	Storage & organization
224	6/18/2011	44	269.1	–81.06	5.98	Bart Folk	Connecticut	6439	East	Office supplies	Paper

Table 3
Summary of interactive visualization software.

Software Characteristic	AnalystX Office	Centrifuge	Spotfire	Tableau	Visual Mining	Excel Dashboard
Location of free software	http://www.officeadvizor.com/contacts	http://centrifugesystems.com/explore/version-2-10/tryit/	https://tryspotfire.tibco.com/us/get-spotfire	http://www.tableausoftware.com/products/desktop/download	http://www.visualmining.com/ncpd/	http://office.microsoft.com/en-us/try/
Terms of software	30 days	14 days	30 days	14 days	15 days	60 days
Advantages of software	Good assistance from vendor via emails, videos, and customer support All charts linked when selecting particular data	Interesting drill chart function Easy to create graph due to dropdown menus	Easy to use Default views with filters allow for easy data manipulation Dropdown menus for changing axis Makes visible important information on dashboard	Easy to use Simple filtering data Drag and drop allows user to see data at all times Easy to import and format data Useful training materials	Multiple wizards make software easy to use Simple filtering data Dropdown menus for changing axis Useful training materials	Excel dashboard is embedded in Excel, no additional IDV software cost Compatible with other Microsoft Office products Simple import and format data
Challenges encountered with software	Difficult to create line graphs Requires user to parse dates Default file type is not compatible with trial software Cannot label chart figures Creating data hierarchies is confusing	Line graphs can only handle one variable per chart Only way to compare two variables is stacked charts with different scales Difficult to import data format since numbers and dates are read as text Difficult to change graph colors and data labels	No significant challenges	Difficult to display multiple graphs on a single worksheet	Difficult to change graph colors and data labels Requires user to format dates before creating dashboard	Excel skills are necessary Difficult to select data, necessary to arrange data in PivotTable first Chart is based on the quality of table created Only one chart can be created from a PivotTable Original file can be changed unless properly protected Users need to play preparer's role to manipulate data

(*continued on next page*)

Table 3 (*continued*)

Software Characteristic	AnalystX Office	Centrifuge	Spotfire	Tableau	Visual Mining	Excel Dashboard
Types of graphs available	Bar Line Pie Histogram Scatterplot Multiscape Parabox Data constellations Time table	Bar Line Pie Table Bubble chart Matrix chart Drill chart Timeline Relationship graph	Bar Line Pie Scatterplot Combination chart Heat map Parallel coordinate map	Bar Line Pie Histogram Scatterplot Text table Heat map Dual axis Gantt	Bar Line Bar Line Pie Table	Bar Line Pie Bubble chart Scatterplot Combination chart Area Doughnut Radar Surface Stock
Ease to select data to display	Somewhat difficult	Easy	Easy	Easy	Easy	Easy
Ease to add labels to data	Could not find a way to label data Placed left curser over bar/point and label appeared	Could not find a way to label data Placed left curser over bar/point and label appeared	Easy	Easy	Could not find a way to label data Placed left curser over bar/point and label appeared	Easy
Ease to add headings to presentations	Easy	Easy	Easy	Easy	Easy	Somewhat difficult
Availability of training materials for software	Link to video gallery is available via email which includes numerous videos on how to build particular dashboards	Training videos available on login page	Training webinars available	Training videos and live training link available on free download site	Installation guide, tutorials, Excel-specific tutorials available on free download site. Sales rep very willing to help answer any questions.	Specific Excel Dashboard tutorials are available for purchase from various vendors

Table 4
Selected directions for using interactive visualization software.

Task	AnalystX Office	Centrifuge	Spotfire	Tableau	Visual Mining	Excel Dashboard
Import data file	Load New Data and follow Wizard instructions	New File/Addition Sign next to Source/ name source and source type/ change necessary parameters/Select	File/Add Data Tables/ Add/File/ Browse/OK	Connect to Data Link, Select Data Source Type, Browse for File, Select Connect Live	Follow Wizard instructions, test data source status, auto-generate data entities	Open Excel, File/Open/ Browse/OK
Move information into work areas	Dropdown menu	Dropdown menu available after selecting visual graph	Pull down menu on both axes	Drag and drop	Dropdown menu	Create PivotTable
Change colors/ formatting	Headings near top of screen (Color Scale and Color by) with dropdown menus to select color scheme and variable colors.	Could not find a way to change colors for bar graph	Click on box in upper right-hand corner and color grid appears. Can color entire graph or by particular variable	Double click on Blue Box in Color bubble Can drag a dimension to bubble to color by particular variable	Could not find a way to change colors for bar graph	Use PivotChart Tools for formatting
Filter data (i.e. allow user to select data)	Click New Text Filter on any page directly below the page tab. To filter by more than one variable, create another filter by clicking on the same button until satisfied.	After graph created, click Configure, Filter, and Add. Select variable desired to be filtered and select. Able to filter by more than one variable at a time.	Filters automatically appear after creating file (if closed, click View Filters). Slide arrows to desired point	Drag dimension to Filter task pane and select filtering criteria from list	After graph created, click Configure, Filter, and Add. Select variable desired to be filtered and select. Able to filter by more than one variable at a time.	Drag dimension to Filter area when creating PivotTable, and select filtering criteria from list
Create drill down data (i.e. allow user to select additional details)	Can customize any field by creating a data hierarchy or name hierarchy Can add as many variables as one would like	Can create a drill chart Can customize drilling to break down data.	Must use filters to drill down	Highlight dimension members by clicking and holding shift, click on Group (i.e., paperclip icon)	Select multiple dimensions when creating the graph. Click on a particular bar and select Show Chart to drill down. To see the actual data, select Drill Down. Can also select Edit Preferences to drill down and filter.	To drill down, need to start with filter Right click column labels/row labels→ Group and Outline→ Show details→ Select the details dimensions

he/she deems appropriate for the decision at hand. The memo is evaluated by examining whether the student clearly explained how and why the IDV was created, summarized the information needed for pricing and product-line strategy decisions, and offered an interpretation of the interaction data visualization created. A sample solution IDV and memo are available from the first author upon request.

3.7. Evidence of efficacy and student perception feedback

We used four methods to obtain evidence regarding case efficacy and student perception feedback. First, selected faculty members carefully reviewed the case and offered constructive suggestions to improve it. Second, the 34 introductory AIS students who field-tested the case in spring 2014 completed pre- and post- project questionnaires to provide both quantitative and qualitative perception feedback.[10] Quantitative feedback, shown in Panel A of Table 5 provides some evidence that the case achieves its stated learning objectives. For example, participants' mean "perceived ability to organize complex accounting data" was 5.39 before completing the case and 7.00 after the case. Further, participants' perceptions of their "graphical design skills," "proficiency with interactive data visualization programs," "ability to generate graphs," "ability to generate pivot tables," and "ability to create 'drill-down charts" were higher after completing the case. Finally, related to the AICPA Core Competencies, after completing the case students (on average) rated their ability to: (1) identify problems, potential solution approaches, and related uncertainties, (2) link data, knowledge, and insights together for decision making purposes, (3) organize and effectively display information so that it is meaningful to the receiving party, and (4) develop strategic uses of technology to enhance work performance as higher after completing the case.

Third, further analysis was undertaken to examine differences in student perceptions between those using interactive visualization software and those using spreadsheets to complete the case study. Ninety-two students were asked to create visualizations in both Tableau and Excel in one assignment.[11] These students completed the same post-project questionnaire discussed earlier. Seventy-four students (80 percent) indicated that interactive visualization software better facilitates data visualization creation while 18 students (20 percent) chose Excel. The post-project questionnaire also included measures (adopted from Venkatesh & Davis, 2000) of perceived ease of use and perceived usefulness for each software.[12] Results are reported in Panel B of Table 5. In general, students using Excel indicated lower levels of perceived ease of use and perceived usefulness. Students perceived that Excel was slightly less difficult to use (mean rating = 6.78, where 1 = very difficult and 10 = very easy) than Tableau at (mean rating = 7.47). In contrast, students perceived that creating visualizations with Tableau was slightly simpler (mean rating = 4.73, where 1 = very simple and 10 = very complex) than Excel (mean rating = 5.01).

Fourth, all students provided qualitative feedback by completing the post-project questionnaire discussed above. They were asked to identify: (1) at least two ways the case influenced their understanding of how complex data may be analyzed using IDV, and (2) two ways the case could be improved for future students. These results are summarized in Panel C of Table 5. In general, student comments indicated a perception that the case achieved each learning objective listed above. Further, several students identified new objectives such as "the writing assignment gave me a chance to improve my critical thinking skills." Suggestions for improvement ranged from "expand the data visualization coverage in this course" to "replace memo with short answer questions asking to describe the intent of visualization."

[10] The pre- and post- project questionnaires are available from the first author.

[11] Half of the students created the visualizations in Tableau first while the other half created the visualizations in Excel first. Statistical analysis of the results indicated there were no differences in feedback responses between the two orders of completion.

[12] We randomized the question order so that half of participants viewed the Tableau questions first. We compared means for each question and found no order effects. Results are available, on request, from the lead author.

Table 5
Student feedback.

Panel A: Quantitative feedback ($n = 34$).		
Rate your level of the following[a]	Pre-project survey	Post-project survey
Graphical design skills	3.68 (2.04)	6.36* (1.75)
Excel proficiency	7.12 (0.95)	8.00* (1.03)
PowerPoint proficiency	7.68 (1.45)	8.24* (1.25)
Proficiency with interactive data visualization programs	1.71 (1.73)	6.18* (1.91)
Ability to organize complex accounting data	5.39 (1.56)	7.00* (1.27)
Ability to generate graphs from Excel	7.53 (1.16)	8.27* (1.18)
Ability to generate graphs using interactive data visualization programs	1.79 (1.92)	7.36* (1.73)
Ability to generate pivot tables using interactive data visualization programs	1.91 (2.02)	6.36* (2.00)
Ability to generate pivot tables in Excel	6.32 (1.53)	7.79* (1.32)
Ability to create "drill-down charts" in Excel	4.24 (2.18)	6.58* (1.87)
Ability to create "drill-down charts using interactive data visualization programs	1.53 (1.86)	6.03* (2.24)
Ability to identify problem, potential solution approaches and related uncertainties	6.47 (1.66)	7.21* (1.14)
Ability to organize and evaluate information, alternatives, cost/benefits, risk and rewards of alternative scenarios	6.47 (1.80)	7.67* (0.96)
Ability to link data, knowledge, and insights together for decision making purposes	7.00 (1.21)	7.97* (1.10)
Ability to identify risk associated with technology and automated business processes.	6.35 (1.76)	7.30* (0.92)
Ability to use software to build models and simulations.	4.91 (1.99)	7.09* (1.61)
Ability to develop strategic uses of technology to enhance work performance	6.24 (1.48)	7.30* (1.16)
Ability to organize and effectively display information so that it is meaningful to the receiving party	7.65 (1.35)	8.09* (1.10)
Ability to make valid and reliable evaluations of information including the significance of evidence or facts for problem definition and solution	6.82 (1.42)	7.58* (0.97)

Panel B: Quantitative feedback visualization software vs. Excel ($n = 92$).		
Statement	Tableau mean (Std deviation)[a]	Excel mean (Std deviation)[a]
Using SOFTWARE NAME[b] in my job improves my performance.	8.24 (1.40)	7.53 (1.59)
Using SOFTWARE NAME in my job increases my productivity.	7.85 (1.54)	7.56 (1.62)
Using SOFTWARE NAME enhances my effectiveness in my job.	8.10** (1.52)	7.61 (1.50)
I find SOFTWARE NAME to be useful.	8.51* (1.58)	8.14 (1.47)
Learning to use SOFTWARE NAME is easy for me.	8.02** (1.55)	7.39 (1.97)
I find it easy to get SOFTWARE NAME to do what I want it to do.	7.62** (1.74)	7.09 (2.11)
My interaction with SOFTWARE NAME is clear and understandable.	7.71 (1.58)	7.39 (1.82)
I find SOFTWARE NAME easy to use.	7.83** (1.73)	7.10 (2.04)
I found the task of creating a IDV using SOFTWARE NAME (very difficult/very easy).	7.47**[c] (1.58)	6.78[c] (1.89)
I found the task of creating a IDV using SOFTWARE NAME (very simple/very complex).	4.73[d] (2.69)	5.01[d] (2.47)

(continued on next page)

Table 5 (*continued*)

Panel C: Qualitative feedback ($n = 216$).
Ways case influenced student understanding of how complex data may be analyzed using IDVs[e]
• The case helped me understand why the data visualization is important.
• The case provided hands-on experience with interactive data visualization in a realistic scenario.
• The case made me think more about how to present data.
• The case introduced me to new data visualization concepts.
• The case allowed me to think about how users may use the data in a visualization.
• I learned that with large complex data sets, there is not one optimal solution.
• Writing assignment gave me a chance to improve my critical thinking skills.
Ways to improve the case for future students[f]
• Expand course coverage of interactive data visualizations.
• Walk through detailed example in class.
• Replace memo with short-answer questions asking to describe the intent of visualization as we know how to write memos already.

* Difference is statistically significant at p = 0.05 level or less using a one-tailed t-test.

[a] Responses based on a eleven point scale with 0 = novice and 10 = expert.

** Difference is statistically significant at $p = 0.05$ level or less using two-tailed t-test.

[a] Responses based on a eleven point scale with 0 = strongly disagree and 10 = strongly agree.

[b] Students who created visualizations with both Tableau and Excel completed two sets of questions. For half of these students, the SOFTWARE NAME was Tableau for the first set and Excel for the second set. The order was reversed for the other students.

[c] Responses based on a eleven point scale with 0 = very difficult and 10 = very easy.

[d] Responses based on a eleven point scale with 0 = very simple and 10 = very complex.

[e] All students were asked to identify at least two ways this case impacted their understanding how complex data may be analyzed using interactive data visualization.

[f] All students were asked to identify at least two ways this case could be improved for future students.

4. Conclusion

Accountants are often asked to provide decision support to senior management by analyzing large, complex data sets. To facilitate this process, many accountants use IDVs (Haverson, 2014). IDVs have an advantage over static representation applications, in that that they allow users to easily select both the information types and formats they view as most useful for decision making. Recent growth in user-friendly interactive visualization packages for commercial use, the exponential growth in data available for analysis, and the demand for quick responses to changing scenarios all drive the need for IDVs to support management decision making. This case introduces students to interactive data visualization concepts and provides hands-on experience creating IDVs. It can be completed using one (or more) of several interactive visualization packages or Excel dashboards. Student perceptual feedback has generally been positive and suggests that the case achieved its learning objectives.

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Appendix A: Interactive data visualization background

A.1. Introduction

Interactive data visualization (IDV) technology allows managers to make sense of data in order to facilitate efficient and effective decision making. IDVs have recently evolved from a scientific, engineering, and mathematical research tool to mainstream adoption for commercial use (Heer & Shneiderman, 2012; Heer et al., 2008). The emergence of business intelligence as a decision support technology has increased the demand for IDVs in order to facilitate organizing and presenting complex

data (Chaudhuri et al., 2011; Heer & Shneiderman, 2012; Romney & Steinbart, 2015). Since IDVs offer accountants the potential to better support data-driven management decision making, especially in situations where an optimal solution does not exist, it is important that students become familiar with this technology.

A.2. What is interactive data visualization?

The term data visualization refers to the "use of computer-supported, interactive, visual representations of data to amplify cognition, or the acquisition and use of knowledge" (Card, Mackinlay, & Shneiderman, 1999, p. 6). In contrast to static information visualization, where preparers select information items and their display formats for decision makers, IDVs allow information users (i.e., decision makers) to perform various data navigation, selection, and representation functions via an easy to use interface (Dilla et al., 2010; Spence, 2007; Yi, Kang, Stasko, & Jacko, 2007). For example, IDVs allow decision makers to explore a large or complex data set and select items of interest, show more or less detailed information (i.e., elaborated or abstracted views), or filter the data based on specific conditions (Yi et al., 2007). Further, this technology allows decision makers to easily show different data representations (i.e., tables versus various types of graphical displays), or reconfigure the way in which data are arranged within a given representation (e.g., by changing whether a given dimension is displayed in rows or columns). The graphical displays incorporated in information visualization packages support perceptual or holistic decision strategies, rather than the analytical decision strategies supported by textual displays. This fit between decision strategy and representation should reduce effort and result in more accurate decision outcomes in tasks that involve assessing trends and relationships among data (Vessey, 1991, 2006).

A.3. Use of interactive visualization software vs. spreadsheet or database applications

While spreadsheet and database applications allow users to perform some navigation (e.g., using hyperlinks to guide the user through a large spreadsheet), selection (e.g., filtering data via database queries), or representation (e.g., developing graphs based on spreadsheet or database tables) functions, interactive visualization software allows users to transition seamlessly among these three functions (Dilla et al., 2010). Further, spreadsheets and databases are often difficult to maintain, may contain errors, and generally cannot produce interactive geographical displays (Klein, 1997; Klein, Goodhue, & Davis, 1997; Panko & Aurigemma, 2010). Finally, since spreadsheets' navigation, selection, and representation functions are limited due to file size restrictions, many companies analyzing large data sets elect to use interactive visualization software rather than spreadsheets to create IDVs (Haverson, 2014; Microsoft, 2013b).

A.4. Accountant's role in interactive data visualization

Accountants may be involved with data visualization as either preparers or users. Figure 1 contrasts the capabilities available to the information preparer and user with static versus interactive visualization tools. The static visualization preparer selects the data elements and display format(s) (e.g., tables or graphs), then provides the visualization to the user. Spreadsheet formats provide the user with somewhat limited capacity to change the data displayed or its format. In contrast, users of pdf or html formats cannot easily change the data displayed or its format. The interactive visualization preparer determines a set of data, variables, and dimensions to be made available to the information user and provides multiple presentation format alternatives. The interactive visualization user is able to navigate the data set, choose among variables and dimensions to be displayed, and determine the display format.

To illustrate these differences, a static visualization might include only quarterly data for sales and cost of sales displayed in a bar graph. In contrast, an interactive visualization would allow the user to choose among these and other performance measures (such as monthly, quarterly, or annual results), as well as from other dimensions (such as product line or location). In addition, the interactive visu-

	Capabilities available to information preparer	Capabilities available to information user
Static data representation	Select specific data, variables, and dimensions to present to information user.	View available data displays.
	Select desired presentation format(s).	Limited capacity to change display or data selection.
Interactive data visualization	Determine the set of data, variables, and dimensions available to information user.	Select relevant information from set of data, dimensions, and variables chosen by information preparer.
	Select presentation format alternatives for information user.	Select desired presentation format from alternatives provided by information preparer.

Fig. 1. Characteristics of static versus interactive data visualization.

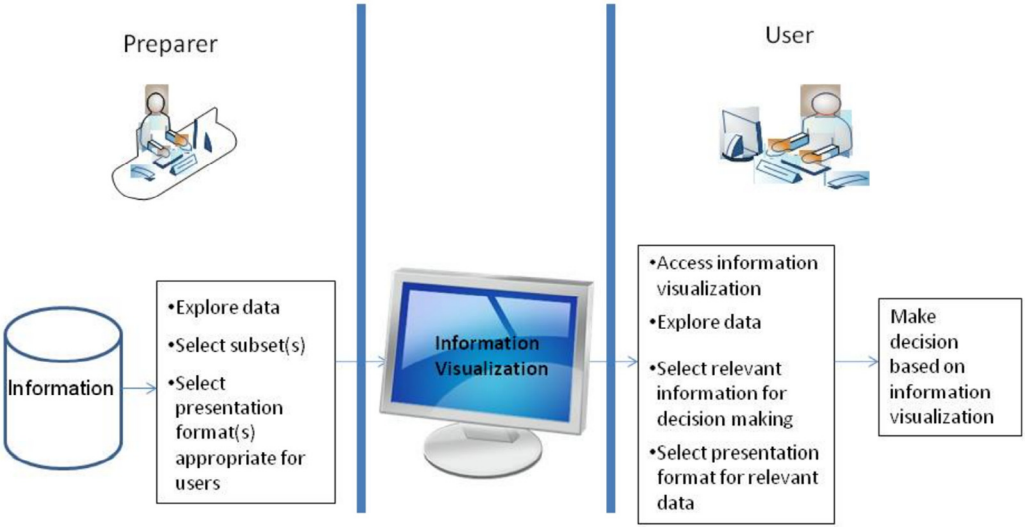

Fig. 2. Overview of interactive data visualization process.

alization user may choose among tabular or a variety of graphical formats, and drill down from summary displays to individual data items.

A.5. Preparing and using IDVs

Figure 2 illustrates the process of preparing and using IDV applications. This process starts with data being imported into an interactive visualization software package. The preparer examines the available data, considers the types of decisions to be supported (e.g., why are sales down in various regions? etc.), and determines the data parameters and display formats to be made available to the user (e.g., user can select sales detail from first quarter 2013 to first quarter 2014 displayed in geographic locations vs via bar charts). The preparer then creates the IDV and makes it available to users. Users employ the IDV to explore the data, select relevant sets of information to analyze, and display it in their preferred formats.

The process of designing and preparing an IDV is important. A complex application providing numerous choices among variables, parameters, and display formats may overwhelm the user with unnecessary details and therefore may not support efficient decision making. On the other hand, an application with too few user options may not provide enough information to support effective decision making. The types and number of different data parameters and display formats that are best for a given situation will likely depend on the nature of the task (Dilla et al., 2010; Yigitbasioglu & Velcu, 2012). For example, a relatively simple task such as evaluating sales performance for a multi-location retail company may require that only a few different variables, dimensions, and display formats be available to the user. On the other hand, a complex task such as detecting money laundering through analysis of bank transfers may require that a large set of variables and dimensions, as well as a variety of different display formats, be available (Chang et al., 2008). Similarly, the degree of experience that users have using IDVs may influence their ability to effectively use these tools to support decision making (cf. Coll, Coll, & Thakur, 1994). Thus, it may be appropriate to develop complex IDVs for experienced users, while it may be best to limit the number of data parameters and display formats available to those who use interactive displays only infrequently.

Appendix B: IDV guidelines

Information systems and design researchers have developed guidelines for designing IDVs and for understanding users' perceptual organization. (Card et al., 1999; Hearst, 2009; Spence, 2007; Ware, 2004). Several guidelines extend static representation guidelines described in Tufte (1997) and Hill and Milner (2003).

B.1. Basic IDV guidelines

- Know your audience. For example, if your investors tend to have high perceptual skills, use more graphical displays than tabular displays.
- Tabular displays are most useful for looking up the precise value of a specific data item. Graphs are more useful for examining relative magnitudes, relationships, and anomalies.
- Comparisons are easier when the items to be compared are adjacent to one another.
- When you are showing a change over time, consider using a time series chart (i.e., line chart with time on the columns shelf).
- When you are showing the highest or lowest value, use a bar chart.
- Place the most important view in the top or top left.
- Group filters and legends to the right or bottom of your interactive data visualization.
- Avoid using multiple color schemes per visualization unless there are natural or independent color schemes in your data.
- In general, keep your visualizations to two or three views. When you add too many views, the big picture can get lost and the IDV becomes difficult to understand.
- Use pie charts only when the wedges represent a percent breakdown of a measure, the area of the pie is a measure (so the circumference is telling the story), or the pie is being used as a map.
- Avoid "scrunched views" that do not allow enough room to read headers, labels or understand the data.
- Emphasize the most important data by using this data on the row or column shelves. Encode in color, size, or shape less important data.
- Order the values in a filter so that they make sense for the data. For example, instead of listing major balance sheet items alphabetically, you should list them as assets, liabilities, and equity.

B.2. Principles of user's perceptual organization

- Proximity – users tend to group together elements that are shown closer together
- Good continuation – users tend to group together/link up dashed or dotted lines
- Similarity – users tend to group together similar marks

- Common fate – users tend to group together lines or marks that seem to be headed in the same directions
- Good form – users see regular enclosed shapes as single units
- Compatibility principle – e.g. continuous data for line graphs

Appendix C: Interactive visualization software demonstration outline

To assist students in learning the interactive visualization software, we developed a 10-minute video tutorial for Tableau. For instructors developing their own demonstration videos, we recommend covering the following topics:

1. Import a data file
2. Drag and drop capabilities, including the ability to drag information into work areas known as trays
3. Use of 'column' and 'row' trays at the top of the screen to request data to place in the trays
4. 'Dimension' section corresponds to the data labels
5. 'Measures' section corresponds to the actual calculations
6. Viewing the various data representations using the 'show me' button
7. Use of filter and a + or – button to filter data
8. Adjust the shape or color to get a better picture of the data and show the results of dragging a dimension or label into the color or shape section
9. Change the scale of the graph
10. Undo changes made using the 'back' button
11. Save the workbook in the format required for viewing using the Tableau reader

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