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Accounting students' learning processes in analytics: A sensemaking perspective

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ABSTRACT

This paper takes a sensemaking perspective for purposes of better understanding the learning processes of students engaged in data analytics tasks and thus provide an enriched approach to teaching the subject. A sensemaking perspective addresses a gap in the accounting education literature by describing the learning processes associated with conducting data analytics tasks. A case study methodology was used by conducting an exploratory study of students' sensemaking activities while engaging in an experiential data analytics project. Findings from the study suggest students engaged in data analytics tasks experience states of uncertainty and ambiguity. They also experience behaviors of wrestling to develop findings and insights, experimenting followed by failure, creating solutions, and regularly evaluating their work progress. The variety of these behaviors, which resemble deep-learning processes can pose challenges to teaching data analytics to accounting students.

1. Introduction

Data analytics tasks are ambiguous and complex given the volume, variety, velocity, and veracity of Big Data (IBM, 2012; Laney, 2001; Zhang, Yang, & Appelbaum, 2015). The importance of data analytics is punctuated by the AACSB requirement of analytics as part of an accounting program in which graduates need skills in creating, sharing, evaluating and interpreting data (Schneider, Dai, Janvrin, Ajayi, & Raschke, 2015). Addressing these issues, the 2017 special edition on Big Data in the *Journal of Accounting Education* aptly provides teaching cases and research papers that focus on the primary goal of accounting: to create and provide information that is relevant to external and internal decision makers (Janvrin & Watson, 2017). Accounting students need resilient skills that are adaptable to multiple situations (Lawson et al., 2014) in light of how data analytics and Big Data will affect the accounting profession for the short and long term (Vasarhelyi, Kogan, & Tuttle, 2015). Having a better understanding of how to teach data analytics to accounting students contributes to their developing resilient skills.

The purpose of this paper is to provide a better understanding of teaching the topic of data analytics to accounting students. Having a description of what the data analytics learning process looks like can enrich one's ability to teach data analytics to future accountants. This paper, therefore, uses sensemaking to illustrate the types of behaviors students experience while learning data analytic tasks. To do this, I implemented a hands-on, experiential learning project in my data analytics course for accounting majors. I use a case study methodology to conduct an exploratory study of students' sensemaking activities while engaging in data analytics tasks.

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The remainder of the paper is structured as follows: (1) a review of the sensemaking literature followed by research questions; (2) methodology of the case study as a research approach; (3) findings from the exploratory case study; (4) discussion of findings; and (5) future research directions.

2. Literature review

This exploratory case study uses sensemaking to capture and identify variables associated with learning data analytics. Weick, Sutcliffe, and Obstfeld (2005) explain sensemaking as an activity where people "organize to make sense of equivocal inputs and enact this sense back into the world to make that world more orderly." (p.410) Sensemaking is the process of converting flux into something coherent that generates action or decisions. A process of creating coherence from unstructured problems resonates of higher order skills needed to confront the realities facing accounting graduates: asking the right questions, employing skills to transform various types of data, applying analytic techniques, and interpreting results (Ernst, 2017).

Occasions for sensemaking are situations of uncertainty and ambiguity (Starbuck, 2009); learning from improbable events (Lampel, Shamise, & Shapira, 2009); the adaptation or failure of wild fire crews (Weick, 1993); the collection, dissemination, brainstorming, and applying ideas in product development (Akgun, Lynn, & Reilly, 2002); and the counter-intuitive approaches to the analysis of complex information (Kurtz & Snowden, 2003).

2.1. Sensemaking

Interrupting events provoke a person to ask, "what's going on here?" followed by "what's next?" (Weick et al., 2005). In some instances, the situation may be so ambiguous one may initially be at a loss on how to confront it and take action (Starbuck, 2009). Weick (1995) identifies seven properties that describe the sensemaking process of finding meaning and coherence on which to act or decide. Sensemaking is:

1. A process grounded in **identity construction**
2. **retrospective**
3. **enactive** of sensible environments
4. **social**
5. **ongoing**
6. focused on and by extracted **cues**
7. driven by **plausibility** rather than accuracy (Weick, 1995, p. 17)

Sensemaking begins with a person encountering a problem or event requiring them to muster up their skills in deriving meaning and action (Weick & Sutcliffe, 2006; Weick, 1995). The process of **identity construction** is a result of a person using their skill sets to confront a problem or event that holds multiple meanings. We construct our identity through the varied skills we have developed over time (Weick, 1995, p. 20). When a person draws from their skill set, they actively evaluate what could work suggesting a certain approach was effective in the past with previous incoherent situations (Weick, 1993). There is a "meaningful lived experience" where learning took place in the past and is part of a person's skill set (Weick, 1995, p. 24). A "meaningful lived experience" is a product of the **retrospective** part of sensemaking: we know what we have done once we have done it (Weick, 1995). The retrospective process of sensemaking means taking action and then considering the outcomes of that action.

When individuals take action to deal with an event or problem they create in part the environment they must face. As such, Weick (1995) describes sensemaking as **enactive** of sensible environments. The outcomes may exacerbate the problem or generate greater coherence (Lampel et al., 2009; Starbuck, 2009; Weick, 1995, 2005). Additionally, sensemaking is **social** and done in the company of others: it is a social activity where shared meaning about the organization or team purpose and current situation are at issue (Lampel et al., 2009; Weick, 1995). Events confronted by individuals occur in the **ongoing** "normal course of business or routine" as interruptions (Weick, 1995). Though a degree of meaning may be achieved by attaining coherence from an interrupting event, similar events can resurface in the future creating new or related problems to be solved (Weick et al., 2005; Weick, 1995).

Individuals apply their skills to an event or problem by noticing what is taking place (Weick, 1995, 2006). Sensemaking focuses on **cues,** which is the activity of classifying key activities of the event, identifying variables in data analysis, or finding clues about the problem or event (Weick et al., 2005). Cues are the datum available that when combined and acted upon offer a diagnosis to generating meaning (McDaniel, 2007; Weick, 2006). Sensemaking is driven by **plausibility** where by solutions are relevant and pragmatically applicable (Weick, 1995). Cues are organized such that plausible actions or decisions become within reach of the sensemaker (Weick & Sutcliffe, 2006). Plausibility is characterized by feasibility, practicality, and creativity (Weick, 1995).

2.2. Research question development

Sandberg and Tsoukas (2015) provide major specific constituents of the sensemaking process as follows: events trigger sensemaking; sensemaking efforts are part of a process; sensemaking results in outcomes; and there are factors influencing sensemaking. I draw from Sandberg and Tsoukas (2015) to focus this exploratory study on three sensemaking properties of plausibility, cues, and retrospection. While all the properties of sensemaking are important, the ability to interpret cues towards plausible goals and re-evaluating them through retrospection captures essential mechanics of the sensemaking process.

2.2.1. Sensemaking behaviors of plausibility, cues, and retrospection

Sensemaking begins when events interrupt ongoing activities creating a need to achieve coherence because the event is either unplanned (unexpected) or planned (implementing a process, etc.) (Sandberg & Tsoukas, 2015; Starbuck, 2009). A priority of gaining understanding results from the event generating equivocality: there are multiple meanings requiring evaluation to achieving coherence via a plausible outcome (Weick, 1995). The following investigates sensemaking behaviors (hereafter SM-behaviors) found in the three properties of cues, plausible goals, and retrospective processes.

A person confronting an event notices cues and works to decipher their meaning. A nurse noticing a newborn's skin color or behavior that are out of the norm from experience is a type of cue (Weick et al., 2005). Large-scale interruptions of critical routines for airline pilots and air controllers create cues under stressful contexts (Weick, 1990) Analyzing multiple forms of data creates its own inherent interruptions requiring interpretation of cues suggested from the data as pattern or causation (Kurtz & Snowden, 2003). In each of the above examples, finding meaning in cues is a process of noticing the types of signals being providing and bracketing them for further attention. The challenge is to distinguish between signals versus noise where focusing on relevant cues contributes to an envisioned plausible outcome.

Cues provide the sensemaker a necessary structure to creating meaning about an interrupting event (Weick et al., 2005; Weick, 1995). Finding a plausible outcome starts when a person notices cues from the event. This process of noticing leads to bracketing cues towards an envisioned plausible outcome, which is again followed by acting on those cues, leading to another cycle of noticing and bracketing (Weick & Sutcliffe, 2006; Weick et al., 2005). This iterative process is a characteristic pattern of sensemaking (Sandberg & Tsoukas, 2015).

Noticing and bracketing serves to structure the problem and is followed by efforts of identifying plausible outcomes. Bracketed cues lead to labeling a plausible outcome, explanation, or decision criteria. The urgency of labeling a plausible outcome is important because the event regularly generates a multiplicity of meanings (Weick, 1993, 2010). For example, the activity of noticing and bracketing these cues is akin to a jury clarifying an opaque verdict they had in mind prior to deliberation (Weick, 1995). The ongoing sensemaking process focuses on having a plausible resolution resulting from a refining process of noticing and bracketing cues.

Retrospection is central to the sensemaking process. It provides a feedback loop of one's actions, stimulates applying previously learned skills from lived experience, and evaluates actions taken to prioritize a new set of bracketed cues, repeating a sequence of action (Sandberg & Tsoukas, 2015). Once a person has acted on their hunches from interpreting cues, they understand what they have done after they have done it (Schutz, 1967; Weick, 1995). When a sensemaker retrospectively determines the outcome of their action the bracketing of cues may in fact change after the fact. Prior to action, the cue was bracketed out of necessity because it was noticed (Weick et al., 2005). Retrospection after taking action provides clarity on the appropriateness of bracketed cues and their usefulness towards a plausible explanation. When the process of re-evaluating one's actions and the bracketing of cues ceases, retrospective processes also stop suggesting the achievement of plausible outcomes (Weick, 1995).

The relationship between retrospectively evaluating cues and a plausible outcome is an important one. A plausible outcome becomes a point of focus whereby cues are extracted from the event and organized into action (Weick et al., 2005). By taking action and retrospectively evaluating, the sensemaker achieves at least two goals: confirmation of trying to achieve a plausible outcome and second, creating either further constraints or opportunities in achieving a plausible outcome. In essence, a person creates the raw materials they must use in dealing with the event, and those materials may provide opportunities or constraints in achieving plausible solutions (Weick, 1995).

People attempt to identify what is plausible during interrupting events to attain clarity (Luscher & Lewis, 2008; Weick, 1995). While cues are noticed and bracketed, plausible goals are labeled as they become attainable (Weick et al., 2005). In medicine, diagnosis provide a basis for functional deployment (Chia, 2000; Weick et al., 2005). Luscher and Lewis (2008) demonstrate how the Lego Company labeled "paradox" as being a plausible outcome therefore necessitating the integration of two opposing solutions to strategic development. Plausible goals are meaningful as clarity of the issues become apparent to the sensemaker. Even if an individual is unclear about the meanings of the event, they seek coherence that justifies actions (Weick, 1995).

An important quality of plausibility is that it is tentative during the process of sensemaking and subject to change based on retrospectively evaluating action and the way cues have been noticed and bracketed (Weick, 1995). As additional actions take place based on bracketed cues, plausible outcomes become more viable or less so requiring additional analysis of cues. When plausible outcomes become clearer, the sensemaker moves from obscurity about understanding the consequences of the event to clarity. In this situation, the person seeks to confirm a greater state of understanding with further actions and retrospectively reasoning outcomes (Weick & Sutcliffe, 2006; Weick, 1995). Invention and creativity constitute the raw

materials of plausible outcomes (Weick, 1995). Regular actions, reflection and bracketing, followed by more bracketing of cues leads to confirmation of a plausible outcome or explanations.

In their research of strategic change, Gioia, Thomas, Clark, and Chitipeddi (1994) found that common symbols serve as a base for senemaking and serve as indicators of different elements of the sensemaking process. While the literature provides rich descriptions of the sensemaking process, distinct behaviors for cues, retrospection, and plausibility that can define the nature of the sensmaking process for data analytics tasks are uncommon. Based on the above, the following represents one of two research questions driving the study with Table 1 providing a summary of each sensemaking property examined in this paper.

Research Question 1: What are distinct SM Behaviors of plausibility, cues, and retrospection in the sensemaking process of learning and doing data analytics type work?

2.2.2. Factors of dynamic sensemaking

In their summarization of the literature, Sandberg and Tsoukas (2015) posit sensemaking is a process constituted by efforts. The process of sensemaking is iterative which involves moving from uncertainty to ambiguity to coherence (Rerup & Feldman, 2011; Weick, 1995). Factors that contribute to changes in the sensemaking process will be a person's understanding of the cues generated by the event, what kinds of attention are given to actions and cues, and determining how close they are to a plausible outcome (Weick & Sutcliffe, 2006; Weick et al., 2005; Weick, 2006). Central to this process is the kinds of retrospective attention given to bracketed cues and diagnostic actions aimed at gaining clarity because uncertainty and ambiguity are barriers to achieving coherence (Weick, 1995). The following examines the kinds of attention retrospectively given to cues that are acted upon to overcome uncertainty and ambiguity in order to better understand how sensemaking changes over time.

Events requiring sensemaking generate equivocal meanings leading to uncertainty or ambiguity (Weick, 1993, 1995). The distinction is important because the retrospective attention given to cues and plausible outcomes are derived from either the sensemaker's uncertainty or their ambiguity about the event's consequences (Weick, 1993). The consequences of a sensemaker's uncertainty of the problem means the difference between gaining coherence or generating results that are thin or misleading (Weick, 1990, 2010).

Uncertainty is a state by which a person is ignorant of how to interpret the equivocality created by an interrupting event (Weick, 1995). They are uncertain of the consequences that may result from their actions (Weick, 1995). Under conditions of equivocality that result in unusually stressful situations, applying previously learned skills is a default action (Weick, 1990). For situations of uncertainty, therefore, a person needs small doses of added information by taking small steps followed by evaluating iterative outcomes (Weick, 1995). A person or group's uncertainty resulting from an event's equivocality may also be rooted in the frames a person or group uses in defining the nature of an event (Magala, 1997; Weick & Sutcliffe, 2003; Weick, 2006). In Weick (2006) investigation of the Space Shuttle Columbia tragedy, he found that uncertainty of events could be imposed by how individuals or organizations define events requiring attention. The label of in-family versus out-of-family events contributed to NASA interpreting the issues not as novel, but within experience. In-family issues were narrowly defined problems that the organization had confronted and experienced. At issue with the Columbia accident is the problem did not entirely fit the definition of in-family but the phenomenon of falling debris was forced into that category. Thus, any cues that NASA engineers wanted to investigate were seen as impeding a successful launch and mission. A lack of understanding equivocality from interrupting events can result from using narrow definitions leading to a failure in defining outcomes to gain coherence (Weick & Sutcliffe, 2003; Weick, 2006). The best approach to overcoming uncertainty in the sensemaking process is to add small amounts of information at incrementally small steps. This is what the NASA engineers wanted to extract in information from the example above.

Ambiguity means the sensemaker is confused by the many meanings of the event (Weick, 1995). They have the knowledge to understand (Weick, 1993, 1995) but the multiplicity of meanings causes confusion (Weick, 1995). Under this situation, a person notices and brackets cues, and proceeds to act on those brackets with the aim of reducing ambiguity (Weick & Sutcliffe, 2006; Weick, 1995). A sensemaker then retrospectively determines their being closer or farther from coherence. When a person is facing ambiguity they do not need additional information because this will not resolve misunderstanding (Weick, 1995). Because the sensemaker is confused by too many meanings, adding additional information may contribute to more meanings and therefore more cues to notice and bracket. Rather, they need rich information that contributes to reduc-

Table 1
Summary of sensemaking properties for exploratory case study method.

Plausibility represents the creation of practical solutions to unstructured and intractable problems. It is the need to explain the situation and/or find resolution. (e.g. outcome, direction, decision support). (Weick, 1995)
Cues represent evidence, partial outcomes from actions, and discoveries of data pieced together. They can be signals that are helpful, or noise that detracts from a solution. (Weick, 1995) Sensemakers filter out noise from meaningful signals in the data they are analyzing to develop plausible outcomes. (Weick et al., 2005)
Retrospection represents the kinds of attention given to cues and plausible outcomes. Retrospective activities interpret and evaluate actions taken on bracketed cues and development of plausible outcomes. Sensemaking involves using existing templates applied in the past that have worked or not worked because we tend to know what we have done once we have done it. (Weick, 1995)

ing confusion (Weick, 1995). Specific types of rich information in the form of face-to-face interaction and verification with others on the direction of the sensemaking process are essential to remove confusion (Luscher & Lewis, 2008; Weick, 1995). Other forms of rich information include meetings; debates; open discussions; brainstorming sessions; and regular follow-up conversations (Weick, 1995). All of these rich forms of information create the setting to ask questions because the sensemaker(s) do not have a clear idea of which interpretations to make of the event (Blatt, Marlys, Sutcliffe, & Rosenthal, 2006; Weick et al., 2005; Weick, 1995). In other words, the sensemaker needs verification or clarity in addition to their retrospective learning. Integrating rich information with retrospective activity provides the sensmaker greater clarity about the outcomes they seek to achieve during each iterative cycle of the sensemaking process.

A feature of the sensemaking process described above in dealing with states of uncertainty and ambiguity is that iterative stages of gaining clarity are the result of actions and the attention given to salient cues (Rerup & Feldman, 2011; Vlaar, van Fenama, & Tiwari, 1996; Weick, 1995). Each iterative process in sensemaking generates iterative outcomes that serve as feedback about the feasibly of attaining a labeled plausible goal (Klein, Moon, & Hoffman, 2006; Sandberg & Tsoukas, 2015). In other words, the feedback of iterative outcomes on the sensmaker determines "how close am I to attaining plausible meaning I've labeled as a goal?"; "Am I to far from the plausible goal?"; "Am I any closer?" (Weick, 1993, 1995) The kinds of attention given retrospectively to acting on bracketed cues is derived from iterative outcomes (Weick, 2005). Taking action on cues means the sensemaker had faith in the cues bracketed (Weick, 1995). Any results will either confirm the action was appropriate, the action takes the sensemaker further from clarity, or the action was meaningless in the eyes of the sensemaker. The attention given to the result of actions and bracketing cues is largely determined by getting closer to achieving plausible outcomes (Weick, 2006). The process of retrospectively evaluating iterative outcomes is important since plausible solutions are tentative and will continue to be refined over time. Iterative outcomes from the sensemaking process serve as critical feedback by which kinds of attention are retrospectively directed to cues for additional enactment (Weick et al., 2005; Weick, 1995, 2007).

Within the literature there are processes describing sensemaking as primarily at the individual level and less so at organizational level (Maitlis & Christianson, 2014; Weber & Glynn, 2006). There are, however, few instances in the literature of defining and labeling iterative stages about sensemaking (Gephart, 1993; Gioia & Chittipeddi, 1991; Gioia et al., 1994; Maitlis, 2005; Rerup & Feldman, 2011). Sensemaking as described in the literature focuses on an ongoing process that eventually leads to an outcome attained, (Gioia & Chittipeddi, 1991; Luscher & Lewis, 2008) or there is a collapse in sensemaking, (Weick, 1993) or sensemaking is stuck in a loop without moving forward (Weick & Sutcliffe, 2003; Weick, 2010). The literature, however, identifies states of sensemaking as follows: uncertainty, ambiguity, and clarity. In between ambiguity and clarity, the literature describes that equifinality is narrowed down to achieve clarity.

Since the attention given to cues and iterative outcomes are central to retrospective activities, identifying the nature of iterative cycles within the sensmaking process would provide an understanding of how sensemaking changes as it moves from uncertainty to clarity. This would be useful in understanding the learning processes associated with doing data analytics tasks for purposes of teaching. As such, the following research question aims to link sensemaking properties, identified SM-behaviors and states of sensemaking.

Research Question 2: How do sensemaking properties of plausibility, cues and retrospection change over the course of learning and doing data analytics tasks?

Fig. 1, my interpretation of sensemaking, represents a model for the second research question. It also provides a model of the sensemaking process derived from the above accounts of the literature. Included with the figure are numeric legends describing the flow of arrows linking the relationships between the sensemaking properties. The figure serves as a guide that summarizes the sensemaking process described in the "Findings" section. It will also be used to summarize the study in the "Discussion" section.

3. Methods

Yin (1994, p. 13) defines a case study as:

"...an empirical inquiry that (1) investigates a contemporary phenomenon within its real-life context, and (2) when the boundaries between phenomenon and context are not clearly evident."

As a research method, case studies offer an approach to examining the "why" and "how" of research questions (Yin, 1994) in addition to identifying phenomena or defining characteristics of a particular study (Creswell, 1998). What follows is the context of this case study; data collection approaches; and data analysis methods.

3.1. Case study context

This case study documents a business analytics course for accounting majors (seniors) that involved a project engagement with a Colorado microbrewer. These project engagements with the microbrewer are ongoing each year during the spring semester. My observations of the students each year prompted me to document their experiences and processes. I

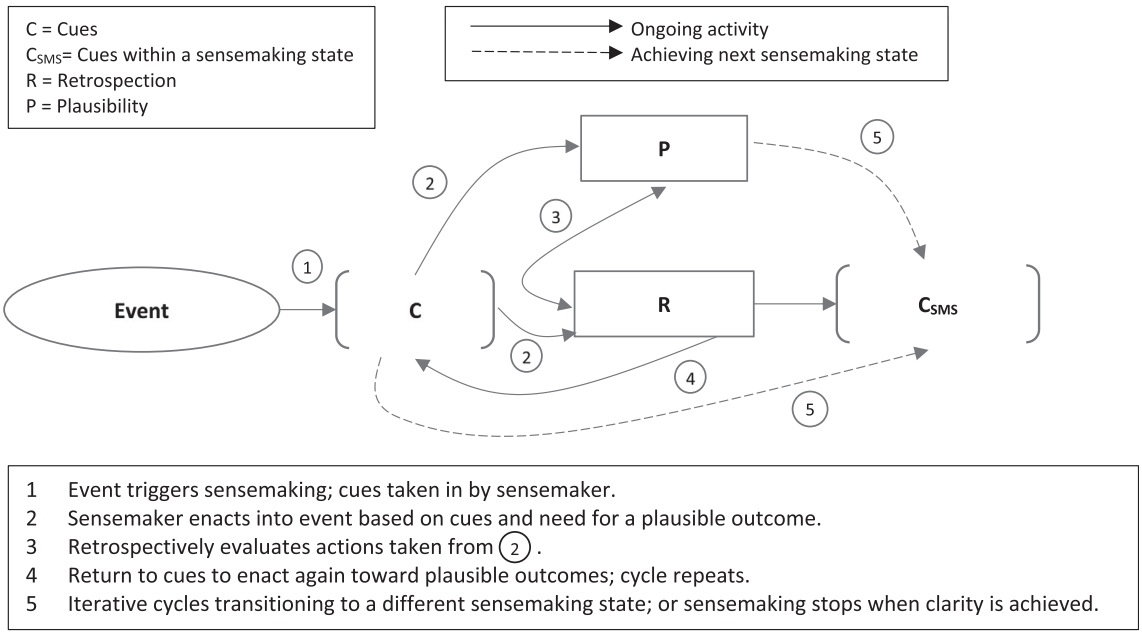


Fig. 1. Sensemaking process iteration model.

selected a sensemaking perspective since my conversations with students' experiences resonated of sensemaking characteristics. These projects provide a qualitatively different pressure to perform on students than do book problems, case studies, and simulations (Chmielewski-Raimondo, McKeown, & Brooks, 2016; Dombrowski, Smith, & Wood, 2013) and as such, the project served as a type of "interrupting event" that triggers sensemaking.

Collaborating with the university for four years and in business for six years, the enterprise continues to grow in revenues with distributions statewide to all major cities, ski resorts, and vacation towns in Colorado. Facility space for production has increased, new beverage lines are regularly developed, and a reliable supply chain is being established.

The class was divided into five teams with three members per team. This provided a manageable set of students for teaching purposes. Below is the client's request during the field trip:

> "Find something in all this data that is relevant. What's the pattern of sales in my beverage lines and what isn't moving? Which lines are profitable and where? Do I expand in production or new labels or both or scale down?"

The above reflects in part the nature of working with data: data needs to be analyzed and patterns need to be interpreted (Duguid & Seely, 2002; Viaene & Van den Bunder, 2011). The project provided a rich learning experience in dealing with uncertainty, unstructured data, incomplete information, and opportunities to apply theory and know-how (Riley, Cadotte, Bonney, & MacGuire, 2013).

Microsoft Excel and IBM Watson Analytics, a cloud based, smart data analysis and visualization tool, were the primary analytic tools used. Table 2 displays an overview of the engagement's data characteristics.

Table 2
Engagement project elements and data variables.

Engagement project elements
4 week project
Data set in Excel: 25,000 + rows and 9 columns
Engagement project data variables
Statewide distribution sales report by price and cost
Multiple product lines (labels or brands)
• 4 flagship brands; 6 secondary brands; 3 additional minor or seasonal brands
Multiple packaging:
• Bottles—Bombers 22 oz.; sold as singles
• Bottles—4-pack 12 oz.
• Cans—4-pack 12 oz.
• Kegs—1/6 kegs and 1/2 kegs
Multiple outlets:
• Liquor stores, pubs, tap rooms, restaurants, warehouse liquor outlets, grocery stores
Multiple geographical statewide locations:
• Cities and regions

3.2. Data collection

Three sensemaking properties of cues, retrospection, and plausibility were the focus of the case study. Because the sensemaking process is highly integrated, studies of it typically do not isolate any of the variables but rather describe the sensemaking process by discussing all or some of the sensemaking properties. However, within the context of learning and doing data analytics work, this study aims to: (1) identify behavior qualities of the selected sensemaking properties; and (2) explain how the sensemaking changes over the course of an interrupting event. Examining the three sensemaking properties allows for a feasible and flexible case analysis while still incorporating any of the other properties as needed.

Weekly survey questions, weekly progress reports from each team, and weekly field observations by the professor were the methods used to capture the characteristics of each sensemaking property. Table 3 exhibits the data collection instruments and their primary purpose.

3.3. Data analysis

Pattern-matching the coded qualitative data was employed for analysis. Pattern-matching is the technique of matching captured data to defined construct characteristics (Guangming, 2007; Yin, 1994). Weick (1995) descriptions of sensemaking serve as the primary source for pattern-matching analysis of data (Creswell, 1998; Yin, 1994). The following Tables 4–6

Table 3
Data collection methods and purpose.

Source	Purpose	Format & collection method	Research question link
Weekly survey	Asking the questions each week provides a candid history of data trends that could reveal Sensemaking properties, learning processes, and learning attributes and outcomes as the project progresses. Students did not know each question was linked to a sensemaking property.	Open ended questions using Poll Everywhere The same three questions were asked each week, at the end of class for the week.	Question on plausibility: *What do you hope to achieve for the client through this consulting engagement?* Question on cues: *What do you need to know for this week to move forward with this project?* Question on retrospective: *What have been your points of reference (anything) that have provided guidance and given structure to this project?*
Weekly progress reports	Collect detailed information on student progress, reflections on work, approaches to dealing with immediate problems with the project, issues that surfaced over the week, and insight on priorities/goals of the group for the week.	Weekly reports in word document submitted each week.	Research question 1: Trends on attempts at defining outcomes; wrestling with the data; reflecting on lessons learned. Research question 2: Compare weekly reports by week for changes in sensemaking properties.
Field observations	Attain data on professor's observations of students Sensemaking process.	Observations documented quickly on paper/laptop during class and immediately after class while memory was still fresh.	Research question 1: Observe defining outcomes or needing to define outcomes (Plausibility); processes of working with the data (Cues); reasoning through the process; learning from mistakes (Retrospective). Research question 2: Compare weekly observations to identify changes in sensemaking properties

Table 4
Descriptions of the cues property.

Property description for data analysis	Reference	
Find starting points to develop a sense of the project and purpose	Weick (1995)	Uncertainty
Search, scan, notice	Weick et al. (2005)	▲
Find frames and context	Weick et al. (2005)	
Bracket, categorize, & make distinctions	Weick (1995)	
Findings link to ideas	Weick et al. (2005)	
The abstract and concrete construct each other	Weick (1995)	
Find concealed differences	Weick (2007)	
Data points/findings become a point of confirmed reference	Weick (2007)	▼
Findings are embellished, developed	Weick (1995)	Clarity

Table 5
Description of retrospective property.

Property description for data analysis	Reference	
Values and preferences are needed	Weick (1995)	Uncertainty
Direct attention to experience	Weick (1995)	
Define meaning early in the project	Weick (1995)	
Discovery based on looking back	Weick (1995)	
Conscious of what was done	Weick and Sutcliffe (2006)	
Responses in past experiences	Weick and Sutcliffe (2006)	
Realized outcomes shape actions and work	Weick (1995)	
Successful/unsuccessful outcomes after action	Weick et al. (2005)	
Generating ideas and giving them structure	Weick and Sutcliffe (2006)	
Set aside categories that are not classified/grouped	Weick (2007)	
Order, clarity and rationality signal the end of retrospective activities	Weick (1995)	Clarity

Table 6
Descriptions of the plausibility property.

Property description for data analysis	Reference	
The need to sense or identify coherence in the problem	Weick (1995)	Uncertainty
What is happening? What actions should we take?	Weick et al. (2005)	
Needed templates to apply are not immediately discernable or available	Starbuck (2009)	
Seeing beyond what is in front	Weick (1995) and Weick (2007)	
Find the interesting, attractive, appealing	Weick (1995)	
Conjecture based on fragments	Weick (2006)	
Experiment various options aiming at solutions	Weick (2006)	
Build possible outcomes: practical, reasonable, creation, invention	Weick (1995)	
Build ideas with enough certainty.	Weick (1995)	
Outcome fits, though maybe imperfectly	Weick (1995) and Weick et al. (2005)	
Speed reduces accuracy as a priority creating tension	Weick (1995)	
Sufficiency	Weick (1995)	Clarity

exhibit descriptions of each sensemaking property used for purposes of pattern-matching. The descriptions are displayed in the order they generally take place during sensemaking proceeding from uncertainty to clarity.

Data analysis proceeded with reading all the survey responses, weekly reports, and observations. Analysis of coding commenced with research question one. In order to find SM-behaviors, I first needed to identify the sensemaking properties in the data set. I applied open coding (Corbin & Strauss, 1990; Saldana, 2016), a process used to identify themes, in this situation the sensemaking properties, within the surveys, weekly reports, and observations (Kets de Vries & Miller, 1987). The most important aspect of analysis at this stage was to identify salient qualities of the sensemaking properties being manifested in the data set (Corbin & Strauss, 1990; Saldana, 2016). Following this procedure, themes were refined by entering the data into text analysis software that generates both key words and context collocates. The text analysis software was used frequently in addition to my own coding and analysis for both research questions throughout the case data analysis process (Saldana, 2016).

For research question one, coded themes for each property were identified using Tables 4–6 (Corbin & Strauss, 1990; Kets de Vries & Miller, 1987). Based on the sequence of moving from uncertainty to clarity for each sensemaking property, SM-behaviors were identified by re-reading and analyzing the data sets. Coded data matching the descriptions on Tables 4–6 were then allocated into categories (Saldana, 2016; Yin, 1994). The categories resulted in identifying SM-behaviors for each sensemaking property. Categories were then refined and labeled resulting in the final SM-behaviors described within the Findings section below.

Axial-coding, analyzing data through a central phenomenon or concept, (Corbin & Strauss, 1990) was a subsequent analysis after the open coding for purposes of examining the second research question on how sensemaking properties changed over time. The central concept used here to axial-code was Weick's description of the retrospective processes as being the kinds of attention given to cues and iterative outcomes during sensemaking (Weick, 1995). The importance of each iterative outcome of students moving from states of uncertainty to clarity in sensemaking emerged as critical to research question two.

SM-behaviors identified for each sensemaking property in research question one and the axial-coding of retrospective attention, contributed to matching the sensemaking states (Saldana, 2016). Weick (1995) descriptions of "uncertainty" and "ambiguity" were matched to the appropriate SM-behaviors matching those descriptions. For "equifinality" (i.e., multiple paths to a solution) and "clarity", I matched the remaining SM-behaviors to each in a similar manner. Appendix A exhibits the results of the data analysis generating SM-behaviors and sensemaking states.

4. Findings

Research question one aimed at identifying SM-behaviors for plausibility, cues, and retrospective activities. SM-behaviors are signposts indicating the nature of activity a student is engaged in and therefore helpful in teaching students data analytics tasks. SM-behaviors are presented below for each sensemaking property using brief descriptions of students' efforts. The order of each behavioral quality generally represents the order students engaged in that behavior during the project.

4.1. Sensemaking behaviors of cues, retrospection, and plausibility

Analyses of the data yielded behavior qualities for each of the sensemaking properties. Cues are as follows. (1) Students filtered through cues (data variables) in the project attempting to decipher what was relevant and what was not. Efforts in filtering cues were most intense at the onset of the project when they attempted to grasp the meaning of the project data. (2) Classifying relevant cues followed the filtering process. Classifying cues into groups such as data patterns, connections between data variables, or separating data sets into categories prompted interpretation of the data set. (3) Comparing classified cues resulted in determining which cues were most relevant to plausible findings the students would pursue. (4) Based on the process of comparing a final set of cues, the students defined that set to support their plausible findings.

Retrospective SM-behaviors were linked to iterative processes. The reasoning for this link is that sensemaking iterations—attention given to cues and plausible outcomes—aim at reducing uncertainty or ambiguity (Weick, 1995). Retrospective behaviors focus on evaluating the outcomes of the sensemaking iteration process in order to gain clarity on what to do next. (1) Prioritizing is a retrospective behavior used to determine the next steps in working with cues and developing plausible outcomes of the project. This behavior was most prevalent at the onset of the project. (2) Recalling how one dealt with previous projects provided guidance or constraints to evaluating cues and plausible outcomes. Retrospective recalling was also giving attention to recent iterative processes and outcomes. (3) Students also rationalized in determining which cues would be used to validate plausible findings that would provide meaning to their analysis. (4) Clarity was the signal that retrospection and sensemaking ended. Each retrospective behavior is a mode of evaluation with the task of determining whether iterations resulted in constraints or in clarity towards a plausible outcome.

Behaviors for plausible outcomes were categorized in tandem with cues. The rational for pairing plausible behaviors with cues is that the later represent the datum, which over iterative processes, forms the validation of plausible findings for the project. Behaviors of plausibility are categorized into four areas. (1) Experiencing multiple meanings from the data set prompted experiencing the need to find a solution (i.e. a plausible meaning) useful to the business owner. A plausible outcome provides meaningful frames of how cues are filtered, classified, and compared. Students traversed through the project data to find meaning from the cues they were filtering. Traversing, therefore, is an apt description of a plausible behavior. It represents the urgency of finding meaning in the data, which should lead to reliable and useful outputs for the client. (2) Upon going through actions to achieve an early understanding of the project data, students began to see a variety of possible goals that could lead to both a meaningful analysis of the data and findings for the client. Seeing possibilities coincides with the process of classifying meaningful cues. (3) By week three, most groups were elaborating plausible findings by comparing the most relevant cues in the data. (4) At project end, students validated their plausible findings by forming reports and a formal presentation to the client.

4.2. Changes in sensemaking properties

For the second research question, changes in sensemaking properties stem from changes in SM-behaviors. For instance, filtering cues is a different behavior than comparing cues; seeing possible plausible targets to analyze is different from validating a final plausible set of findings. As such, sensemaking properties exhibit different behaviors over the course of the process. The kinds of attention (retrospection) given to cues and plausible outcomes from iterative cycles drives the behavioral changes in each of the sensemaking properties. What follows is a description from the aggregate data findings.

4.2.1. Week one: uncertainty and equivocality

Uncertainty characterized the students' sensemaking situation. They did not have the knowledge or context to discern the equivocal meanings found in the project data. They knew the project data was sales of beverage lines, but the format, variety of variables, and interrelatedness of the data remained enigmatic to them. Attempting to ascertain plausible meaning in the data characterized students' sensemaking the first week.

Students' retrospective behaviors of prioritizing tasks and recalling previous experiences with projects were applied to their current situation. Adding to their state of uncertainty students also lacked the templates for action (Weick, 1995) to initially confront the project. This exacerbated matters such that students were uncertain of the consequences that would result by working with the data. Finally, the data set's variables were different and the data structure was different. It did not resemble the traditional accounting report or schedule format of which students were accustomed.

Students created the constraints they would have to deal with in their current state of uncertainty. This will be an ongoing issue, but more so in the early stages of the project. Add to that, because students experienced the need to do something they defaulted to what felt familiar (Weick, 1990). For instance, when the students received the data set they attempted to load it into the analytics software and assume the output would readily be useful and easily interpretable. The outcomes of this iteration did not provide useful output. Furthermore, students lacked the knowledge and practice to interpret the output. More important at this state, the project data needed to be reformatted and cleaned. In this situation, the students created barriers to gaining an understanding of the data set and developed early assumptions about the usefulness of the analytics program. Additionally, if any patterns were identified, they were false leads because the data had not been adequately cleaned and formatted for the analytics software.

For two weeks students took small steps in reformatting sections of the project data followed by reentering it into the analytics software. They incrementally learned what certain data variables meant (e.g. industry measurements). Iterative results became increasingly coherent, but still incomplete. In summary, their iterative processes were characterized as uncertain and equivocal yet moving into ambiguity.

4.2.2. Week two: ambiguity and equivocality

In week two, students were still preoccupied with filtering the project data in an attempt to grasp meanings and patterns. While filtering cues, students also took steps in determining the meaning of the variables by becoming familiar with measurements and conversion charts used in the brewing industry, the variations in packaging (bottles, cans, kegs), and distribution channels that spanned liquor stores, restaurants, tap houses and grocery stores. Retrospectively, students were still prioritizing work in cleaning the data (traverse) and noticing cues about the data variables (filtered then classified). There was a greater focus, though, on retrospectively evaluating the outcomes of their current actions. Having variables from the data set defined allowed for meaningful bracketing of cues leading to classifications. Once cues were classified into groups, this lead to iterative outcomes where uncertainty diminished and plausible outcomes became less abstract. Students began to see possibilities for project goals such as sales in ski resorts, sales by brand in regions, sales by major city, and differences in packaging by venue or brand, all of which were related to profitability and cost behavior.

Iterative cycles from the sensemaking process resulted in shifting away from uncertainty and moving into a state of ambiguity. For most groups (differences discussed below), the problem of too many meanings at this stage translated into confusion. Whereas equivocality under uncertainty meant students could not understand few if any of the meanings in the data, equivocality under ambiguity meant students began to recognize meanings in the project data. The issue at this stage is they were confused by the cacophony of meanings. Retrospective attention to cues was less on sifting out noise than on finding meaningful classification of cues. Attention was also given to identifying plausible outcomes now that meanings were recognized in the data. In summary, Iterative outcomes moved away from uncertainty to ambiguity. Meanings in the project data were recognized but there were too many to comprehend.

4.2.3. Week three: equifinality

Students' state of sensemaking moved from ambiguity to equifinality. Recognizing plausible outcomes such as ski resort sales patterns and other data findings prompted students to give attention to cues and plausible outcomes differently. Specifically, there were multiple paths to achieving a set of findings.

By week three, students were reducing the variety of plausible findings they could finalize. Their iterative outcomes from week two were being re-examined with behaviors of filtering and classifying, but with the goal of comparing groups of data that would support plausible results. Additionally, retrospective activity was rationalizing how to incorporate data comparisons into a few plausible findings.

It is important to recognize that while sensemaking properties were changing, certain behaviors were still a part of the iterative process. The purpose of the behavior, however, had changed given the kinds of retrospective attention given to them. For example, filtering was still a behavioral characteristic of cues into week three, but with a different purpose. Filtering received retrospective attention in order to support the elaboration of a final plausible outcome. Students were focusing their analysis to relevant data variables and their connections to each other. In weeks three and four filtering served the purpose of narrowing and justifying a plausible target compared to weeks one and two where the purpose of filtering was to acquire a basic understanding of the project data.

In part, rationalizing behavior was stimulated in week three since only one week was left to complete the project. As we will see later in discussing group differences, all groups were generally at this stage in week three but at different qualitative levels of clarity. To summarize, iterative outcomes in week three transformed from ambiguity to equifinality of possible outcomes. The process of minimizing approaches to a narrow set of potential results of the project were the priority.

4.2.4. Week four: clarity

For weeks three into four, the primary constraint faced by the students is that regardless of the plausible findings each group was targeting, time was limited, and therefore restricted the potential of more insightful findings. Students focused on validating final plausible findings in the fourth week. Retrospective activities also ceased with the achievement of clarity and validated plausible findings.

4.3. Group differences and sensemaking dynamics

The above provided aggregated findings for all of the student groups working on the project. What follows is a summary of each group with differences highlighted in the sensemaking process based on the kinds of retrospective attention given to cues and plausible outcomes. Each group is labeled to reflect the nature of their sensemaking processes.

4.3.1. The focus group

The focus group started the project with a plausible outcome they defined in the first week. This group's sensemaking process followed a sequence of ensuring they were closer to their specific target of scaling down operations. Because retrospective attention given to cues and plausible outcomes was highly influenced by the frame of scaling back brands, this set in motion a sequence of sensemaking activities having fewer iterative cycles than other groups. The target of scaling down brands provided narrower questions of what the group was asking of the data. This is a viable approach in practice, particularly under time constraints.

Though the desired results of the project were clear for the group, they still had to wrestle with uncertainty in the first week. The project data imposed multiple meanings on the group of which they had little knowledge to interpret. The goal established early in the first week was the frame used to filter cues. Only data relevant to verifying their goal resulted in those cues being noticed and bracketed. Since a plausible finding was set, classifying and comparing cues were evaluated based on supporting the reduction of slow moving brands. Retrospective behaviors were driven by the question of "how can the group support an argument to scale down minor brands with low sales?"

By week three, the group was well on its way to elaborating which brands to be reduced and in week four their final results were completed. One set of findings by the group was to remove all minor brands from production. This was impractical from the client's standpoint. Another finding of the group recommended that some minor labels be offered seasonally. This positively resonated with ideas the client had been entertaining.

4.3.2. The exploring group

Curiosity and creativity characterized this group of students. Their willingness to explore the data at a wider range than the other groups resulted in their findings to be more interesting and catching the client's attention.

Uncertainty also characterized this group's experience when starting the project. Though they did not have the knowledge to comprehend the multiple meanings hidden within the project data, they started by finding what was interesting. Filtering the data to reduce iterative cycles of uncertainty was still a priority but envisioning plausible outcomes was dependent on identifying interesting data patterns. Discovering interesting findings in the data influenced retrospective attention to cues and plausible findings. This process also generated more iterative cycles compared to the other groups. Iterative cycles during a state of ambiguity lingered into week three because interesting findings created a dilemma of which plausible findings to pursue. Rich information in the form of dialogue and debate was used to focus on a plausible set of findings.

By the end of week three, attention given to cues and plausible outcomes were concentrated on filtering, classifying and comparing in order to narrow their findings for the client. The creative iterative outcomes yielded insightful findings for the client. Additionally, students gave careful attention to diagrams supporting their analysis. The client eventually incorporated part of the group's findings and repackaged a minor brand as a limited offering each year in an attempt to boost sales statewide. This minor label had high sales in only one region of the state and was therefore still important to the client.

4.3.3. The diligently cautious group

Research data for this group consisted of combining two groups as they both exhibited similar approaches in sensemaking through the project. This group's type of retrospective attention was influenced by their inability to move from iterative outcomes during their state of ambiguity. Iterative cycles centered on repeated sequences of filtering and classifying cues of largely all the data for nearly three weeks in an attempt to deal with ambiguity and decide on a set of analysis targets to pursue.

Much of their efforts were circular because their plausible goals changed in weeks two and three. This was primarily from an inability to move out of being confused by too many meanings in the data set. The group attempted to learn what each variable meant at once rather than in small steps (measurements in the industry, how packaging equates to different measurements). This created the need to simplify the project by focusing on broad targets (e.g. total sales in a ski resort). They were diligent, but a different quality of information—rich information—would have served better to overcome ambiguity and identify a plausible outcome. Essentially, the group was trapped in a state of ambiguity. Selecting a very broad target was a way of simplifying or avoiding ambiguity.

Part of the difficulty in the group was a lack of communication. The members got along, but communication of who was doing what and meeting times were unclear. This social property of sensemaking is important as will be highlighted with the next group. They needed to discuss, debate, and question how to manage multiple meanings in the data and begin focusing on a plausible set of findings. Interestingly, the group finalized their findings, but did so out of expediency and focusing on what seemed a most feasible and plausible outcome for the project. This resulted in very broad findings of which the client already knew.

4.3.4. The uncertain group

This group was always in a state of uncertainty. They completed the project the last minute by forcing the data to support a final solution. There were three factors that affected the group's inability to move out of the iterative outcome of uncertainty: (1) group members were rarely together in class working on the project; (2) they never met outside of class time to work the project; (3) group members promised work outcomes but did not deliver or complete their tasks. Uncertainty shaped the retrospective attention given to cues and plausibility. Specifically, retrospective attention given to cues was primarily on working to prepare the data for the software well into week three in an attempt to attain the "right" output from the software. Few iterative cycles with the software were attempted. Additionally, any analysis work on filtered cues in the first two weeks was repeated by other members or incomplete.

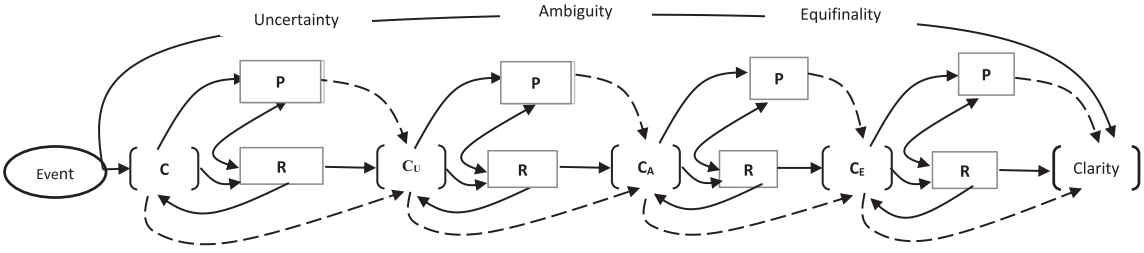
Teaching this group was particularly challenging because all members were never present in class nor visited during office hours. Any recommendations or guidance provided to members present in class was never communicated to absent members. If the group had been in class and met outside of class they could have taken small steps and gradually found patterns in the data set. Last minute efforts of completing the project resulted in forcing validated findings the final week of the project. The client immediately recognized this and found the findings lacking relevance.

5. Discussion

The purpose of this paper is to gain a better understanding of teaching data analytics to accounting students. To do this a sensemaking perspective was used to capture student-learning activities. This resulted in identifying sensemaking behaviors and how sensemaking behaviors change over the course of learning and doing data analytics tasks. The following sections below provide a summary of students' sensemaking states during the weeks of the project, along with suggestions for faculty to consider as they work with students engaged in data analytics projects. A summary of aggregated results are summarized in Fig. 2. SM-behaviors are listed in priority of importance at each stage for uncertainty, ambiguity, equifinality, and clarity. Fig. 2 may also be reviewed in tandem with Table 7 in Appendix A in relation to the discussion below.

5.1. State of uncertainty and sensemaking behaviors

The first two weeks of the project posed a significant challenge to the students. Uncertainty characterized students' sensemaking state. At this stage in the project, equivocality, the multiple meanings in the data, were largely incoherent to the students. They had difficulty envisioning what their actions would result in and were also ignorant of how the diversity of data variables were related. This type of uncertainty coupled with managing complex problems is also found in business simulations that provide occasions for developing practical and resilient skills (Riley et al., 2013). Actions students eventually took created both the constraints, opportunities and raw materials they would have to cope with for the remainder of the project.



Behaviors & uncertainty	Behaviors & ambiguity	Behaviors & equifinality	Behaviors & clarity
Cues • Filtering	Cues • Classifying • Filtering	Cues • Comparing • Classifying • Filtering	Cues • Defining • Comparing
Plausbility • Traversing	Plausbility • Seeing Possibilities • Traversing	Plausbility • Elaborating • Seeing Possibilities	Plausbility • Validating • Elaborating
Retrospective • Prioritizing	Retrospective • Prioritizing • Recalling	Retrospective • Rationalizing • Recalling	Retrospective • Clarity • Rationalizing

C_U = Cues under uncertainty | C_A = Cues under ambiguity | C_E = Cues under equifinality

Fig. 2. Sensemaking behaviors and sensemaking state.

Creating constraints and opportunities resulting from student actions was a persistent learning opportunity throughout the project and is a fundamental quality of sensemaking (Blatt et al., 2006).

5.1.1. Teaching considerations—uncertainty and sensemaking behaviors

- Allow failure and additional experimentation. Many outcomes may be unfruitful.
- Aim to provide optimal feedback for the groups as they experiment with the data. Incremental small steps in experimenting will be helpful for students to see how consequences pan out given their state of uncertainty. (e.g. adding data, definitions, meaning of variables, etc.) and by analogy a type of scaffolding (Abraham & Jones, 2016).
- SM-behaviors will favor filtering, traversing (trying to see a plausible goal), and prioritizing or attempts to prioritize tasks.
- Students may need guidance on identifying the most promising iterative outcomes.

5.2. State of ambiguity and sensemaking behaviors

In weeks two and into three students started to recognize patterns in the data and see possible targets to pursue in their analysis. However, while students were able to begin interpreting parts of the data, there were too many meanings to decipher which lead to confusion. In essence, they were overwhelmed with options of what to pursue as a viable analysis target. Signposts of moving from uncertainty to ambiguity is that students are not preoccupied with filtering cues and traversing towards a type of outcome. Rather, their attentive actions are on classifying data sets into patterns that point to a series of plausible insights about the data. The main struggle is deciphering which target to pursue because the variety of meanings in the data set are intertwined.

5.2.1. Teaching considerations—ambiguity and sensemaking behaviors

- Continue encouraging experimentation and exploration but within the frames of identified plausible outcomes and categorized data patterns.
- Encourage rich information exchange: Asking questions, comparing alternatives, and discussing with others what tasks will be driving the next stage of data analysis. This rich information exchange serves to deepen learning for accounting students (Lucas, 2001) which contributes to higher level skills essential in a changing environment (Sawyer & Tomlinson, 2000).
- Multiple behaviors are being applied at this stage. Sensemaking behaviors favor classifying cues into groups, seeing possible findings to pursue, and recalling iterative cycle outcomes from experimenting.

Some groups may require direct guidance in minimizing the plausible outcomes identified if students are still preoccupied with filtering and traversing behavior that highly resembles the first week of activity. For example, are the students filtering the entire data set rather than large components of it? This stage is particularly problematic for students and teacher. Recognizing if the student/group needs rich information versus additional data type information in incremental steps is critical. The instructor can provide critical questions for students to reflect on and be aware of providing optimal feedback (Abraham & Jones, 2016). The difference may result in shallow outcomes or well-defined outcomes (Weick, 1995, 2005)

5.3. State of equifinality and sensemaking behaviors

During week three, the equifinal stage, students were engaged in narrowing the choice of paths to achieving results for the client. In the equifinal state students were still filtering and classifying data sets but limited to only a few (e.g. 1–2) feasible paths to attain their results. Again, all groups had distinct behaviors at this stage, but most were narrowing their findings.

5.3.1. Teaching considerations—equifinality and sensemaking behaviors

- At this point of learning, continue encouraging rich information exchange to minimize options that can be used to attain a plausible outcome. Encouraging discourse, debate, asking questions, and working out feasible paths through open communications stimulates deeper-level learning (Lucas & Leng, 2014).
- Multiple sensemaking behaviors will be applied. Priority behaviors will be comparing a narrower set of data groups, elaborating a more specific set of findings (plausible outcomes) and rationalizing the approach to finalize the project (rich information exchange).
- If students are working in small groups, be aware of them being too preoccupied with individual analysis for long periods of time without substantive rich information exchange. The results at this stage makes integrating the findings of individual tasks more difficult when students are isolated in their tasks.

5.4. State of clarity and sensemaking behaviors

In week four students were finalizing their results and preparing formal reports and presentations for the client. Sensemaking largely had stopped because students had meaningful results. Sensemaking, however, is an ongoing activity. Students were surprised, after their client presentations, that a significant learning outcome they took from the project is how their outcomes were not final but instead lead to additional questions and more targets to further explore and refine.

5.4.1. Teaching considerations—clarity and sensemaking behaviors

- Provide guidance in drafting the report: The purpose of the analysis, findings, and implications for the client.
- Offer practice runs if presentations are required. Interpreting analysis results is challenging.
- When students have completed the assignment, consider discussing future areas of continued analysis from the projects.

As a final discussion note, the findings for this study suggest that faculty will need to be sensitive to student tasks during data analytics projects. They may need to be conscientiously self-aware sensemakers themselves. Sensemaking is a complex process involving many iterative cycles that may result in progress, regress or stasis (Maitlis & Christianson, 2014; Maitlis, 2005). All are learning possibilities that resonate of deep-learning competencies required of accountants in a data driven environment (Sawyer & Tomlinson, 2000; Stanley & Marsden, 2013).

6. Future research

Four areas of future research emerge from this exploratory case study. First, the need to conduct research on students engaged in data analytics tasks that captures the other sensemaking properties of identity, enactment, sensemaking as ongoing, and sensemaking as a social activity. Research in any of these properties would provide additional insights into teaching accounting students data analytics. The following are some research questions regarding the above.

- What are the SM-behaviors for identity, enacting, social dynamics and/or ongoing processes in learning and doing data analytics tasks?
- How do all of the sensemaking properties interact when students are engaged in data analytic activities?
- How can learning data analytics positively shape students' identities as future accountants from a sensemaking perspective?

Second, the difference in unusual interrupting events (Starbuck, 2009; Weick, 1990, 1995, 2005) versus routine events, including complex planned events (Feldman, 2000; Sandberg & Tsoukas, 2015; Turner & Rindova, 2012) offers fruitful research for purposes of teaching and incorporating data analytics into the curriculum. Some relevant future research questions could be as follows:

- What types of existing accounting assignments can be converted into data analytic assignments that have unusual interrupting qualities?
- What types of existing accounting assignments can be converted into a series of data analytic assignments having familiar data and common business problems?

Third, the sensemaking process of progressing out of uncertainty to clarity through iterative cycles is applicable to changes facing accounting students upon graduation. (Lucas & Leng, 2014) Deep learning has a re-evaluation process of one's outcomes from actions as do the sensemaking iterative cycles (Lucas & Leng, 2013; Lucas, 2001) This resembles Fischer (1980) cognitive development and Schenck and Cruickshank (2015) continual learning construct by being exposed to new applicable models based on prior knowledge (Schwering, 2015). The following is a possible future research question in accounting data analytics education:

- How can existing accounting assignments having few if any iterative processes be modified into data analytics assignments that foster iterative cycles?

The fourth issue is on the reliability and relevance of results attained from data analytics tasks. Related to relevance and reliability of analytics information is the skill in asking good questions grounded in skepticism (McKinney, Yoos, & Snead, 2017). These are areas of particular interest to accountants given non-GAAP metrics, internal reporting metrics of success and the rise of independent data analytic tasks fostered by standalone analytics software (McKinney et al., 2017; Riggins & Klamm, 2017). From a sensemaking perspective the following may be applicable.

- What are the criteria by which plausible data analytics findings are both relevant and reliable?
- What are the teaching issues that incorporate professional skepticism and a sensemaking approach in data analytics assignments?

7. Conclusion

The purpose of this paper is to better understand the nuances of teaching data analytics. Understanding how sensemaking and learning data analytics tasks are related sheds light on how the human element will be more important to accounting as analytic tasks and AI are implemented (Dowdell, 2018; Schmidt, 2018; Vetter, 2018). It has described the learning processes of accounting students engaged in data analytics tasks; how sensemaking proceeds from uncertainty to clarity; and is punctuated by behaviors of extracting cues, retrospectively evaluating one's actions and establishing plausible outcomes. Students engaged in the four-week project experienced numerous iterative cycle outcomes resulting in the creation of constraints and opportunities of which students needed to negotiate. This learning process and its outcomes resonate of the American Accounting Association Pathways Commission report on accounting curriculum of connecting mapped competencies (Lawson, Pincus, Sorensen, Stocks, & Stout, 2017). A sensemaking perspective that animates approaches of how data analytic competencies are taught and learned through the integration of accounting disciplines may determine if graduates attain resilient capabilities versus entry-level skills in a Big Data environment.

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Appendix A. Results of data coding and analysis

A.1. Column descriptions for panels A and B

Below, Table 7 exhibits the data analysis results that generated the sensemaking behaviors and sensemaking states. Panel A exhibits the results of the data analysis process described in Section 3.3 of the paper.

- The "SM property description" column lists the characteristics of the sensemaking property found in the literature and corresponds to Tables 4–6 in the body of the paper.
- The "case themes" column is the categorization of coded data associated with sensemaking behaviors.
- The "Behavior for cues", "plausibility behavior", and "retrospective behavior" columns are definitions for each sensmaking property behavior.

Table 7
Finalized data coding results.

SM property description: cues	Case themes	Behavior for ces	Sensemaking states	Reference
Panel A: Sensemaking behaviors and sensemaking states				
Starting points to develop a sense of the project and purpose. Search, scan, notice Find frames and context	There is a need to dive in and work with the data by identifying signal from noise and filter accordingly.	**Filtering** *Just work with the data and filter signal from noise; find a map, anything, in the "data wilderness".*	**Uncertainty** *Simplify the multiple meanings available in the project; establishing a context or frame.*	Weick (1995) Weick et al. (2005)
Bracket, label, categorize, & make distinctions.	Noticing classes, groups, or patterns in the data. Classification serves to provide meaningful & plausible paths, solutions, outcomes, or recommendations.	**Classifying** *Classify, pile or group promising signals to find additional cues towards emerging possible outcomes.*	**Ambiguity** *Classify, categorize, & identify combinations of data that may lead to multiple paths to a few envisioned outcomes.*	Weick (1995) Weick et al. (2005) Weick and Sutcliffe (2006)
Findings link to ideas. Abstract and concrete construct each other. Find concealed differences	Classifications generate narrower targets and paths to plausible solutions. Cues allow adding or comparing existing data sets to confirm paths, solutions, outcomes, or recommendations.	**Comparing** *Confirm ideas that are sound and reasonable; minimize the number of paths towards plausible outcomes.*	**Equifinality** *Evaluate identified data sets/information and decide on a final set of targets to analyze for outcomes.*	Weick (1995) Weick (2007)

Table 7 (*continued*)

SM property description: cues	Case themes	Behavior for ces	Sensemaking states	Reference
Data points/findings become a point of confirmed reference. Findings are embellished, developed.	Comparisons and re-iterations of the data are made to finalize plausible outcomes. Comparing data & patterns that provide a defined set of outcomes (few outcomes or results).	**Defining** *There is a coherent story to the data. Keep what is immediately relevant. Keep data in "bins" for future use.*	**Confirm** *Build a coherent data story or outcomes with an established set of confirmed data patterns and associations.*	Weick (1995)
SM property description: Retrospective	**Case themes**	**Retrospective behaviors**	**Sensemaking states**	**Reference**
Values and preferences are needed. Direct attention to experience. Define meaning early in the project.	A set of priorities (values) are needed. Too much data/ information; requirements are burdensome; multiple meanings of the project. Attempting to make sense of too many meanings.	**Prioritizing** *Priorities are needed to make sense of something that is unclear; there is an urgency to solve.*	**Uncertainty** *Prioritize minimizing multiple meanings by simply working with the data and/or defining a general goal.*	Weick (1995)
Discovery based on looking back. Conscious of what was done. Responses in past experiences.	Drawing from recent memory of past projects; previous courses; current course material; or other related work. Each serves as a template that brings familiarity to the current problem aimed at feasible and plausible outcomes.	**Recalling** *Recent projects, courses, lectures, one-on-one discussions; brainstorming; recent iterative outcomes are given attention to possible outcomes.*	**Ambiguity** *Apply previous templates of learning, projects, decisions, organizing to the project.*	Weick (1995) Weick (2006)
Realized outcomes shape actions and work. Successful/unsuccessful outcomes realized after action. Generating ideas and giving them structure. Set aside categories that are not classified/grouped.	Solutions, experiments, and various paths to outcomes based on recent memory, are reflected upon, tested, placed as a template of meaning over the project results and/or are used to confirm viable solutions, ideas, and additional experiments.	**Rationalizing** *Solutions, ideas, experiments are tried by drawing from/applying past experience templates or professor help.*	**Equifinality** *Experimenting and developing ideas towards final outcomes, recommendations.*	Weick (1995) Weick et al. (2005) Weick and Sutcliffe (2006) Weick (2007)
Order, clarity and rationality signal the end of retrospective activities.	Retrospection stops when order and clarity about the plausible outcome is achieved. Finalizing results via confirming is re-confirmed to finalize plausible outcomes.	**Clarity** *Clear direction to work or complete the project is available. Uncertainty greatly diminished.*	**Confirm** *Create interpretations of the data with clarity and transparency.*	Weick (1995)
SM property description: plausibility	**Case themes**	**Plausibility behaviors**	**Sensemaking states**	**Reference**
The need to sense/identify something. What is happening? What actions should we take? Needed frames not available.	Initial reactions to project reveal the need for filters to reduce the multiple meanings that are signals or noise towards pursuing solution, outcome or recommendation.	**Traversing** *Something needs to be discovered, anything to start.*	**Uncertainty** *Dealing with multiple meanings as a way to define outcomes or targets for the project.*	Weick (1995) Weick et al. (2005) Starbuck (2009)
Seeing beyond what is in front. Find the interesting, attractive, appealing. Conjecture based on fragments; experiment given many paths.	General targets, outcomes, or goals (sales, market, opportunity, location, cost, expense, etc…). There are targets in sight, a start, but which classification of signal or noise leads to promising trails to investigate. There are multiple paths to a solution/outcome/ recommendation.	**Seeing Possibilities** *Something is discovered; hunches are considered; generic targets to get started.*	**Ambiguity** *Realizing multiple paths is possible towards attaining project outcomes or findings.*	Weick (1995) Weick (1995) Weick (2006)
Build on possible outcomes: practical, reasonable, creation, invention. Build on ideas with enough certainty.	Targets discovered need to be developed. Comparisons of classified data lead to multiple paths, but minimizing the number of paths is the priority.	**Elaborating** *Initial targets, hunches, ideas developed. Confirming utility and relevance.*	**Equifinality** *Multiple plausible outcomes; develop findings and patterns in the data; develop story in data.*	Weick (1995)
Outcome fits what we have, imperfectly. Speed reduces accuracy priority. Sufficiency.	Developed results are finalized, compared to verify outcomes, with a narrow set of outcomes, recommendations or solutions.	**Validating** *Concrete targets finalized for recommendation, communication, & application.*	**Confirm** *Create a final set of outcomes or findings for the project.*	Weick (1995)

Behaviors for cues	Student comments from case evidence	Behavior description
Panel B: Sensemaking behaviors and case evidence		
Filtering	*Anything to give more clarity. It's so vague.* *What in the world I'm I trying to look for?*	**Filtering** *Just work with the data and filter signal from noise; find a map, anything, in the "data wilderness".*
Classifying	*Understanding what variables mean.* *What do the columns mean in the distribution report?* *The process of compiling data is slow. . ..* *The process of [restructuring] the data set in Excel for Watson Analytics is burdensome and inefficient.*	**Classifying** *Classify, pile or group promising signals into "bins"; find additional cues that support emerging possible outcomes.*
Comparing	*The biggest breakthrough we had this week was finding multiple ways to plot the data by location.* *After our visit to the Cider facility where we had questions answered by the owner, we came back with an invigorated and clear mind as to what would be valuable.* *. . .. we have started to look at trends and dive deeper into exploring in Watson Analytics.*	**Comparing** *Confirm ideas that are sound and reasonable; minimize the number of paths towards plausible outcomes.*
Defining	*It took a few times talking through the findings to reach conclusions and clear points of analysis.* *We will present three perspectives on the topic of sales behavior—by monthly trends, by major city, and by margin.* *Finding the correct graphics to relay the correct information we are wanting to communicate took a lot of time and effort. We need it to be right/clear.*	**Defining** *Paths and outcomes are defined and finalized. There is a coherent story to the data. Filter out unneeded data; keep what is immediately relevant. Keep data in "bins" for future use.*
Retrospective Behaviors	Student Comments from Case Evidence	Behavior Descriptions
Prioritizing	*Still unsure what direction we are going to take with this project*	**Prioritizing** *Priorities are needed to make sense of something that is unclear; there is an urgency to solve. Attention given to minimizing uncertainty.*
Recalling	*Professor feedback on prior projects, current guidance* *Past experience and projects have helped with what to look for in the data* *CIS 101 has been very helpful for this class and also taking managerial accounting.* *Whatever works in Watson is whatever I pursue further.* *The data from the client, principles from the class, and outside research.*	**Recalling** *Recent projects, courses, lectures, one-on-one discussions; brainstorming; ideas are brought to bear in on focusing towards possible outcomes. Recent iterative outcomes considered to reduce ambiguity.*
Rationalizing	*The biggest breakthrough we had this week was finding multiple ways to plot the data by location.* *Be able to segment the population of regions by county/district.* *Pursuing information by location and purchases over season/months.*	**Rationalizing** *Solutions, ideas, experiments are tried by drawing from/ applying past experience templates or professor help. Verify a final set of results.*
Clarity	*While the judgment of the efficacy of our presentation is ultimately in the hands of the client and the professor, we are pleased with the product of our work.*	**Clarity** *Clear direction to work or complete the project is available.*
Plausibility Behaviors	Student Comments from Case Evidence	Behavior Description
Traversing	*What exactly the client wants from the data.*	**Traversing** *Something needs to be discovered, anything to start.*
Seeing Possibilities	*I hope we can help them understand their market and where opportunity may be.* *Clarity about operational strategies.*	**Seeing Possibilities** *Something is discovered; hunches are considered; generic targets emerge.*
Elaborating	*Provide data that is useful, such as which customers prefer which products.* *Data that can verify previous knowledge or new data that can help them improve operations.* *Blue Ocean markets seem to exist in pockets within the state.*	**Elaborating** *Initial targets, hunches, ideas developed. Confirming utility and relevance.*
Validating	*Profitability for top and bottom cities by label.* *How to scale operation.* *Findings by size and label for locations based on time.* *Sales behavior in "Blue Ocean" markets/regions.*	**Validating** *Concrete targets finalized for recommendation, communication, & application.*

- The "sensemaking states" column represents the state of sensemaking associated with each sensemaking behavior.
- The "reference" column lists literature citations for the "SM property description" column.

Panel B provides case evidence examples associated with sensemaking behaviors.

- The "plausibility behaviors" column lists the behavior for each sensemaking property of plausibility, cues, and retrospection.
- The "student comments from case evidence" lists samples taken from the coded data associated with the sensemaking behavior.
- The "behavior description" column provides a definition for the sensemaking behavior.

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