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PEDAGOGICAL OPPORTUNITIES OF MICROSOFT’S ADVENTURE WORKS BUSINESS CASE AND DATA MODEL

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ABSTRACT

Database management and querying skills are a key element of a robust information systems curriculum. The data structure and content of a useful pedagogically-oriented database should be realistic and lifelike, and the database should contain data that accurately depicts the business processes, functions, and entities of a realistic organization, organized in a way that demonstrates best practices in database design. Most database textbooks include some sample databases, but these are often relatively small and sparse of data. By contrast, Microsoft’s Adventure Works (AW) database presents a robust, realistic, and comprehensive framework for many important educational objectives in an Information Systems curriculum. This paper introduces the AW business case and database, and illustrates several pedagogical uses in an undergraduate CIS program.

Keywords
Database, data warehouse, case study, active learning exercises, curriculum, OLTP, OLAP, balanced scorecard, dashboards, data mining, Web applications.

INTRODUCTION

Database management and querying skills are vital for any respectable information systems curriculum. IS 2010 (Topi et al, 2010) repeatedly stresses the importance of database management and database retrieval as foundational elements of an IS program. IS 2010 also cites the importance of robust database technology and realistic database samples: “Various courses and areas of study have their own specialized requirements, such as the large database with realistic sample data that are needed for effective work in the area of data management (Topi et al 2010, p 389).” Data management is also an important criterion in ABET’s information systems accreditation process (ABET 2014).

A lifelike sample (instructional) database system should contain data that accurately depicts the business processes, functions, and entities of a realistic organization, and organizes it in a way that demonstrates best practices in database design. For a relational database, this implies a structure that maximizes normalization and minimizes data duplication, in order to prevent transaction anomalies (Hoffer et al 2013 p176). If tied to a particular business case, the database should include elements (structure and content) for all business functions throughout the value chain (Porter 1985). A database with sound structure and comprehensive organizational coverage will be the most effective at demonstrating realistic scenarios for students in a business-oriented database class.

This paper argues that Microsoft’s Adventure Works (AW) sample database and business model provide a comprehensive and genuine format for studying database design and usage in a realistic (albeit fictional) company narrative. The paper describes the Adventure Works business model and database, then discusses several pedagogically relevant opportunities utilizing AW in a variety of classroom settings involving active learning exercises. As you will see, Adventure Works includes a rich set of features that can be used to reinforce students’ understanding of data modeling, security, analytics, specialized data type processing, and a host of other useful educational objectives.

THE ADVENTURE WORKS BUSINESS CASE

Adventure Works (AW) is a fictional company that specializes in manufacturing bicycles (Microsoft 2014). The company’s product line includes 97 different brands of bikes, grouped into three categories: mountain bikes, road bikes, and touring bikes. In addition to manufacturing bicycles, AW also manufactures some of its own components. Other components are purchased from outside vendors, as well as all accessories and clothing.

Obviously, AW is primarily in the business of selling bicycles, but they also sell accessories (such as bottles, bike racks, brakes, etc.), clothing (such as caps, gloves, jerseys, etc.), and components (such as brakes, chains, derailleurs, etc.). Many of these are made by outside vendors, so in this capacity AW serves as a reseller. AW has a global presence, selling to...
customers throughout the United States, Canada, Australia, the United Kingdom, France, and Germany. The AW business model divides customers into two categories: retail stores that sell bikes, and individual customers. Although AW does not have any brick-and-mortar stores itself, the manufacturer does sell products directly to individuals via an Internet presence.

AW has a total of 290 employees, serving various functions such as sales, production, purchasing, engineering, finance, information services, marketing, shipping and receiving, and R&D. Their customer base includes 701 stores and over 19,000 individuals worldwide. AW utilizes the services of 104 vendor companies that serve as suppliers of components, accessories, clothing, and raw materials.

Thus, the Adventure Works business case, although fictional, is a highly realistic case study for students in an information systems course. As described below, its database and data warehouse provide tremendous opportunities for students to learn about various aspects of information systems in a business context.

THE ADVENTURE WORKS DATABASE AND DATA WAREHOUSE

Adventure Works includes two databases, both of which are implemented in Microsoft SQL Server. The first is an online transaction processing (OLTP) database, which is rich in structure, content, and variety. The second is a data warehouse, which is useful for online analytical processing (OLAP) as well as teaching data warehouse concepts and structures.

The OLTP database is composed of 71 tables grouped into five schemas related to AW’s business model: Sales, Purchasing, Production, Human Resources, and Person. The database (in its raw state) contains data of almost 20,000 people (employees, customers, and contacts of various types). It also contains data of over 31,000 sales transactions to customers and over 4000 purchasing transactions from suppliers. The data in AW’s most recently deployed database pertains to the years 2004-2008, but this can easily be modified by updating the date fields and making the database appear more current. The data in AW’s OLTP database is very comprehensive compared with data volume in a typical textbook’s sample database. There are also several advanced data types that are demonstrated in AW’s OLTP database, including bitmapped product photographs, XML documents, and hierarchyid fields for representing hierarchical data relationships. The wealth of data in AW’s OLTP database provides a rich set of pedagogical opportunities, as described later in the paper.

The AW data warehouse is best described as a centralized warehouse architecture consisting of Fact tables and Dimension tables (Hoffer et al. 2014, chapter 9), and containing data obtained from the OLTP database and other data sources via a traditional extract/transform/load (ELT) process. There are a total of 10 fact tables, with subject areas ranging from Internet and reseller sales to financials to product inventory. These Fact tables are surrounded by 16 dimension tables, representing customers, product lines, accounts, employees, departments, geographic regions, and time. Thus, AW’s data warehouse is a useful venue for discussing many key data warehousing topics, and serves as a springboard for OLAP cube building and data mining.

PEDAGOGICAL OPPORTUNITIES OF ADVENTURE WORKS

I’ve used Adventure Works in two classes in our CIS curriculum: (1) a 400-level system development and implementation class (our capstone), and (2) a 400-level business intelligence elective. Although it could also be used in our 300-level database design class, AW is probably better suited for more advanced classes.

Both of these classes are held in the computer lab, so much in-class time is spent on active learning hands-on exercises, mostly using Microsoft SQL Server and Visual Studio. In both classes, the Adventure Works business model is emphasized and elaborated throughout the semester. By the time students have completed the course, they’ve had a realistic technical and business immersion, and developed key design skills along the way. The following are a set of active learning exercises centered on AW data.

Reverse Engineering to a Business Entity

The AW OLTP database has an interesting organization in many respects. One of these involves the concept of a business entity. Within the Person schema, there is a table called BusinessEntity. This table is directly related, via a one-to-one relationship to three other tables in the AW database: Person, Store, and Vendor. Person is further related, also in a one-to-one fashion, to Employee, which is further related one-to-one with SalesPerson. For all of these tables, the primary key is the same, called BusinessEntityID. This provides students with an opportunity to discover an implicit supertype-subtype hierarchy, as shown below. Database students will often experience data modeling of enhanced (or extended) ER modeling involving supertype-subtype relationships (Hoffer et al. 2014, chapter 3) when constructing data mods and designing
relational databases. But they may not get much opportunity to reverse engineer the supertype-subtype business model by analyzing a company’s relational database structure. AW provides an opportunity to do this. A resulting ER diagram may look like this:

![ER Diagram](image)

**Figure 1. Supertype-subtype relationships in Adventure Works data model**

This type of reverse engineering is common practice in IT consulting, where a consultant may come into an environment with inadequate and outdated documentation (Briand et al 2006, Van Geet and Demey 2010). This requires the consultant to work backward from the data in order to glean the underlying business model by analyzing both the structure and the content of the database. Reverse engineering is a useful educational technique (Ozkul 2012), and the AW database structure gives a useful realistic reverse-engineering learning experience to IS students.

**Hashed Passwords Fields and Best Security Practices**

The AW database includes a **Password** table, with a field for a 128-bit hashed password and a corresponding salt value. This provides opportunities to teach about cryptographic hashing (Azad and Pathan 2014), and in particular to implement login features in applications that use Adventure Works. Our capstone class involves Web application development in ASP .NET and C#, so we make use of the .NET login web components and apply hashing algorithms for creating passwords and validating logins of AW users. Students could do this directly using .NET libraries; alternatively there are also many sample simplifying code snippets on the Web, which are used in the capstone for implementing applications of MD5, SHA1, and other hashing algorithms.

The capstone project involves development of a web application for Adventure Works. One of the system requirements is to provide user login and profile setting purposes, and enforce security requirements. Students are required to use cryptographic hashing, using the **Password** table, and in general abide by the AW rules for creating and managing users. They are also required to follow other best practices (OWASP 2014), such as preventing SQL injection by using parameterized queries.

**Incorporating XML into SQL Processing**

The Adventure Works database includes several data fields with the XML data type. Examples are the **Resume** column of the **HumanResources.JobCandidate** table, the **CatalogDescription** and **Instructions** columns of the **Production.ProductModel** table, and the **Demographics** column of the **Sales.Store** table.

XML data querying is an important skill for processing semi-structured data, which outstrips structured (e.g. relational DB) data in volume. Traditionally, database classes have focused on relational, SQL-based database structures, but increasingly there is a need to address other structures, especially those accessed via Web services. Many of these are in XML format; many others are in JSON format. Database textbooks increasingly include content regarding XML and typical format and use of Web services (Hoffer et al 2013, chapter 8). So, a database that includes XML content provides valuable educational opportunities in a technical IS curriculum.

Mastering this skill requires instruction and practice in XPath and XQuery, and also an understanding of how to incorporate XPath and XQuery with SQL in the Microsoft environment. An effective query for extracting relevant data from an XML field requires considerably more specialized skills than those learned in a typical database class. For example, here is a query involving the **Production.ProductModel.Instructions** column.
This query involves reference to an XML namespace, use of XQuery functions value and nodes, and use of the CROSS APPLY T-SQL clause. CROSS APPLY is used to “shred” the results of the XPath path expression //AW:tool, so that the different tool elements from the XML document in a single row are returned in individual rows of the result set. This nuance of XML/SQL combinations makes a nice experiential bridge for students as they contrast XML and relational data structures and learn more advanced query skills.

Dashboards and Balanced Scorecard

Because the AW database is so comprehensive in scope and volume, it offers a good opportunity for students to practice data visualization skills. Also, since the database includes data pertaining to all functional areas of the business, it contains a wealth of information that would be useful business process management (BPM) (Sharada et al. 2014), and in particular balanced scorecard (BSC) techniques for performance assessment (Kaplan and Norton 1992). For our BI course, BPM/BSC is an important conceptual learning objective, and use of data visualization tools is an important technical learning objective. So, one key project for students is to create a dashboard based on Adventure Works data that addresses the four main perspectives of the balanced scorecard: financial, customer, internal process, and learning and growth.

There are many ways to incorporate data visualization in a BI class. Ours is fairly technical, so we use JavaScript-based Google Charts APIs (https://developers.google.com/chart/interactive/docs/index). Other possibilities include linking SQL Server data to Excel charts, using products like Tableau or SAS Visual Analytics, developing ASP .NET applications with charting capabilities, or providing customized tools for mapping queries to visualizations (Mitri 2012). Our BI class’s dashboard project requires students to build a data visualization for each of the four BSC perspectives, and the ability to drill down from each data visualization for more detailed information. The four perspectives can easily be found in the AW database and data warehouse. Sales data and customer information are found in the Sales schema, and these are broken into Internet and Reseller sales subject areas of the data warehouse. Internal process information can be readily found in the Product schema, which includes much useful data on AW’s manufacturing process. Financial data is found in all schemas, and is also a subject area in the data warehouse. Learning and growth can be found by linking together elements from different schemas, or by going to the more subject-oriented data warehouse.

Data Integration

The Adventure Works data warehouse brings opportunities for BI students to gain practice in a variety of tasks related to data integration via Microsoft’s SQL Server Integration Services (SSIS). In order to use these features, students must have access to SQL Server’s Business Intelligence data tools which can be obtained for free in universities that are members of Microsoft’s Developer Network Academic Alliance (MSDNAA).

Microsoft provides tutorials for integrating data from Excel spreadsheets, folders containing text files, and the AW OLTP database itself. However, rather than have students just follow the step-by-step instructions in the tutorials, I find that it is far more effective to memorize and condense the steps of the tutorials and incorporate these into a hands-on classroom exercise in which the instructor guides the students through the integration process while relating these steps to the conceptual elements of data integration theory and practice. Using SSIS in this way gives students hands-on experience with the entire ETL process. SSIS data source connection managers are used to link with a variety of data sources (containing structured, semistructured, or unstructured data) for extraction purposes. The data flow tasks in SSIS allow students to create data flow linkages between data sources and data destinations. Data flow tasks also allow for a wide variety of techniques for implementing data transformations. Using SSIS, student gain a practical, active learning experience that helps to cement their conceptual understanding of data integration (Hoffer et al. 2014, chapter 10).

OLAP and Multidimensional Databases

The Adventure Works data warehouse brings opportunities for BI students to gain practice in a variety of tasks related to online analytical processing (OLAP) via Microsoft’s SQL Server Analysis Services (SSAS). For our BI class, the SSAS tutorials are condensed and presented as a collective class exercise, similar to the SSIS presentation described earlier. The instructor guides the students through the cube-building and deployment process while relating these steps to the conceptual elements of online analytical processing and multidimensional databases. The Microsoft tutorials include practice in...
dimension member hierarchies, discretization, pivot tables, slicing and dicing operations. During the exercises, students also get experience working with Multidimensional Expressions (MDX) for cube querying.

Data Mining

Microsoft’s SSAS includes data mining features. Users can apply a set of supervised and unsupervised learning algorithms to a variety of data sets. Microsoft includes tutorials for applying decision trees, Naïve Bayes, clustering, and association rules for a variety of Adventure Works mining tasks. These include use of demographic data to predict bike buyer likelihood, market basket analysis based on AW’s transaction history, and identifying “natural” groupings of AW’s customer base. In our BI class, students learn the theory and concept of several data mining algorithms (e.g. ID3 decision trees, backpropagation neural networks, K-means clustering, and Apriori association rules), and for each one, we apply a simple example using SSAS on Adventure Works data. In this way, students get a basic understanding of different approaches to data mining and some hands-on experience working with Microsoft data mining models.

E-Commerce

Adventure Work’s OLTP database has everything you need to create data-rich Web-based e-commerce applications. Our capstone course provides students an opportunity to create ASP .NET applications for AW in e-commerce or a wide variety of other application areas. A typical B2C e-commerce application caters to three types of users: (1) an Internet-based customer, (2) a customer service representative (or salesperson), and (3) a decision-maker or knowledge worker. For customers, the application includes a product catalog and order processing system, along with customer profiling and secure login (as described earlier). For salespeople, the application provides the capability to track customers and monitor inventory levels, making purchasing requests when needed. For managers, it includes decision support capabilities including charts for dashboard functionality (also described earlier). Because of the rich amount of data found in AW’s database, including multimedia data, some very impressive student projects have been accomplished by students working with AW data, as shown below.

![Figure 3. ASP .NET e-commerce application based on Adventure Works database (student project)](image)

STUDENT PERCEPTIONS OF ADVENTURE WORKS

In order to evaluate the effectiveness of Adventure Works as a case and database example, an online survey was presented to students in our BI class at the end of the fall 2014 semester. Out of 18 students who took the course, 11 students completed the survey. Questions were asked about a variety of student experiences and opinions regarding technical areas including advanced database querying, data integration, multidimensional databases, data mining, and data visualization. Questions were also asked about the effectiveness of the Adventure Works database for student learning.

The results indicate that students strongly appreciate the efficacy of AW in a learning environment. One survey question was: “How useful was the Adventure Works database for helping you to gain a deeper understanding of database technology and querying skills?” The possible answers were very useful, useful, neutral, very useless, and useless. Of the 11 students, nine rated AW as very useful and two rated it as useful. When asked “Please write a brief description of how the Adventure Works database either contributed to or hindered (or both) your understanding and skill level in database querying?” students gave several answers that pointed to AW’s real-world relevance and practical usefulness. Example statements are listed below:
• It was a good practical business model to use to design queries and other exercises around. It brought relevance.
• I feel that the Adventure Works database helped in that it was like a real world example of how a real company would be set up.
• It really helped me to visualize how OLTP and OLAP databases are laid out visually. Also, since it is a widely used database, it was helpful to be able to find tutorials when I got stuck.
• It was helpful because it applied database and SQL query concepts we were learning in class with practical business concepts; it interwove the two in what was a realistic representation of what I thought an enterprise-wide business database would look like.

CONCLUSION

This paper presented Microsoft’s Adventure Works business model and database as a pedagogical tool for gaining practical insight into the data model of a realistic business case. The data in AW’s database and data warehouse is comprehensive enough to present many useful pedagogical opportunities for a technically oriented information systems curriculum. With creativity, imagination, business acumen, and technical discipline, students can leverage AW’s data to implement many practical, realistic, and rewarding information systems. In this way, the AW business case and database offers many benefits to IS instructors who wish to provide an active learning experience to their students.

REFERENCES

1. ABET (2014) Accreditation Policy and Procedure Manual,


