

Bringing Business Intelligence to Health Information Technology Curriculum

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ABSTRACT

Business intelligence (BI) and healthcare analytics are the emerging technologies that provide analytical capability to help healthcare industry improve service quality, reduce cost, and manage risks. However, such component on analytical healthcare data processing is largely missed from current healthcare information technology (HIT) or health informatics (HI) curricula. In this paper, we took an initial step to fill this gap. We investigated the current HIT educational programs, BI industry, and healthcare BI job listings, and students' perceptions of BI and how BI could be incorporated into HIT programs. The student survey results showed strong interests from students in a HIT course containing BI components or a BI course specialized in the healthcare context. Based on the student survey and investigation of BI industry and job market, as well as HIT educational programs, we developed a general curriculum framework and exemplar implementation strategies to demonstrate how BI can be incorporated into an HI or HIT program. To the best of our knowledge, this research is the first of its kind. Our approach of integrating information from students, the HIT industry and other HIT programs can also be used as a model for general HIT curriculum development and improvement.

Keywords: Business intelligence, Health care, Curriculum design and development

1. INTRODUCTION

The universal need for improved patient care and reduced healthcare costs combined with the 2009 American Recovery and Reinvestment Act (ARRA) has elevated the attention on healthcare data management and analysis (Tibken, 2013). Healthcare industry depends on many sources of data to support the diagnosis, treatment and prevention of disease, illness, injury and other physical and mental impairments in humans, as well as the operation of healthcare service providers and organizations. Healthcare data includes patient information, clinical data, financial data, medical knowledge, and operational data (Groves et al., 2013).

Healthcare data has some unique features such as multiple sources of data, complexity of different datasets (Weber, 2013), levels of regulation, and the potential impact on a patient's health and life. For example, the data in a hospital or clinic is in various formats and comes from multiple sources including clinical and operational data. As the result, such data is difficult to analyze and often fail to deliver its value to users. Another major challenge to healthcare IT today is the explosive data growth, such as digital imaging and electronic health records in general. This is where business intelligence (BI) systems come in to help manage and integrate data, turn data into meaningful information, and therefore improve patient care, reduce

costs, and optimize service provision (Madsen, 2012; Weber, 2013). BI is believed to be the key for enhancing healthcare quality with less cost (Madsen, 2012).

Demand for BI applications for healthcare continues to grow with the increasing volume of data and the desire to learn from the data. The demand for data management and analysis expertise in healthcare is growing at a rapid rate. "Healthcare as an industry is behind in adopting BI, yet no other industry needs it more", as stated in (Madsen, 2012). The KLAS report showed more than half of the healthcare organizations intended to purchase new or replace existing BI systems, and providers are looking at a wide variety of BI tool sets and products to satisfy this need (Graaff and Cameron, 2012). However, the lack of industry knowledge and experience slows the implementation and adoption of BI in healthcare settings.

Academic institutions also realize the trend (College of Coastal Georgia, 2011; Martz et al., 2007) and have laid out great visions on developing such programs. But one of the barriers is the limited educational and training resources (e.g., model curriculum and programs) to focus on the use of information for higher level analytical processing. In the already few healthcare information technology or health informatics programs, fewer have specifically cover the BI component.

We believe that there is a need to bring education and training on BI concepts, technologies, and processes to HIT curricula and programs. The questions are: Is there a strong student interest and demand for BI coverage? What learning outcomes should be achieved and what content need to be covered? How do we design modules, courses, or tracks in different situations? And what teaching resources are available? In this paper, we first introduce BI in healthcare and the current situation of BI coverage in HIT programs. We also report survey results on HIT students' perceptions of BI and how BI could be incorporated into HIT programs. We then propose a curriculum framework for delivering BI education in HIT programs. The paper discusses different implementation strategies that can potentially serve as a curriculum development reference.

2. BUSINESS INTELLIGENCE OVERVIEW

Business intelligence is a broad term to describe a set of methods, processes, architectures, applications, and technologies that transform raw data into meaningful and useful information to support business operation and growth (Cardin, 2007). It is used to enable more effective strategic, tactical, and operational insights and decision-making. BI systems combine data gathering, data storage, data integration, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision makers (Negash, 2004). Traditionally it has evolved from executive information systems and management information systems to specifically focus on data driven decision making (Power, 2007).

With each new iteration, BI system's capabilities increased as enterprises grew more sophisticated in their computational and analytical needs and as computer hardware and software matured (Negash, 2004). A complete BI enterprise system is able to cover the full spectrum of a BI process, including major components of data management and integration, analysis, presentation, delivery, and domain applications which involve all components.

The data management and integration component prepares data to be ready for analysis and reporting. It is the starting stage of the BI process to acquire and store data (Olszak and Ziemba, 2007). The major functions of the component usually include data modeling, storage, collection, integration, and management. Popular technologies and tools used include database, data warehouse, data mart, data model, and ETL (extraction, transformation, and loading).

The analysis component spans multiple levels of data analysis, including simple descriptive and operational queries, specialized multidimensional analysis such as OLAP (online analytical processing, a particular data processing and analysis based on data facts and dimensions), statistical analysis, business analytics, advanced data mining techniques, and even visual analytics (Thomas and Cook, 2006). It is the analytics that drives the transformation of data into meaningful and relevant information and knowledge, which supports decision making.

The presentation component is a more recently focused layer which brings sense-making and decision support directly to users. It includes various interaction and

visualization techniques that add additional intuition and cognition to decision makers (Tegarden, 1999). Common tools include reporting (static and interactive reports), digital dashboards, and more complex analytical visualizations.

The delivery component focuses on user access to data, reports, presentations, and all kinds of analysis and reporting tools. Common delivery approaches include BI web portal, personal office applications such as Excel, mobile applications, etc.

Finally, many common business or industry specific functions require all components above work together to realize a complete solution. This includes common horizontal business management at strategic, tactical, and operations levels (Olszak and Ziemba, 2007), such as performance management, strategic management, customer relationship management, and also includes industry specific businesses and processes such as institutional effectiveness, learning analytics, web analytics, patient care, etc. Specifically in the healthcare industry, the four areas of focus include financial, clinical compliance, quality improvement, and patient satisfaction/marketing (Kudyba and Temple, 2010).

BI is also an important component in the healthcare IT to prepare, analyze, interpret, evaluate and present clinical and operational data to enhance healthcare quality, effectiveness, efficiency and safety. Many healthcare BI related jobs have specified skills similar to the components above. A recent search for healthcare BI related job postings from HIMSS JobMine, LinkedIn, and Indeed showed these skills include understanding business requirements and translate the appropriate technical solutions to implement a BI solution to end users; ensuring high levels of BI availability through support function; designing data structures and in-depth testing; developing and generating standard and ad-hoc reporting capabilities from new and existing data sources; working towards automation of systems in order to meet Meaningful Use guidelines as per regulatory requirements; assisting in data integration; and working with nurses and physicians to increase EHR adoption as mandated by the HITECH ACT.

3. BI EDUCATION IN CURRENT HIT PROGRAMS

We are interested in how current HIT programs in higher education institutions have responded to the market demand and what level of healthcare business intelligence is covered in their HIT curricula. We used the Health IS Programs list compiled by AIS SIG-Health (Wilson and Tulu, 2010) to examine the programs. The list includes healthcare-related academic programs that are based in or substantially comprised of Information Systems, Information Science, and/or Computer Science academic units. The list has a total of 32 institutions worldwide. Three authors independently examine all institutions and programs by following the web links and browsing the public course information related to HIT programs and curricula published on the institution websites. A general curriculum/program assessment template was used. The assessment items in the template include institution location, program level, HIT program focus, BI course availability, focus, level and coverage. We then cross-examined the findings and verified the information together

for a few schools that showed different results from the individual assessment.

The result indicates a limited effort in the comprehensive BI-HIT education (Table 1). Among the 32 institutions, only 4 of them are found to have a specific course covering BI and decision support; only one of them is explicitly related to BI. Nine institutions offer BI related courses in a healthcare context, but the course commonly only cover one component of BI, such as data management, database design, or analysis.

BI course type	# of institutions
Specific BI in the healthcare context	4
BI related course with a healthcare context	9
Only BI related course without a specific context (excluding those institutions which have BI courses with the healthcare context)	5

Table 1: Institutions with Health IT or IS programs which Offer BI Relevant Courses

The findings showed that BI has not yet become a mainstream in current established HIT curricula, although a number of programs at least cover some part of BI such as data analysis and data management. Some institutions have shown a good vision on health informatics and BI. They have recognized the missing part in health informatics which is about using data to facilitate the business of delivering healthcare and enable health practitioners make better decisions about patient care and service (College of Coastal Georgia, 2011). As informatics and BI are getting their due attention in the industry, education and training should also address the gap in the curricula.

4. STUDENT SURVEY

Student interest and demand are two important factors when offering new courses. We conducted a student survey to investigate students' perception about BI and how BI could be incorporated into HIT programs. The survey was designed to gather the following information: 1) demographic information of the participants; 2) students' awareness and perception of BI in general, and their experience in BI; and 3) students' perception toward BI education in HIT and perceived importance of BI skills. The survey has a total of 19 questions. The subjects of this survey are the students from multiple sections of an introductory Health IT course.

The course was cross-listed at both undergraduate and graduate levels.

In the introductory HIT course, an online discussion assignment about BI in healthcare was assigned in the middle of the semester when the topic of current trends in HIT (which includes BI) was introduced. Students were asked to search a recent case study of how healthcare organizations use BI and discuss with the class in the online forum. The student survey was distributed after the BI discussion was completed. The participation in the survey was voluntary and anonymous. The participants were given a web link in which they can complete the questionnaire at their spare time.

4.1 Demographic Information

The survey was distributed to all 91 students who enrolled in the participating course. We received 62 entries and 59 of them were valid (three incomplete entries were removed). The response rate was 65%. Among all participants, around 71% were graduate students and the rest were undergraduate students. Majority of respondents were taking the class either as required (51%) or as an elective course (42%). 76% of students were 25 years old or older and 64% of them were male. 68% of the respondents either worked full-time or part-time. The demographic distribution of the participants was consistent with general student body of the participating school except for the gender.

4.2 Survey Results

Experience of BI Education. 37% of the participants had taken or were currently taking a BI course or a course that has a BI component, such as data management, analysis and reporting. The top three reasons that they took such courses were (participants are allowed to choose multiple answers): 1) the content seems interesting (59%); 2) plan to work in BI area (32%); 3) BI seems to be a hot area (27%). It showed that personal interests and career related factors are the main motivation for the students to study BI. The vast majority of the participants (86%) held a positive attitude toward BI and think BI content they learned was relevant to the program/track they enrolled in. However, only 27% of the participants were very satisfied with software used in their BI course. This is an area we need to put attention to when designing HIT BI courses.

Perception of Business Intelligence. In the survey, the participants were asked to share their opinions on a list of statements. The statements were categorized as personal interest and career related, two top factors that impact what

Category	Statement	Perceptions/ Opinions				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Personal interest	BI is an exciting and relevant area	2%	0%	19%	51%	29%
	I'm interested in learning more about BI	2%	2%	12%	51%	34%
Career related	There are plenty of Job opportunities existing in the field of BI	3%	0%	31%	46%	20%
	BI is a fast growing field	2%	0%	25%	37%	36%

Table 2: Participants' Perception towards Business Intelligence

Note: the percentage is calculated using number of responses chose that option divided by total number of participants.

Statement	Perceptions/ Opinions				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A HIT course containing BI components will add value to my degree/education	2%	3%	8%	46%	41%
A BI course specialized in HIT will add value to my degree	2%	3%	7%	47%	41%
I'm interested in enrolling in a HIT BI track if it is available	2%	7%	18%	49%	24%

Table 3: Students' Perception on BI Education in HIT Program

Note: the percentage is calculated using number of responses chose that option divided by total number of participants.

students want to study (Hogan and Li, 2011). Their responses are summarized in Table 2. The result clearly showed that most of participants were interested in the BI field and wanted to learn more about it. Majority of them also believed BI is a fast-growing field and there are many job opportunities. The survey result evidently indicated strong demands for BI education from the students.

Perception on BI in HIT program. After inquiring the participants' perception on BI, the next logical step was to understand their opinions on how BI education should be incorporated into HIT program or track. As illustrated in Table 3, participants expressed strong interests in a HIT course containing BI components or a BI course specialized in HIT. Most of the participants were even interested in a HIT BI track. In summary, the survey results showed strong demand from the students to incorporate BI education into HIT programs.

BI Skills for HIT Program. In the survey, we also investigated the participants' opinions on what BI specialties should be covered. We hoped this would give us some guidance on developing the contents of a BI course or a BI module. The survey results are shown in Table 4. The top three ranked skills were data modeling, data analysis and data integration. BI process management and process management also received high marks. Since many participants have never taken a BI course before, their perception may have come from other sources such as news, blogs, and word-of-mouth recommendations. Thus, we only use the information gathered in this section as a reference.

5. A PROPOSED FRAMEWORK TO DELIVER BI IN HIT CURRICULA AND PROGRAMS

Based on the conceptual analysis of general BI systems and processes, characteristics of BI in healthcare, the industry demand and student survey feedback, we propose a framework of delivering BI in Healthcare IT from both technical and managerial perspective. The framework corresponds to the full spectrum of BI system (data management, analysis, presentation, and delivery) from both technical and healthcare perspectives (Figure 1). The technical focus emphasizes healthcare BI system development, deployment, and administration. The healthcare focus emphasizes healthcare service provider performance management, healthcare business analysis, and usage of user oriented reporting applications. In this section, we will discuss in details of major components.

BI Skills in HIT Context	Percentage of Selection
Data Modeling: healthcare data model and database design	73%
Data Analysis: analyzing healthcare related data using common analytical models	71%
Data Integration: data extraction, transformation, and loading from multiple sources	64%
Performance Management: using BI technologies to measure business (healthcare) operations and performance	59%
BI Process management: managing BI projects and processes	58%
Data Presentation/Reporting: report and digital dashboard authoring and development	47%
BI Application Development: user-oriented application development	37%

Table 4. BI Skills ranked by the Participants

Note: 1) the percentage is calculated using number of selections divided by total number of participants. 2) participants can select multiple options.

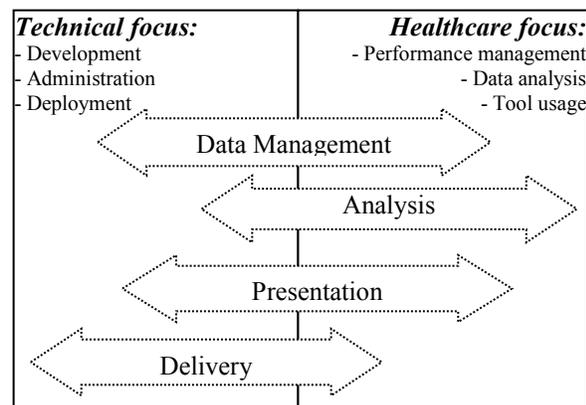


Figure 1: Coverage of BI in an HIT Curriculum

5.1 Data Management and Integration

Toward a technical focus, students need to know data modeling and storage technologies such as data warehousing technologies and practices specifically for clinic data warehouse. They should be able to use data warehouse

products to design, implement, and maintain a financial data warehouse or a clinic data warehouse using common data schemas.

Data integration is also an important technical skill in BI. Students will be exposed to general data integration approaches as well as hands-on training on using ETL (extract, transform, and load) tools and programming languages. These skills enable them to collect and consolidate patient, medical, and financial data from different sources. To achieve this goal, students need to know general common data integration techniques and systems, and have hands-on experience with health information exchange systems, such as national health information network (NHIN, or eHealth Exchange), Health Informatics Service Architecture, and various healthcare data standards and medical coding such as HL7 and ICD10. The understanding of data formats and codes is essential for working with health information exchange standards.

Toward a healthcare perspective, students need to understand the meaning and structure of both general operational data and healthcare specific data from different sources such as health records, clinical data, lab data, insurance data, research, and public health. They should be able to describe and specify the multidimensionality of data. A solid understanding of these data and how it is used in real life situations is a requirement for data modeling, which is a prerequisite for data warehouse design and data integration. A sound knowledge of the data can also help design data queries and reports that make business sense and meet expectations at different levels. In addition, the concepts of enterprise-wide data governance and data provisioning in healthcare need to be introduced to students so they know how to manage data and metadata, realize value of it, minimize cost and complexity, manage risk, and ensure compliance with regulations and other requirements.

5.2 Analysis

From a technical perspective, students will learn the technologies and tools that drive different levels of analytics from standard reports to optimization (Burke, 2010). This also includes the traditional OLAP (online analytical processing) technologies and commonly used query languages such as MDX (multidimensional expression) to formulate OLAP queries. They also need to learn how to design and deploy OLAP cubes, and configure different analytics program packages to work seamlessly with the data source. All these queries and analysis should be in a healthcare business context. For instance, public health may need to analyze the distribution of disease and health outcomes in relevant population of interest.

From a healthcare point of view, clinical analysis and business analysis constitute a big portion of healthcare BI (Burke, 2010). A data analyst should be able to use common business oriented query and analysis software such as Excel to retrieve data from databases, and conduct data analysis at various levels. Students may not need to know the query language behind the scene but they should know the nature of each kind of query and be able to use typical client tools to formulate queries and get data. An analyst should also be able to understand common types of healthcare domain specific calculations and analysis. For example, integration

of clinical and business data helps assess the effectiveness and efficiency of clinical interventions or processes. Other types of analysis that can aid informed decisions include those to improve clinical and healthcare outcomes, financial performance, research activities, and business operations, get customer insights, and manage risks (Burke, 2013).

Data analysts are also responsible for designing and specifying key metrics and indicators, and interpreting query results. The clinical analytics results will be applied to various context of quality improvement, such as chronic disease, patient utilization, population health, and public health, to name a few.

5.3 Presentation and UI

Reporting is essential for assessment and decision making. Healthcare industry needs a variety of reports in enterprise intelligence and medical intelligence to assess patient outcomes and quality of care, understand the potential impacts of regulatory proposals. The evolving regulations and quality initiatives require the reports on many quality measures, such as Meaningful Use, Physician Quality Reporting System (PQRS), Healthcare Effectiveness Data and Information Set (HEDIS) & Performance Management, Accountable Care Organizations (ACO), Electronic Health Records (EHR) and clinical applications.

From a technical focus, much of the BI course coverage can be on the development of static and interactive reports, dashboard applications, and information visualizations, among others, in the healthcare context. Report development is a common job role in companies and organizations including healthcare service providers and agencies. Students need hands-on practice using typical development and programming platform such as Crystal Reports. A recent emerging area in BI is digital dashboard. Informational dashboards are increasingly included in hospital information systems and integrated with electronic health records. Key Performance Indicator (KPI) dashboard is an important tool that ensures key metrics to be available for front-line staff in a format that is relevant and easily understood. In addition, students may need to know basic business information visualization techniques (including design of visual properties and elements) and create dashboards using popular software like QlikView.

From a business user's perspective, it is important to understand the meaning of common business data visualizations (Tegarden, 1999), including basic chart types (line chart, pie chart, etc.) and more specific charting and diagrams, for example, bridge chart, perceptual mapping, tree map, and others. Students are expected to build non-automated presentations using common office software (e.g. Excel). They should also be clear about the purpose, usage, pros and cons of each type of chart, and correctly choose the chart type to deliver meaning and correctly interpret the results at the same time.

5.4 Delivery

The delivery component is more from a technical aspect. This part follows general BI delivery practices in technology choice (hardware and software) and system administration. Students should know common ways to deliver applications and results to users at different levels and places, and

configure devices and applications accurately and securely. For example, physicians can view dashboards with their wireless devices on the go. At a nurse station, a dashboard on a PC desktop displays metrics about patient and bed allocation. At patient waiting areas, key performance indicators (e.g., wait time) can be communicated via multimedia applications in large flat panel displays. For administrators and planners, a dashboard can consolidate the operational metrics they need. Major topics within this component in a BI course include desktop application management, office application integration, web portal setup, mobile application configuration, mobile device management, user permission management and access control, etc.

5.5 Applications

The technology aspect focuses on the development and implementation of an enterprise information system to cover all components of a BI system and configure them to work together. Such a system can be configured and customized to a number of general business functions like performance management and strategic management using traffic light systems and balanced scorecard systems (Kaplan and Norton, 1996). The uniqueness in the healthcare industry is to know healthcare business specific key performance indicators (KPIs), the meaning and definition of the KPIs and how they are measured and used, and what types of decisions they support. For example, how doctor performance is evaluated, or how hospital utilization is defined and measured. Student may need to know commonly used healthcare KPIs include clinical outcomes, ER waiting times, lab turnaround time, readmission rate, bed occupancy rate, surgical site infection rate, claims denial rate, etc.

BI technologies and systems can be applied to a number of healthcare specific processes. Kudyba and Temple (2010) summarized these processes into four major areas including financial, clinical compliance, quality improvement, and patient satisfaction. For example, the advanced analytics may help suggest treatment options to doctors, based on medical records, patient history, research databases and other sources. The analytics can also help predict whether patients with chronic conditions (e.g., diabetes) follow doctors’ instructions based on patient records and claims histories. Such systems need a complete solution from data collection to results delivery. Many healthcare providers also use BI

system to identify and monitor who is at risk of a hospital admission. Effective prediction of who was going to be hospitalized could reallocate resources to prevent unnecessary hospitalization and put the resources to use for cure rather than care (Tibken, 2013).

6. IMPLEMENTATION STRATEGY AND TEACHING RESOURCES

6.1 Implementation Strategy

The curriculum framework describes a theoretic picture of BI education and training in the healthcare domain. However, it is difficult to deliver an HIT or healthcare management program that implements all aspects of the framework. Resources and expertise may be two major factors when considering a BI focus. The availability of data and cases could also limit the content coverage. The best practice is to identify the program with a focus before deciding which courses to offer and how to offer them. HIT programs, when considering offering healthcare BI related courses, can use the proposed framework in this paper as a guide by (1) identifying the focus of their program (technical or healthcare); (2) making it flexible for IT or healthcare programs to customize the BI curriculum based on their goals and requirements; and (3) focusing on certain BI modules/phases in the customization process. The programs can consider the following implementation strategies for BI curricula (Table 5).

1. If BI specific courses are not available yet in the program, then specific learning modules of BI can be part of existing HIT courses. For example, in an EHR course, one or two modules can be planned to focus on data standards and integration technologies.
2. If BI-related courses are already available but not in an HIT program, these courses can be directly included in the curriculum as electives without additional customization. They simply provide a content coverage of business intelligence to the HIT students.
3. Existing BI courses (or some offering sections of these courses) can be customized to the healthcare context such as using healthcare datasets or adding healthcare cases and projects. For example, in a data warehousing course, a special section can be offered using a clinic data warehouse as the major sample data throughout the

Offering Strategies	Course availability (General BI / Healthcare Specific BI)	Integration level	Coverage depth
1. Learning module	No / No	Include BI modules to HIT courses	Concepts and theories focused
2. General BI course	Yes / No	Low. May not be in healthcare context.	Coverage of BI in a general sense
3. Customized BI course	Yes / No	Add healthcare content to BI course	Major cases and student works involve healthcare specific data
4. Specialized BI course	Yes / Yes	Specialized BI course	All course contents are in the healthcare context
5. Healthcare BI track	Yes / Yes	Sequence of healthcare BI courses	A serial of specialized BI-HIT courses with either a technical or management aspect

Table 5. Health BI Course Implementation Strategies Ordered by Level of Coverage

course. To provide students with solution-driven project experience, designing a data mart for a hospital as a term project could also be considered if it is practical.

4. If resources are available, independent and specialized healthcare BI courses can be designed to cover all the BI system components in healthcare settings. The course can be flexibly adjusted to have a technical focus or management focus based on the program mission and goals.
5. If aligned with department or college's strategic plan, a more complete curriculum with 3 or more healthcare BI courses can be designed. They may cover technical and management aspects respectively, and include various enterprise and medical intelligence applications. This strategy can be used when a concentration in BI or a healthcare BI program is under consideration.

6.2 Example Healthcare BI course design

In this section, we describe a sample stand-alone introductory healthcare BI course design with a technical focus.

This course intends to be an introductory healthcare BI course that covers the basics of BI system and technologies applied in the healthcare domain. The course introduces concepts and practices in each of the BI system component and gives students a broad picture of the technical landscape of healthcare BI. It can be the first course in a specific BI-HIT program that may cover deeper BI content with follow-up BI courses. Students should have taken a prerequisite course that covers the basics of health IT and major health related data and terminologies.

The learning outcomes of the course may include:

1. Discuss concepts and practices of enterprise and medical intelligence and decision support in healthcare settings
2. Explain technologies and components of healthcare business intelligence systems
3. Describe the structure of clinical data warehouse and the process of data extraction, transformation and loading related to healthcare data
4. Analyze multidimensional data from various healthcare data sources
5. Design reporting solutions utilizing information visualization techniques and digital dashboards for different healthcare stakeholders

The course can have the following learning modules listed in Table 6. Some modules may span more than one week if needed. The first two modules are described in further details below.

The first module is a general introduction of business intelligence system and process. It provides an overview of the basic concepts and different components of a BI system. It also explains basic steps in a general enterprise BI process. The importance and the needs of BI applications in healthcare are emphasized with example decisions and usage scenarios. Students will be able to get some idea of the possible career aspects.

The second module introduces the widely used dimensional data model basics. The understanding of the

dimensional model is critical in later modules such as data warehouse design and OLAP analysis. Students will have hands-on modeling experiences using healthcare related data.

#	Module
1	Healthcare BI Introduction
2	Healthcare Dimensional Data Models
3	Data Warehouse Technologies
4	Healthcare Data Exchange and Integration
5	OLAP Query
6	Healthcare Financial Analysis
7	Healthcare Provider Operational Analysis
8	Healthcare Report Development
9	Healthcare Data Visualization and Dashboard Design
10	Healthcare BI market and trend. For example, mobile BI used in healthcare and big data systems and analytics (Weber, 2013).

Table 6: Sample Learning Modules

The above suggested learning outcomes and course topics intend to prepare students for the roles of BI specialist who provide technical support to clinical and operational analysts. Other roles may also benefit from the courses, such as data warehouse administrators, systems analysts and database architects working in different healthcare settings.

6.3 Health-related datasets and resources

The most important resources for healthcare BI courses are Health-related datasets. The datasets ensure students to have a sound context and get familiar with the healthcare data and data sources as well as the entire data analytics process.

Health-related datasets that are available free of charge:

- Health-related data <http://www.healthdata.gov/>
- Healthcare datasets at the Center of Medicare and Medicaid Services <https://data.cms.gov>
- HIMSS analytics <http://www.himssanalytics.org/home/index.aspx>
- Ambulatory Health Care Data at Centers for Disease Control and Prevention (CDC) http://www.cdc.gov/nchs/ahcd/ahcd_questionnaire.htm
- National health-related data at U.S. Census Bureau <http://dataferrett.census.gov/datasets.html>
- Web portal for large health data sets at EHDP <http://www.ehdp.com/vitalnet/datasets.htm>
- The Dartmouth Atlas of Health Care <http://www.dartmouthatlas.org>
- NIH Data sets: <http://www.nlm.nih.gov/hsrinfo/datasites.html>
- Agency for Health care Research and Quality <http://www.ahrq.gov/research/data/dataresources.html>
- World Health Organization Data Sets <http://apps.who.int/gho/data/view.main>
- World Bank Health Care Data Sets <http://data.worldbank.org/country>

Understanding the BI software and applications used in healthcare and the emerging BI solution leaders in the industry are important for the course as well. A couple of exemplar BI solutions are:

- Microsoft business intelligence for healthcare providers: <http://www.microsoft.com/health/en-us/solutions/Pages/bi-providers.aspx>
- McKesson BI tool specific to healthcare <http://www.mckesson.com/providers/health-systems/diagnostic-imaging/enterprise-document-management-system/mckesson-patient-folder-analytics/>
- CitiusTech's BI-Clinical Platform for Healthcare BI & Analytics <http://www.citiustech.com/bi-clinical>
- Life Sciences and Healthcare - Business Intelligence (BI) Solutions <http://www.qlikview.com/us/explore/solutions/industries/life-science-healthcare/healthcare>
- More tools are provided by (McGee, 2012). More resource can be found at <http://www.healthcarebisummit.com/>

These textbooks can be considered for healthcare BI courses:

- The following books focus on and cover various aspects of analysis:
 - Healthcare Analytics for Quality and Performance Improvement, by Trevor Strome,
 - Health Analytics: Gaining the Insights to Transform Health Care Hardcover, by Jason Burke.
 - The Health Care Data Guide: Learning from Data for Improvement, by Lloyd Provost and Sandra Murray
- SAS Business Intelligence for the Health Care Industry: Practical Applications, by Renu Gehring: this book provides hands-on BI practices with an enterprise tool.
- Healthcare Business Intelligence: A Guide to Empowering Successful Data Reporting and Analytics, by Laura Madsen (<http://healthcarebi-thebook.com>): the book focuses on high level organizational issues.
- Healthcare Informatics: Improving Efficiency and Productivity, by Stephan Kudyba: the book is good for a complementary reading.

7. DISCUSSION AND FUTURE RESEARCH

The concepts, principles, tools and applications in business intelligence can provide valuable data management and analysis capabilities to healthcare organizations, including hospitals, physician groups and networks and health insurance companies. However, BI education and training has not caught up with this vision even though both the industry and academia have realized its importance. In this paper, based on our investigation of current HIT programs, BI-related job listings, and student survey results, we developed an educational framework for delivering business intelligence content in HIT curriculum and programs. Based on our knowledge, our research is the first of its kind. Our

approach can also be used as a model for general HIT curriculum development and improvement.

We plan to expand our investigation and get more empirical data to validate and improve the BI education framework. The effort will include a nationwide HIT program survey and an industry survey from practitioner and employer's perspective. The industry survey will particularly offer some insights from potential employers. Potential respondents will include HIT companies, healthcare providers, government agencies, and healthcare service consulting companies. The integration of BI component in HIT programs can better prepare the HIT graduates for the different roles in the healthcare IT industry. We hope more HIT programs will recognize the importance of the healthcare BI and the development of healthcare BI curriculum.

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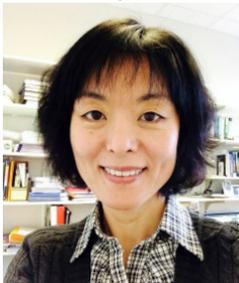


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ISSN 1055-3096