**Outline**

*Proposed Thesis Topic: Business Analytics--Interdisciplinary approach of computer science, math and business skills.  Would combined education result in a better understanding of complex business problems?* Can an evaluation tool be created to evaluate curriculum? Can curriculum be created with industry practitioners?

**Introduction**

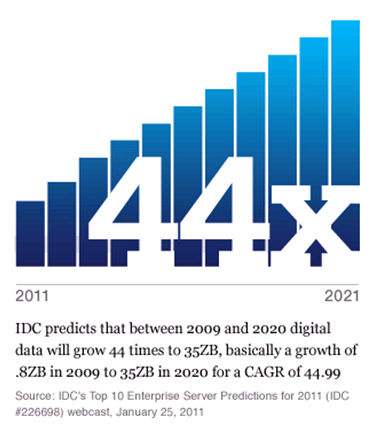
This paper reviews interdisciplinary education, analytics, and how the combination can create a higher-education curriculum that can help the IT industry fill jobs. Changes and innovations in higher education have been studied, debated, and reported in many publications (e.g., Alavi, 1994; Alavi, Wheeler & Valacich, 1994; Leidner & Jarvenpaa, 1993; Norman, 1992; Schlechter, 1990; Shneiderman, 1993; Shneiderman, Alavi, Norman & Borkouski, 1995). The technology fields deal with ever-changing landscapes where new concepts and approaches emerge incessantly. Employers, in an effort to increase their pool of qualified employees look to universities but there is a yawning gap in skillsets. Companies may decide to create internal training programs that require employees to define, investigate, and report on business problems that are relevant to them. Companies may also partner colleges to provide the desired skills through the creation of specialized higher-education curricula.

Employers typically seek employees who have significant specialization in one discipline area and broad knowledge in other relevant disciplines, such as applied math, computer science, and business. Employees with a combination of these skills, along with the ability to communicate information often provide a competitive advantage for companies. Currently, there is a gap in the available skills and often, companies in order to retain these key employees, must focus on talent management (Elkeles &Phillips, 2007; Cheese, Thomas & Craig, 2007; Harris, Craig &Egan, 2009) and provide additional in-house training.

Employers need to build a larger pool of talent as the rapid pace of technological change continues to fuel the need for high aptitude, multi-skilled employees (Cohen & Pfeffer, 1986; Stross, 1996); along with enabling growth of business strategies that depend on high employee involvement for success (Cohen & Levinthal,1990; Hamel, 2000), and the rise of “knowledge-based” companies that create value through the intellectual capital of their employees (Quinn, 1992; Stewart, 1997). Consequently, the alignment between higher institutional programs and actual business needs becomes paramount.

IBM believes in competitive advantage being achieved if data analysis is performed by employees who receive training not only in math and computer science, but business and communication too. IBM is one of many technology leaders advocating a change in teaching methodologies to assist companies in creating the competitive advantage with hard-to-duplicate analysis, unique analytics, and employees who are adaptable in using the analytics in diverse situations. IBM is not unique in this given other technology companies are seeking to support programs that develop a curriculum that broadens students’ perspective and introduces an expanded range of material. Applying the broad skills to actual challenges that may be confronted within a work environment may be seen as preparing students for this dynamic environment (Newell, 2001).The IT industry is looking for employees who are deep in a discipline yet broad in skills. This need is driving universities to champion new approaches in teaching an aspect of the computer science, math and business curriculums. The goal is to prepare students to embrace the challenge of a complex world where information is more readily available and technology (e.g. network, software tools) is enhancing analytic capability. Meeting this need in the industry requires fundamental changes in the way in which universities deliver practical educational experiences.

Given the tremendous advances in technology, there is significant need to utilize analytics to spot emerging trends to address business issues (Kohavi, Rothleder & Simoudis, 2002).Data Analytics is the science of using statistics to create models that can explain and predict customer behavior and company operations (Davenport & Harris, 2007). Business Analytics (or Big Data) is an area where broader skills taught in an interdisciplinary manner could benefit employers. IDC, a company that analyzes trends has predicted that data will increase from .8 ZB (Zettabyte) in 2009 to 35ZB in 2011. A large portion of the growth is in the sphere of digital data. Digital data growth in part, is attributed to the five billion mobile phones, 30 billion pieces of content shared on Facebook every month, and 30 billion RFID (Radio Frequency Identification Device) tags.



The low cost of digital storage and advances in cloud computing have made data storage so inexpensive that all of the world’s music can be stored on a disc drive that costs less than US$ 600. This amount of unstructured data today accounts for about 988 Exabytes, which is equated with the approximate equivalent of books stacked between the Earth and Pluto twice over (IBM slide deck). As a result, companies seem to be investing in information systems infrastructure in order to manage the large amounts of data being collated and stored.

Analyzing the data and providing insights into that data is undertaken by employees called data scientists. The term ‘data scientist’ actually conveys a new role with a definite broadening of skills. It is not just about math and statistics; it is also an intersection with industry domain expertise. Another role currently being discussed in organizations and is different from a data scientist is that of the user interface. This role helps visualize the data. Now there are unique ways in which information may be visualized so that a human being can synthesize the information very quickly and discern where the real patterns are evolving and what should be explored further. The data artists’ skills of design and creativity mix with the data scientist’s skills. So these roles focus on understanding a target audience and how best to present information to a target audience ergonomically so that the user can actually synthesize the information (Michele Chambers, CTO Revolution, Conversation, 2013).

A business case study on what Chief Marketing Officers (Rust, Moorman & Bhalla, 2010) were specifically looking for in analytics-skilled employees cited broad skills or T-shaped people (Iansiti, 1993; Barton, 1995; Johannenssen, 1999). These T-shaped people have broad expertise with depth in some area and the roles span those of customer managers in some organizations. These positions are seen as being most effective when they are T-shaped and combine deep knowledge of particular customers or segments with broad knowledge of the firm and its products. These managers must be sophisticated data interpreters who can decipher the key issues and provide creative solutions regardless of where the data resides. This is a change for employers. There are traditional marketers and there are analytics-focused employees. The more traditional style marketing employees are the ones who are actually bringing home the basics and the study has found that the new analytics employees are not getting the job done as they lack business expertise. The study concludes that the people who produce better results for organizations are those with grit and those that are not solely analytic-oriented.

The data scientist and data artist roles require grounding in scientific methods as well as soft qualitative skills including the ability to communicate, be open-minded, possess some emotional intelligence, be willing to try out new approaches while accepting failure and learning all over again. The employees should adopt an adaptive learning-style, but should also enjoy enhancing their math, science, statistics, or data mining skills. There may be some combined success indicators that would talk about multidisciplinary.(Job Descriptions Career Builder, HR Manager IBM; Swan & Brown, 2008)

“Organizations that want employees to be more data oriented in their thinking and decision making must train them to know when to draw on the data and how to frame questions, build hypothesis, conduct experiments and interpret results. Most business schools do not currently teach this. That should change.” (Rod Beresford --Brown University).

Companies that lack the analytic ability and focus may miss a shift in the market. But those that recognize the shift may be able to attract and retain skilled talent, which will offer them a competitive advantage.

*The growth of interdisciplinary programs in higher education in the United States*

Interdisciplinary research and teaching of the sciences has been seen since the time of Plato. He was the first to advocate philosophy as a unified science and his student Aristotle tried to organize information in politics, poetics, and metaphysics. The Roman higher education system debated if one discipline was satisfactory as a channel for advanced education (Klein, 1990). Interdisciplinary research has had strong roots in the United States since its introduction in the 1920s. The term “interdisciplinary[it]y” seems to have been used first by the United States Social Science Research Council. In the 1920s, documents produced by the Social Science Research Council (SSCR), indicated a desire to foster research that was based on more than one discipline (Woodworth, 1990). Margaret Mead in 1931 called for cooperation across the social sciences (Sakar, 1996). Over time, the interdisciplinary approach became a general requirement for exploration of new areas and potential knowledge as certain problems were particularly amenable to interdisciplinary research (Maasen, 2000). Scientific and technological advances, accelerated by World War II and the Cold War research, opened up possibilities for new kinds of conjunctive research between physics and other sciences, and engineering (Ellis, 2009).

Interdisciplinary programs are prevalent in today’s academic environment. The Association of Integrative Studies was founded in 1979 to promote the exchange of ideas within a diverse community of scholars, teachers, administrators, and the public regarding interdisciplinary integration. The organization envisioned the use of an interdisciplinary approach to address complex problems and give a direction to education that would enable it to match an increasingly complex global world. William Rees, Professor at the University of British Columbia in an interview (2010) highlighted that education needed to focus on the deep discipline but then, embed those individuals in a more integrated experience so they could draw connections between issues. Many colleges today, address and create this type of experience. Miami University in Oxford, Ohio, is an example of an established interdisciplinary program that was established in 1974 and is more defined than many in current literature and represents in detail the learning that needs to occur using an interdisciplinary approach.

Miami University is a four-year-degree granting school of 300 students and 14 full-time academic staff that offers team-developed but individually-taught majors culminating in a year-long senior project. The focus is on three core areas in the first academic year of the program: humanities, social sciences, and natural science with broad topics. The second year brings together core areas to discuss more complex topics. The third year focuses on further specialized topics to exemplify interdisciplinary methodologies in each core area. The fourth year emphasizes challenging the students’ unexamined assumptions about themselves and their worlds, the strengths of each discipline, and the development of a holistic approach and understanding through their capstone projects. Interdisciplinary problems are often open-ended and complex. The ability to solve these types of issues is enhanced by drawing from a number of disciplinary fields, which provides a rich variety of perspectives (Edwards, 1996).

Interdisciplinary work may ignore some areas of knowledge in the various disciplines. Simultaneously, it may explore linkages with the disciplines that would otherwise have been overlooked. In *General Education: The Changing Agenda* (1999), Jerry Gaff argued that greater attention was being paid to fundamental skills with a heightened interest in active, experiential, technological, and collaborative methods of learning. Ethics, diversity, and a global approach are being incorporated and the first and the senior years are being identified as crucial points in an undergraduate student’s experience. Collaborative learning and other innovative pedagogies are encouraging integration to fully connect and ensure applicable learning. Parents expect the result of the experience to lead to a career. But companies look for programs at the post-graduate level that may impact strategic programs and projects within their organizations. Analytics education can benefit from a cross-discipline experience to develop the aforementioned T-shaped employees.

*Teaching Curriculum*

This is an evolving approach in interdisciplinary education. The curriculum needs to be conceptualized on the basis of current pedagogical models and that assessment criteria needs to be expressed differently. There is also recognition that the assessment criteria are not sufficiently transparent and may not be necessarily understood by the students in the way the staff intends them to be (Steffani with Peter Shand, University of Auckland, personal communication, 2005). Many multi-institutions have created workshops to train their faculty to create new curricula and provide examples of successful programs. After working with a few colleges in the Raleigh North Carolina area, Meredith College in Raleigh developed an interdisciplinary curriculum for their environmental sustainability program. The school’s Director of General Education, Paul Winterhoff, worked with his team as they cataloged courses across a range of academic fields to substantially focus on sustainability-related concepts and ideas. They did not limit themselves to identifying existing courses, but also introduced new initiatives in a variety of areas of study, created living learning laboratories, such as a student reuse store and a rainwater harvesting lake (Johnston, 2013).

Within an interdisciplinary program, instructors would tend be more rooted significantly in one discipline than another. However, interdisciplinary programs demand teaching teams with disciplinary origins that are as broad as possible. The team then needs to work closely to develop a concept of shared territory and reach shared conceptions of the curriculum for their interdisciplinary programs (B. M Grant, personal communication, 2004). This can be challenging, because academic educators become “encultured” into the language and traditions of their disciplines. In turn, they may subconsciously “enculture” their students into that discipline. (Godfrey, 2003; Lave & Wegner, 1991). Any perceived dilution of a disciplinary culture will tend to be strongly resisted by academic staff.

According to Stefani, students may not receive an effective enculturation into the means/methodologies/basic principles of the “parent” disciplines of an interdisciplinary program, and it may be difficult for faculty members who are deeply entrenched in a particular discipline to develop alternative research paradigms and epistemologies suited to new and different subject areas (Stefani, 2009, p47). In a changing world, where knowledge is transient and the ability to transform and manipulate it to solve more complex problems is a key to economic success and sustainability (Breivik, 1998), these barriers must be overcome to allow interdisciplinary to flourish.

University partnerships with companies in the field of analytics are being sought to help define and support curriculum. IBM partners with several universities and provides an academic initiative web portal, access to a software portfolio, open data sources, white papers, case studies, videos, games, and in house experts. This partnership is important as IBM and others like it will be hire graduates of the program. (Fodell, conversation, 2013)

*Business Analytics and Interdisciplinary approach*

Business analytics is very popular right now, especially in business schools according to the Program Director, Global University Programs, Skills for the 21st Century at IBM. The curricula are focused on predictive analytics or the use of data to make decisions or provide insights. IBM working with Fordham and Yale is a perfect example of this. They focus on the marketing aspects of analytics and customer sentiments, and investigate how one can drive decisions about consumers and work practices using analytics. The second example of focus on curriculum shifts the spotlight on to data that includes established information management programs. These programs develop data scientists: individuals who are trained to manipulate, warehouse, manage, and secure data. In essence, data scientists prepare data so it can be used in analytics. The first example falls into the category of business analytics; using data to make business decisions. The second example highlights the competency of understanding the data and working with it. Getting the data right is 90% of the work in analytics. A third example of focus in the curriculum relates to deep computing analytics, which is more mathematical, and is usually seen in the School of Informatics or Mathematics; or in the business world, as being akin to operations research. This area of analytics focuses on building algorithms or getting insights and really understanding the linear regression analysis and the hypotheses, testing it deep in statistics. All three skills are necessary to move forward with the visualization and designing of how to present data. These skills could come from the School of Art and Design. These are three different roles and three different types of curricula in most higher education institutions (Dianne Fodell, IBM research, conversation, 2013)

Business analytics projects are typically complex and require cross-functional activities. There is a business need for both, real-time decision-making in areas reacting to the weather, traffic, and crime. There is also a reflective nature of data which encompasses deep analysis that is needed to generate predictions and insights in business, opportunities, and trends. In a business-driven environment, the management determines a strategy and the operational area determines the information needed and the best way to support that strategy. The team develops metrics to determine if they are on track to meet the overall management strategy. This process requires the input of decision-makers from the sales, marketing, production, general management, and HR departments for the overall management strategy to work. If the objective is to increase ad revenue from a website, for example, it is necessary to identify metrics that will be used to determine if changes in business strategy can achieve that objective. The trends in analytics are increasing in complexity and there are different types of analytics. From the basics of reporting and drilling down into reports to figure out what the problems are, how many, and how often they occur to studying the optimization of how to achieve the best outcomes to the most recent trend of Stochastic Optimization, which is how can we achieve the best outcome including the effects of variability (Davenport & Harris, 2007).

There are clear skill requirements that data scientists must possess to work in this area. Specifically, professional competencies are required within the fields of business, methods, data, and communication. The methods and data education usually comes from a computer science, math, or engineering background. There is a requirement for a basic understanding of how to retrieve and process data through knowledge of Structured Query Language (SQL). Business competencies are needed to understand the business processes that the data scientists are supporting and how the information can add value at the strategic levels. With regard to method competencies, the data scientists need to clearly visualize and organize information so that relevant knowledge is provided when the user receives the data (Davenport &Harris, 2010).

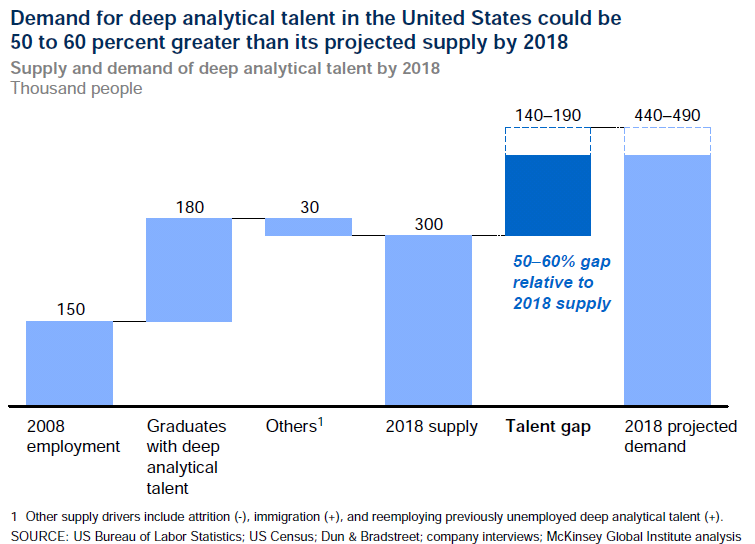
Data scientists have usually ended up in their roles by accident rather than by design. They may be qualified for their roles either as domain experts who have acquired specialist data skills in the course of their careers, or by originating as computer scientists with domain knowledge acquisitions made over time. Swan and Brown (2008) assert that most data scientists have learned their skills on-the-job because proper training opportunities were lacking. Although until recently there has been no tight specification for qualifications, the trend now is increasingly in favor of post-graduate training in informatics. In practice, data scientists need a wide range of skills: domain expertise and computing skills are pre-requisites but people skills are equally critical as a major part of the role.

In Advancing Interdisciplinary Studies, Klein and Newell (1997) defined interdisciplinary study as “a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession.” In “Interdisciplinary Thought,” Ursula Hübenthal (1994) asserts that interdisciplinary collaboration is required because “problems are much too complex to be judged appropriately, much less solved, merely with the subject-knowledge of a single discipline” (p. 727). An interdisciplinary approach to analytics in an age where the human mind needs the technology to perform analysis may be appropriate given those interdisciplinary visionaries.

*Employment*

The employment gap for analytics is a strong motivator for employers to assist higher educational institutions. Employers want employees who are not only deep in one or more subjects but broadly knowledgeable across many. The depth is usually in engineering, computer science, or business consulting. The breadth is in communications skills and understanding people and culture, understanding different industries or an industry. The expectations from data scientists necessitate broad skills where domain experience is necessary to develop the right questions from proper data. The management skills of knowing when and how to use data for decision-making and visualizations to present data in meaningful ways is as critical as skills needed to create mathematical and operations to develop analytics algorithms and tool developers to mask the complexity of data and analytics to lower skill boundaries. That is why there is a skill gap to fill data scientists’ positions globally.

Higher learning programs are needed to address a shortage of 140,000 to 190,000 people with analytical and managerial expertise and 1.5 M managers and data scientists with the skills to understand and make decisions based upon the study of big data in the United States. The need for skilled labor is not unique to the United States. However, the chart below from McKinsey represents the gap in the supply of analytic talent.



McKinsey Global Institute Report, May 2011

*Current Curricula in Higher Education*

The curricula of analytic courses involve using business cases, gaming, videos, problem-based learning approaches, and communication skills. As the field of technology education evolves, providing students with well-developed curricula that reinforce academic content and higher order thinking skills that promote active involvement with technology becomes a unique mission (Johnson, 1991). Academic programs should acknowledge the widening gap between theory and practice, especially since they have enormous implications for their graduates’ abilities to find work (Androlie, 2006).

In their article, “The Current State of Business Intelligence in Academia,” Wixom et al. (2011) report four key findings:

(1) Universities should provide a broader range of business intelligence (BI) skills within BI classes and programs.

(2) Universities can produce students with a broader range of BI skills using an interdisciplinary approach.

(3) Instructors believe they need better access to BI teaching resources.

(4) Academic BI offerings should be better aligned with the needs of practice.

These findings suggest that academics may be behind the curve in delivering effective analytic programs and course offerings to students (Chaing, Goes & Stohr, 2012). The business analytics curriculum resides in business schools, and the fields of computer science, engineering, and math. DePaul, Fordham, Ghent, and Yale have programs focusing on predictive analytics. These analytics focus on the “what could happen next,” “what will happen next,” “what if trends continue,” and “what actions are needed.” Boston University, University of Lyon, and Peking University have programs on Information Architecture focusing on the management of data, security, and quantitative methods. The state of North Carolina has a deep computing analytics program where graduates in engineering, math, or computer science focus on statistical methods, data mining, analytic tools, financial and risk analytics. The world of business analytics is embedded in the curriculum but more recently, programs at Northwestern University Engineering, Syracuse University, and Miami University have offered analytics at the undergraduate, graduate, or even both levels of programs. (AIS, Association for Integrative Studies website)

To provide some context, Northwestern University has two programs: One is in the School

of Continuing Education, focused on predictive analytics business analytics. IBM is working

with the School of Engineering, to create a premier degree in analytics. This program started last

Fall and is a 15-month program after the undergraduate degree is completed.

The state of North Carolina State has an Institute for Advanced Analytics. This is a nine-month program where the students have to be in the classroom five days a week, and five hours a day. But those students are getting hired fast

by Wall Street. They teach tools with a focus on SAS and SPSS; two technologies used for

analysis. This is program that has been placed the longest, and is the most renowned program in analytics according to technologists at IBM.

The transformation of the curriculum is not the only transformation. Utilization of

information technology is required in the classroom. There are 4 stages of implementation that

occur over time. Stage 0 entails some planning, experimentation, and recognition that others are

ahead. Stage 1 witnesses capital investment yet, progress for applications is slow on items that

have never been attempted. Stage 2 is where there costs stabilize and utilization climbs and

Stage 2 is where there are new levels of effectiveness. (Green, Gilbert, 1995).

The faculty on an interdisciplinary team needs to recognize when tools are needed,

collaboration is necessary, and when individual skills should be assessed. This will move the faculty to

shift from teaching to learning to facilitate this type of learning experience. Research indicates

that students learn differently today, so there is a need to shift the faculty to meet those needs (Bennett & Bennett, L. 2004) and ensure learning efficiency and retention (Frye, 1999; Becker & Dwyer, 1998).

*Teaching Methodology*

Adoption-diffusion theories refer to the process of the spread of a new idea over time (Straub, 2013). Teaching with an interdisciplinary education methodology from general education can be helpful in an analytics curriculum. The learning is a change from the standard lecture process and e-learning tools can be used to support these processes. For example, some tools (e.g., chat tools and discussion boards) allow students from different disciplines to negotiate and construct a shared understanding of the problem without the need to meet face-to-face. Other tools (e.g., shared workspace, e-portfolios) make the sharing of resources easier across members of groups when compared to situations where sharing requires personal contact. Blended learning, the combination of face-to-face and e-learning, combines the best of both traditional and on-line learning approaches. The concept of technology literacy to facilitate this type of curricula to create an integrated learning is necessary. (Barron, Kernker, Harmes & Kalaydijian, 2003). Virtual classroom studies have tested students who demonstrated better than their counterparts who learned in a traditional classroom (Rogers, 2000).

Tools offer some advantages over face-to-face discussions. On-line asynchronous discussions are written rather than spoken and hence, a permanent record of the discussion is available. This enables students to reflect upon past discussions and learn from them. For example, if the discussion leads to the solution of a problem, the students are able to review a comprehensive record of the problem-solving process, one that illustrates how the various disciplines intersect and work together (Littlejohn & Nichol, 2009, p39).

Business cases are key tools to throwing up a significant issue that broadens the students’ thinking. Problem-based Learning (PBL) approaches have attracted increased interest in higher education due to claims that it provides a more active learning environment. Problem-based learning has an advantage in this environment since it teaches the different skilled people on the team to work together and demonstrates, in a safe environment, the challenges of interdisciplinary working groups. Proponents of PBL (Major & Palmer, 2001; Savin-Baden & Wilkie, 2004) surmise that students here perform at least as well as students in the conventional programs but also demonstrate greater ability to apply their learning and a better understanding of the principles taught to them.

*Environment*

Most classrooms instructors keep tables and chairs in a traditional classroom seating arrangement and class is devoted to teacher-directed instruction. Instructors are deeply focused on their specific disciplines. Feedback to students is expressed through grading. The suggested environment for an interdisciplinary program is to establish classrooms that foster student-to-student interactions, gaming scenarios, multimedia projectors, sound systems, and access to the Internet. Activities in the classroom and assignments in the curriculum should provide student research and project opportunities with ongoing feedback from instructors. Faculty should be trained in performance-based assessments. The same learning objectives, content, and learning sequence and assessment should be used. Face-to-face learning can be a powerful tool when trying to teach people how to work outside of their discipline/across disciplines. Activities in this environment need to give students the experience of working across disciplines so that the experience, as well as the content of the exercise, is part of the learning. (Chandramohan & Fallows, 2009)

*Assessment*

There are several assessments that are needed in an analytics course of study: the alignment with the jobs that the graduates seek, the overall curriculum, the effectiveness, and the productivity of a student in his or her work are primary. It is incumbent upon the course and the program designers to use models of curriculum development, which seek to align the assessment strategy with the intended or stated learning outcomes of any course. “Authentic Assessment” is becoming a more desirable means of judging student ability because it entails setting learning tasks as closely related as possible to those that would be involved in the profession to which the degree is orientated (TEDI, 2001; Wiggins, 1993).

The overall assessment strategy will depend on the model upon which the interdisciplinary program is based. For example, according to Knight and Yorke (2003), within modular programs in which students can choose which units of study to pursue, student development in subject disciplines may be less structured than in single subject programs. A lack of immersion in a single subject might lead to the assumption that multidisciplinary students do not perform as well in a specific area of learning as their mono-disciplinary peers. However, the research suggests otherwise.

Many subject areas or multi-subject areas of study, such as medicine and engineering are turning to problem-based learning (PBL) paradigms as suitable modes of study. This learning mode involves a different approach to teaching and significantly innovative approaches to the assessment of learning. PBL generally involves students working in groups, a situation which enables the development of a range of products and process skills, but also requires staff to clearly inform students about peer and self-assessment processes (Boud, 1995; Duch et al., 2001; Stefani, 2004; Tariq et al., 1998).

The evaluation of curriculum is needed to determine if the employers who hire the graduates are finding an increase in productivity or if they have to continue to supplement skills. There are several options for evaluation: the actual program could be evaluated against other program criteria or a template created by the company to assess the graduates and their impact/performance in the specific organization. Regardless of these, a measurement system of evaluation is needed for companies to assess the need for deeper partnerships with universities to ensure that the fundamentals are learned along with the ability to deal with complex business problems that change market trends. The measurement system, the ability to collect the data and the frequency of ensuring that it keeps current with the changing technology is crucial. Companies can rely on the universities to provide a baseline and focus learning and development functions on greater company-specific knowledge. The end result will be that a company may leverage the university approach and augment curriculum with a more specific set of skills. Without an evaluation tool, companies will continue to allocate money and resources to programs that may or may not be successful in their efforts to produce results. Traditionally, assessment and evaluation have been the means by which feedback about performance has been provided to both, the learners and the instructors (Kealey, 2010).

Most of today’s learning and training evaluation theory is based on Donald L. Kirpatrick’s Level 1–4 model. Level 1 is the reaction of the student; essentially what they thought and felt about the training. Level 2 is learning, which is the resultant increase in knowledge or capacity. Level 3 is the behavior, which is the extent of behavior and capability improvement, and implementation/application. Finally, Level 4 is the effect on the trainee’s performance on the business or environment (Kirkpatrick & Kirkpatrick, 2006).

Kirkpatrick’s Level 1–2 will not be appropriate for the level of information and its correlation to success as Level 1 and Level 2 focus on whether the individual enjoyed the training and what his reaction to it may have been. In this case, the instructor sends out a survey after the training, validating the content, the length of time, and the competence of the facilitator. Level 2 is more to do with what could have motivated them to attend. The literature suggests that people attend these programs because they want to, they generally get more out of the program, and there is a higher transfer rate. Transfer implies that when they go back onto the job, they transfer the skills. So Level 2 is really centered on assessing learning. This is helpful in the continuous improvement stage and can be used as a baseline since any transfer of the skills to the job means the employees are actually doing what they learned, and what they learned was effective. If this is the case, then, success will follow. Levels 3 and 4 say that success would entail an assessment and evaluation of ratings over time, which indicates that there is a high level of transfer and ability to navigate an organization (Cromwell & Kolb, 2004).

The Success Case Method maybe a more useful method of evaluation as it is a process for collecting information about the effectiveness of a training program through the use of case studies. The method is used with the intent to collect both, positive examples of where training is working and negative examples of where training has failed in some way. The process of data gathering is undertaken to help identify and create case studies that are then shared within the

organization (Brinkerhoff).

Rather than undertake assessments with Kirkpatrick, Brinkerhoff et al. there seems to be another option: Tom Davenport’s (2010) methodology for analytics at work is another way to address the assessment. Using a set of key performance factors of the identified analytics programs at higher education institutions, he evaluates various programs on the basis of how the analysis of a program would be different from another, would the GREs be predictors, work experience/internships, partnerships with Industry....i.e., what factors would make some programs successful? (Measurements could be hiring rates and performance data). The definition of the key success factors determined with employers would be critical to this evaluation methodology.

*Potential Pitfalls with the approach*

One apprehension related to this interdisciplinary approach stems from the assumption that it takes specialization and time devoted to a single field of study to develop practical expertise. If students are to develop a feel for a discipline’s perspective, they must learn to think like practitioners of that discipline. Members of a discipline are not so much characterized by the conclusions they arrive at but by the way they approach the topic, the questions they ask, the concepts that come to mind, and the theories behind them. A discipline’s perspective provides the means by which a question is answered, not the answer itself. However, interdisciplinary courses are more than pieces of the disciplines from which they are constructed. They extract the perspective embedded in each of these components, compare them, and ferret out their underlying assumptions when they conflict, and then, integrate or synthesize them into a broader, more holistic perspective.

Critics point to the difficulty of measuring the effectiveness on interdisciplinary programs. However, Miami University found that the course scores of students who were in an interdisciplinary program were higher in the discipline courses than those of students who were solely focused on a disciplined approach to learning. Miami University faculty surmised that this broader framework of knowledge could provide students with clarity in understanding how the knowledge they had gained could be applied, and this in turn could improve their overall comprehension.

The faculty that teaches an interdisciplinary program faces a quandary: namely, how to teach broadly without teaching superficially. Most institutions’ primary focus is on the specific, isolated disciplines, so they create and teach broad-based education that requires an unconventional approach to both, teaching and curriculum development. This requires collaborating and teaching with colleagues across disciplines. This also requires a change in the measurement of faculty from solely the rigor of their of their scientific research to more grounding in actual business practice that is relevant to practitioners (Bennis & O’Toole, 2005).

To develop effective data scientists, for example, the curriculum needs to include proficiency in data and people. Although quantitative and technical skills are paramount (i.e., stochastic volatility analysis in finance, biometrics in pharmaceutical, and informatics in health care), students also have to understand software development to build models with solid decision-making rules. Within an interdisciplinary program, the range of concepts and theories drawn from disciplines, the rigor and technical precision with which they are developed are primarily functions of the disciplines involved and the academic strength of the students taught more than the particular definition of interdisciplinary studies, according to Newell (2008). The ability to define business needs is also critical, so grounding in general business practices is a core element. Relationships and communications skills are important to enable data scientists to collaborate effectively and accurately convey the results of their analytical work. Companies are looking for this full spectrum of skills, however, only a few individuals seem equipped for the task.

The interdisciplinary process is suited for the promotion of what Richard Paul (1987) calls a “strong sense critical thinking,” while disciplinary courses are often more likely to promote a “weak sense critical thinking.” The former includes a number of valuable, informal logic skills, such as distinguishing evidence from conclusion, relevant from irrelevant facts, and facts from ideals; assessing the validity of assumptions and arguments; and recognizing internal contradictions, implicit value judgments, unstated implications of arguments, and the power and appropriateness of rhetorical devices” (Newell, 1988, p. 220). Through these processes, students derive insights into topics that a focused disciplined approach to learning may not unveil.

Critics of interdisciplinary education state that there are programs that are just a collection of disciplinary perspectives organized under an interdisciplinary heading. This does not meet the criteria as there must be explicit interdisciplinary programs that provide structure, process, and opportunity to study multiple facets. The programs must be intentional and institutionally recognized. Organizing this kind of multidisciplinary, project-based education can be quite expensive. The approach is based on a multitude of hands-on sessions and laboratory work, and computers, and software licenses to effectively create the experience can stress a budget.

*Conclusion*

In the business world, information is central to the creation, delivery, and service of products that a company’s performance is based upon along with how quickly it can respond to changes in the market, customer behavior patterns, climate changes etc. Executives will need to have a clear understanding of data and its transformative capabilities to provide direction to their organizations. Organizations that base and evaluate their decision-making will have an advantage over those who do not (Dhar, V., Sundararajan, A., 2007).

In an ever-changing employment climate with new, technology being continuously introduced, skills training becomes an ongoing component to keep experience and expertise at the necessary levels. It takes many years and tremendous focus on learning a particular discipline to ensure competence and by creating a greater cross-discipline approach, the focus on depth in a topic is potentially sacrificed. Students in an analytics curriculum need strong fundamentals in their understanding of data distribution, probability theory, and hypotheses testing. They also need business understanding of where the pain points are in a company or product and where the company is struggling to make decisions. The ability to evaluate the risks and benefits of making decisions, the ability of a data scientist to be in sync with new technology, along with the ability to align with subject matter experts can be a significant asset to the overall business as well as a retention tool for those employees.

Informal training, focused skills, and job-related learning was found to be complementary in studies by Gross (1976) and Mincer (1962).These studies were focused on the economic impact but stated that the combination of colleges producing students with a focus on jobs increased human wealth by increasing marketable skills and indirectly so, by increasing learning efficiency. In 2008, the Accenture Institute for High Performance conducted a research study, “Talent Engagement, Attitudes, and Motivations” to investigate influences that kept analytic talent engaged. The research found that trained data scientists who contributed to the business were significantly more engaged at work, more satisfied with their jobs, and more committed to their organization than other types of employees.

The gap between what institutions are teaching in analytics and where businesses are advancing with this technology is widening. This paper argues that there are steps that can be taken that will benefit students and institutions. Some institutions have taken steps to close that gap. The impact of classroom dynamics with a group of students from multiple disciplines, adjustments to the curriculum and the environment imply a positive change for institutions dealing with higher education. As the faculty becomes comfortable with the curriculum and skill requirements along with collaborations with the industry, the potential for providing students to help address the job gap will be positive. The new curricula will enhance the quality of education for students and provide them significant career opportunities and rewarding work environments at the workplace.

**References**

Alavi, M., Yoo, Y., Vogel, D. (1997).Using Information Technology to Add Value to Management

Education, *The Academy of Management Journal*, 40, 6 pp. 1310–1333.

Androile, S. (2006). Business Technology Education in the Early 21st Century: The Ongoing Quest for Relevance, *J*o*urnal of Information Technology Education, vol.5.*

Associated Press. 2012. Columbia U plans new institute for data sciences. http://www.cbsnews.com/8301-505245 162-57482466/columbia-u-plans-new-institute- for-data-sciences/.

Barton, L. (1995). D. *Wellsprings of Knowledge: Building and Sustaining the Sources of*

*Innovation.* Boston: Harvard Business School Press.

Becker, D'A. , Dwyer, M. (1998). The impact of student verbal/visual learning style preferences on implementing groupware in classroom. *Journal of Asynchronous Learning Networks*, 2(2), 61–69.

Bennett, J., & Bennett, L. (2004). Structuring an Instructional Training Program for Faculty

Based on Diffusion of Innovation Theory. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, 2004, 1, pp. 3275–3278.

Bennis, W, O'Toole, J. (2005). How Business Schools Lost Their Way, *Harvard Business Review,* May on-line version

Bishop, J. (1996). What we know about Employer-Provided Training: A Review of the Literature, New York State School of Industrial and Labor Relations-Cornell University, working paper #96–09

Bloomberg Businessweek Research Services, 2011. The current state of business analytics: Where do we go from here? Bloomberg *Businessweek,* 9/11.

Brinkerhoff, R. O. (2005). The Success Case Method: A Strategic Evaluation Approach

to Increasing the Value and Effect of Training. *Advances in Developing*

*Human Resources, 7*(1), 86–101.

Chandramohan, B., Fallows, S. (2009). Interdisciplinary Learning and Teaching in Higher Education: Theory and Practice, Routledge, NY.

Cheese, P., Thomas, R., Craig, E. (2007) The Talent Power Organization. London:Kogan Page.

Chiang, R., Goes, P., Stohr, E. (2012). Business Intelligence and Analytics Education, and Program Development: A Unique Opportunity for the Information Systems Discipline. ACM Transactions on Management Information Systems, 2,3, article 12.

Davenport, T., Harris, J. (2007) *Competing on Analytics*, Harvard Business School Press, Boston MA.

Davenport, T, Harris, J, Morrison, R. (2010) *Analytics at Work*, Harvard Business Press, Boston MA.

Davenport, T, Manville, B (2012). *Judgment Calls 12 Stories of Big Decisions and the Teams that got them Right,* Harvard Business Review Press, Boston MA.

Davies, M, Devlin, M, Tight, M. (2010*) Interdisciplinary Higher Education: Perspectives and Practicalities*, Emerald Group, Bengbu UK.

Debone, E. (1985) *Six Thinking Hats*, Little Brown and Company, Boston MA.

Dear, V., Sundararajan, A. (2007). Information Technologies in Business: A Blueprint for Education and Research*, Information Systems Research*, 18, 2, pp125–141.

Edwards, Alan (1996). *Interdisciplinary Undergraduate Programs A Directory,* Copley Publishing Acton MA.

Elkeles, T., Philips, J. (2011). *The Chief Learning Officer*, Routledge NY.

Frye, C. (1999). Learning online: Style matters. *Inside Technology Training*; 40–42, 47/

Green, K, Gilbert, S. (1995). Great Expectations: Content, Communications, Productivity and the Role of Information Technology in Higher Education, *Change*, 27,2, pp. 8–18.

Harris, J., Craig, E., Egan, H. (2009) “How to Organize your Analytical Talent” Research report, Accenture Institute for High Performance.

Iansiti, M. (1993). Real-world R&D: Jumping the product generation gap. *Harvard Business*

*Review, 71,* 3 pp.138–147.

Johannenssen, J-A., Olsen, B., and Olaisen, J. (1999). Aspects of innovation theory based on

knowledge management. *International Journal of Information Management, 19,* 2 pp.

121–139.

Johnston, L. (2013) *Higher Education For Sustainability,* Routledge NY.

Kohavi, R., Rothleder, N., Simoudis, E. (2002). Emerging trends in business analytics, Communication ACM, 45, 8, pp 45–48.

Kirkpatrick, D. L. K. J. D. (2006). *Evaluating Training Programs: The Four Levels* (3rd

Ed.): Berrett-Koehler Publishers, Inc.

Klein, J (1990). *Interdisciplinary History, Theory and Practice*, Wayne State Press, Detroit MI.

Lavalle, S., Lesser, E., Shocklye, R. Hopkinks, M. S., Kruchwitiz, N. (2010). Analytics: The new path to value: How the smartest organizations are embedding analytics to transform insights into action. *MIT Sloan Management Review*, 12/10.

Lavalle, S., Lesser, E., Shocklye, R. Hopkinks, M. S., Kruchwitiz, N. (2011). Big data, analytics and the path from insights to value, *MIT Sloan Management Review, 52*, 2, 21–31

Newell, W., Klein, J. (1996) Interdisciplinary Studies into the 21st Century, *The Journal of General Education*, 45, No. 2, pp. 152–169.

Petrie, H (1992). Interdisciplinary Education: Are We Faced with Insurmountable Opportunities?, *American Educational Journal,* 18, 229–333.

Rogers, D. L. (2000). A paradigm shift: Technology integration for higher education in the new millennium. *AACE Journal*, *1*(13), 19–33.

Rosen, S. A.(1976) Theory of Life Earnings Journal of Political Economy, Vol. 84, No. 4, Part 2: Essays in Labor Economics pp. S45-S67Published by: The University of Chicago Press Stable URL: http://www.jstor.org/stable/1831102

Rust, R., Moorman, C., Bala, G. (2010). Rethinking Marketing, *Harvard Business Review*, January-February.

Straub, E. (2013) Understanding Technology Adoptions: Theory and Future Directions for In formal Learning. *Review of Educational Research*, June 2009, 79. 2 pp 625–649.

Stufflebeam, D.L, and Shinkfield, A.J. (2007). Evaluation Theory, Models and Applications. Jossey-Bass. San Francisco, California.

Subedi, B.S. (2004) Emerging Trends of Research on Transfer of Learning, *International Education Journal Vol 5, No 4*

Swan, A., Brown, S. (2008) The skills, role and career structure of data scientists and curators: An assessment of the current practice and future needs. Report to the JISC, Key Perspectives

Trank, C., Rynes, S., Bretz, R. (2002). Attracting Applicants in the War for Talent: Differences in Work Preferences among High Achievers, *Journal of Business and Psychology*, 16, 3 pp. 331–345.

Wixom, B., Ariyachandra, T., Goul, M. Gray, P., Kulkarni, U., Phillips-Wren, G. (2011). The current state of business intelligence in academia. *Comm. Assoc. Inform. Syst. 29*, Article 16. Received April 2012; revised August 2012; accepted August 2012 ACM Transactions on Management Information Systems, Vol. 3, No. 3, Article 12, Publication date: October 2012