Business Intelligence & Analytics Education: An Exploratory Study of Business & Non-Business School IS Program Offerings

Completed Research Paper

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Abstract

Business intelligence (BI) has been recognized as the most essential and valuable technology for business. CIOs surveyed by the Society for Information Management have consistently ranked it as one of the most important business applications for the past ten years. BI has become incredibly important to an organization's decision-making process. There is, however, uncertainty regarding whether there is enough being done to prepare college students to enter the work force with adequate technical and analytical skills to meet the current need for BI analysts. In this paper we examine whether there is a difference in the proportion of schools offering either BI coursework or BI degrees in a Business vs. Non-Business IS program. The results indicate differences in the proportion of schools offering BI courses and BI degrees *located in Colleges of Business or Non-Colleges of Business*. Although the research is exploratory we provide implications for the findings.

Keywords:

Business intelligence, IT education, business analytics, information systems education, AACSB

Introduction

Business Intelligence (BI) allows organizations to make sense of the vast volumes of information they acquire during their normal course of operations (Zeleny, 2006). Organizations can use BI applications to perform multidimensional analysis on measures such as sales, profit and cost per dimensions such as products, promotions, time and region (Andoh-Baidoo, 2011). For example an organization can use a BI application to compare sales for a particular product in a specific sales region for the second quarters in 2013 and 2014. Data mining techniques, such as decision tree, can be used to predict a person who is likely to discontinue using telecommunication services at the end of the initial promotion period. Such analysis provides valuable insights and allows decision makers to take actions that would affect the future standing of their organizations. Decisions such as defensive strategies to ward off competitors' market-share advances, pricing strategies, inventory levels, customer trends, supplier trends, and various other applications have highlighted how insightful BI can be. Though numerous studies have been conducted to better define and describe the exact machinations of BI applications, the essence of it boils down to a process by which an organization's raw data (information) is converted into actionable intelligence (knowledge) (Zeleny, 2006). BI belongs to and is the manifestation of modern day decision support systems. A major component of BI is analytics.

Both the industry and academia recognize the importance of BI and related areas such as business analytics and big data. For the industry, both the Society for Information Management (SIM) (Luftman and Derksen, 2012) and IBM Tech trends (2011) acknowledge BI as critical technology for businesses. In academia, major and minor conferences in information systems, decision sciences and other management disciplines discuss business intelligence, big data and other related topics as standalone tracks with most of them organizing special workshops on tools for teaching these concepts and technologies during their annual conferences. In addition, special issues have been organized on the topic in academic journals. Notable among these is the special issue on business intelligence published in MISQ in December 2012 (Cheng et al, 2012).

The lack of experts in BI and related areas is a great challenge to organizations. A Mckinsey Global Institute report (Manyika et al. 2011) predicts shortage of approximately 200,000 professionals with requisite knowledge in business intelligence/analytical skills by 2018. Furthermore, Hal Varian, Chief Economist at Google and Stanford emeritus professor, recognizes the shortage and therefore advises students to develop deep analytical skills to address the gap in skilled workers in this growing and critical field (Cheng et al., 2012). This shortage of skilled labor for BI, business analytics and other related areas pose several questions: Is it possible that institutions will be able to provide the necessary skills? Will there be enough skilled labor to fill the anticipated vacancies? Will business programs rise up to the challenge of producing these highly analytical students?

These issues have not been addressed although some scholars have examined the skills that need to be taught and proposed the use of interdisciplinary approach to deliver BI and analytic skills (Wixom et al., 2011) while others have proposed various options by which graduate BI analytics programs can be offered (Chiang et al., 2012). We seek to contribute to addressing the research gap. We use Business Intelligence and Analytics (BI&A) to refer to BI, analytics and other related areas such as big data (Chiang, Goes, Stohr, 2012). Schools offering IT related and decision related programs offer BI&A courses while some schools offer complete BI&A degrees. BI&A is business-oriented demanding that those who develop skills also develop complementary knowledge and skills in business. Although Wixom et al. (2011) encourage interdisciplinary mode of delivering BI&A courses, they appeal to IS programs to lead. Similarly, Chiang et al. (2012) task IS programs to respond to the challenge and opportunities in producing a new generation BI&A professionals.

The purpose of this paper is to explore whether colleges are offering BI. In order for BI&A applications to be useful, understanding the business domains for which the applications can be applied are critical. Hence we believe that IS/IT related programs located within business schools are required and will be more interested in offering BI&A courses. Further, The Association to Advance Collegiate Schools of Business (AACSB) in recent times recognized the critical relevance of the impact of teaching, service and research. One of the measures of impact is students' placement. Since there is a greater need for graduates with knowledge and skills in BI&A it makes sense that IS/IT related programs within the college of business have incentives to encourage the teaching of skills with great demand to demonstrate the impact of their programs.

We investigate two specific research hypotheses in this paper.

H1: The proportion of schools that offer BI&A courses for degree programs in the College of Business is higher than that in Non-College of Business

H2: The proportion of schools that offer BI&A as a degree program within the College of Business is higher than that in Non-College of Business

Using the membership list of U.S. business schools accredited by the AACSB, we surveyed the website of schools that are offering courses in IS/IT related programs in order to examine the extent of their IS/IT curriculum offerings. Although our research is exploratory, it presents several implications. We argue that business school programs should consider offering these courses otherwise non business schools will rise up to the demand and challenge leading to the output of individuals with technical expertise that may lack business domain knowledge that organizations seek (Wixom et al., 2011).

In the proceeding sections of this study we look at some of the prevailing ideas about BI&A and its potential insofar as creating value for the organization. Then, we provide an overview of our methodology.

Subsequently we present our findings. Finally, we conclude with discussions on the implications, limitations and potential future research.

Literature Review

BI&A can retrace its steps back to the late 1960s in the early days of the Decision Support System (DSS). These systems were designed to support the managerial decision making process, and, while it has undergone many transformations throughout its brief history, its underlying purpose has always remained the same: streamlining business, improving decision making and increasing profits. In the 1980s, DSSfacilitated the flurry of business process re-engineering efforts that many enterprises undertook in an effort to reduce their costs and increase their profits through an integration of the knowledge that DSS of the time provided (Zeleny, 2006, p752). In the 1990's, decision support systems underwent a paradigm shift of sorts. Prior to then much of the focus on data collection and analysis had been on *internal resources* – sources of information that were generated within the normal course of operations (Zeleny, 2006, p753). Some of these items included transaction histories, inventory levels, inventory costs, and employee salaries/wages. In the mid-to-late 1990s, however, the focus of data collection expanded beyond the traditional *internal* resources and began to consider *external resources* such as suppliers and, more importantly, the customers (Zeleny, 2006, 753). Four powerful tools that helped change DSS were data warehouses, OLAP, data mining, and web-based DSS (Shim et al. 2002). In recent years, both in practice and research, business intelligence is the common terminology used when referring to applications that provide decision support capabilities in decision making and especially those that provide analytics (Watson et al. 2007).

For over a decade, SIM surveyed IT executives in over 15 industries to list what they felt were the top 5 application and technologies affecting the ability of businesses to compete in order of importance (Luftman and Derksen, 2012). BI&A has become so important in the business world that IT executives have consistently ranked it amongst the top 3 for the past 10 years. It was ranked first for five of those years, second in four years, and third in one year.

Much of the importance placed on BI&A technologies are derived from the value that they can impart – perceived or otherwise. On its own, raw data such as inventory levels, previous years' sales figures, and purchase records do not necessarily impart too much meaning. However, when large amounts of these data are amassed and then analyzed for features such as dependence and trends, the business can truly begin to take advantage of the information they have amassed as a result of their operations. This *intelligence,* such as customer purchasing trends, supplier pricing trends, inventory depletion rates, average employee age, and salary/wages then becomes *actionable intelligence*, or, what can be called *knowledge* (Zeleny, 2006). BI&A applications allow the user to transform unprocessed data into meaningful information. This information then becomes knowledge the moment it allows its users to perform any type of coordinated action towards some goal or objective based on the analysis of the processed data (Zeleny, 2006). Ultimately, or at least *hopefully*, with the increased ability to identify events such as customer purchasing trends, supplier pricing trends, and redundancies in their business processes, this coordinated action stands to provide future value for the organization either in the form of increased sales, profits, customer satisfaction, and so on.

So then, the question becomes – why is BI&A so important? We believethat BI&A is so important not only because of how easily it facilitates and expedites the decision making process but, also, because of what it adds – *value*.

In order for this value to be created someone must first make sense and analyze the masses of data that are at an organization's disposal. This person must possess certain knowledge and skills of their own that allow them to do this type of analysis effectively. This person must possess a technical, analytical, and business savvy that allows them to gather, manipulate and interpret the information that is at their disposal (Chiang, Goes, Stohr, 2012). This person, however, is in short supply.

The problem here is one that is becoming all too common: the skills necessary for highly technical jobs – such as those required in BI&A – are severely lacking (Manyika et al. 2011). BI&A professionals must be able to perform complex queries, analyze and interpret data from a business perspective, offer advice based on this knowledge, and a great number of other things. This is troubling considering how important those CIOs surveyed by SIM in 2012 felt BI&A technologies and applications have been and will continue to be (Luftman and Derksen, 2012). Ultimately, the technology is only as useful as the person using it and if the person using the technology cannot fully utilize it or the information it has the potential to provide

then, sadly, the organization stands to lose money and miss opportunities because of unskilled BI&A professionals. Skills and familiarity with items such as data architectures, analytical tools, database management systems, text and data mining techniques, and business applications can hardly be considered a common set of skills amongst most business professionals (Chiang et al, 2012). In fact, one would be hard pressed to find a university-level business program that addresses these topics sufficiently and with enough depth.

Wixom et al (2011) organized a congress and surveyed IS scholars that teach BI&A courses to understand the state of BI&A in academia. The authors use BI&A as a general umbrella to cover analytics and other related areas as used in this paper. The general findings can be summarized as follows:

- Universities should provide a broader BI&A skills within BI&A classes or programs

- Universities can produce students with broader range of BI&A skills using an interdisciplinary approach

- Instructors believe that they need better access to BI&A resources

- Academic BI&A offerings should better align with the needs of practice

It is one thing to say that in order to produce some value from the stored information a user must simply access, manipulate, and analyze the information. It is, however, another thing entirely when it comes to finding the right persons to entrust with those responsibilities. Moreover, this is not merely a trust issue – as they are privy to company information – it is also an issue of competency.

BI and analytics are a data science that when applied in a business context allow a business to increase its competitiveness (Chiang et al, 2012). This assumes there is someone available to make sense of it all. This again is the problem: businesses are facing a new challenge in finding those individuals that have the skills to analyze this data. This analysis allows a business to meet or adjust its objectives based on the trends discovered from the data analysis. These discoveries allow the business to create forecasting models and make any necessary adjustments in strategies and/or processes in order to enhance their performance (Chiang et al, 2012).

Furthermore, data analysis falls primarily into three categories (Chiang et al, 2012, p12:2):

- Descriptive – What happened in the past.
- Predictive – What could happen in the future.
- Prescriptive – Prescribe the best course of action for the future.

Each of these three provides valuable insight into a company's performance with individual cases determining which of these holds the most value at any given moment. However, at the core of the ability to produce such information lays the assumption that the persons responsible for producing such information have at least some familiarity with data architectures, analytical tools, database management systems, text and data mining techniques, business applications, etc (Chiang et al, 2012).

In fact, these are skills that require a deep understanding of the many methods and technologies involved in producing valuable and actionable intelligence. They are, however, the minimum set of skills required of today's BI&A analysts. These skills can largely be grouped into 3 components (Chiang et al, 2012, p12:4):

- Analytical Skills: data/text mining, deviational analyses, opinion/sentiment analysis, statistical analysis such as logistic regression, and forecasting.

- IT Knowledge & Skills: relational databases, data marts and warehousing, extraction, transformation, and loading, visualization and dashboard design, massive data file systems, semi-structured and un-structured data management.

- Business Knowledge & Communication Skills: accounting, finance, marketing, logistics, operations management, ability to understand and explain what is being analyzed.

It is important that the analyst understands how to communicate their findings because this is where the value to the organization is potentially added.

Methodology

In conducting our research it became evident that we needed to devise a way in which to fruitfully select our data points. It seemed fairly evident that we would be auditing curricula within the business school. So with that in mind it was decided that the most appropriate way to go about this was to use a set of standards that we could easily apply to a broad range of schools. We believe the best way to do this was by invoking a set of rules or standards that are used to regulate the following: the manner in which the school is managed, the manner in which student and faculty participation is conducted, and, more importantly, the expectations set to ensure the inception of a quality education for the students involved.

In short, we decided to rely upon an accreditation of some sort. That being decided, we were now faced with which accreditation to submit to. In searching through some of the country's more prestigious programs – The Harvard School of Business (Harvard University), Red McCombs School of Business (University of Texas – Austin), Eller College of Management (University of Arizona), and the MIT Sloan School of Management (Massachusetts Institute of Technology) to name a few – we noticed they were bound by a common thread: their accreditation through The AACSB. We chose to audit those schools within the United States that have been accredited by the AACSB.

After settling on the accreditation we still had a need to further define our data. Realizing we could not audit the BI&A curricula of schools that did not offer any type of Information Systems (IS) or Information Technology (IT) programs we first had to determine if they offered any type of IS/IT-type program. The following is a set of criteria we set to help define our search and the resultant data:

1. Determine whether an IS/IT-type program is being offered
2. Determine the name of the IS/IT-type program that is being offered
3. If the program is not offered by the school of business, determine where within the associated university such a program is being offered, if at all
4. Determine if the schools offering an IS/IT-type program offer any BI-related courses within their curriculum
5. Determine if the schools offering an IS/IT-type program offer any BI-specific degrees as part of their degree offerings.

We used the readily available membership list of U.S. accredited schools provided by the AACSB via their website to conduct our audit. Once the audit was complete we recorded our data on a spreadsheet that correlated to the five criteria we have previously defined. Of specific interest to us were the findings for criteria 3, 4, and 5.

As each university listed within the AACSB's membership list is accompanied by a link to that respective university's college/school of business web page, this is where we decided to begin our search. After following the link it was a fairly straightforward approach in locating the courses and degrees offered by each school as they were often times highlighted and categorized by department (such as finance, accounting, computer information systems, management, etc.) on the very first page we arrived at. However, as is to be expected, there were a few sites that provided us with some issue.

The most common issue we encountered involved being taken to the respective university's home page. From this position there was only one logical recourse: get to the college/school of business' representative web page. In order to avoid traversing the labyrinth that many university web pages can be we simply decided to do a web search for the name of the college/school of business in question – as provided by the membership list – and its respective university. Once at the proper location we simply carried on as before; finding the appropriate courses and degrees offered as listed by individual departments.

However, in the event that the information wasn't so prominently or readily displayed, we were then left having to search for the individual departments housed within a college/school of business by searching through the college/school of business web page.

Once we had determined whether or not the schools offered an IS/IT-type program and the name of the program, we had to determine whether or not it was being offered within the appropriate college of

business listed by the AACSB. If it was not, however, we had to determine where within the associated university the program was being offered. In several cases it was offered either in the respective university's colleges of computer science, engineering, information technology, or, interestingly enough, within the college of education.

We then conducted the audit of the school's curriculum for any signs of BI&A or analytics courses. Drawing inspiration from the 3 components of the consummate BI&A analyst set forth by Chiang, Goes, and Stohr (2012) we realized that our audit needed to address the multiplicity of topics that are often referred to under the umbrella term "Business Intelligence". The following is a list of keywords upon which we based our audit: Business Intelligence, Business Analytics, Analytics, Data Mining, Data Analysis, Data Analytics, Data Processing, Data Warehousing, Decision Support Systems (DSS), Management Support Systems (MSS), Data Management, Dashboards, Dashboard Design, Big Data, Text Analytics, Text Mining,

Finally, we then determined whether or not the particular college of business – or the appropriate college offering the BI&A instruction – offered any type of BI-specific degree as part of their degree offerings.

Results

It is important to note that as AACSB's membership list does not differentiate between graduate and undergraduate classifications, neither do we. We have merely taken the list wholly as it is and present our findings as such.

Once the audit was completed we conducted Pearson's Chi-Squared ($\chi 2$) test to determine if there was any significance to our findings presented below as Table 1 – which states the relationship between BI&A Courses offered within and outside of a respective college of business – and Table 2 – which studies the relationship between BI&A Degrees offered within and outside of a respective college of business – and the results are as follows:

			BI&A Courses Offered?		Total
			0 (No)	1 (Yes)	
Within the College of Business?	0 (No)	Count	123	38	161
		% within College	76.4%	23.6%	100.0%
	1 (Yes)	Count	218	121	339
		% within College	64.3%	35.7%	100.0%
Total		Count	341	159	500
		% within College	100.0%	31.8%	100.0%

Table 1. Differences in BI&A courses in Business and Non-Business Programs

Table 1 shows a breakdown of where BI&A courses are offered in regards to the schools/colleges within the university. More specifically we are interested in determining the relationship between those schools that offer BI&A courses within the college of business and those that do not offer BI&A courses within the college of business. In this case we can see that the proportion of programs that offer BI&A courses are 23.6% and 35.7 % for non-business and business schools respectively demonstrating that the proportion is higher for programs located in business schools. In order to determine whether our audit figures revealed any real significance we conducted Pearson's Chi-Squared ($\chi 2$) test on the data from Table 2 – which evaluated the relationship between schools that offer BI-Courses within the college of business and outside the college of business – and attained a value of 7.358 with an associated Asymptotic Significance

of 0.007, signifying that there is a significance in the difference between the proportion of schools that offer BI&A courses within the college of business versus those that offer BI&A courses outside the college of business.

We believe the reason why a greater proportion of BI&A courses are being offered within the college of business – as opposed to outside the college of business – is a simple one. With an increase in both the recognition of the role that BI&A plays in an organization's decision-making-process and the demand for those individuals that have the necessary skills – as previously listed – that are required for an effective BI&A analyst, business schools have recognized that they are perhaps more favorably suited to help employers meet these demands than any other school/college within their respective university. This supports prior work that businesses are looking for professionals with technical analytics as well as business and communication skills (Wixom et al., 2011; Chiang et al., 2012).

			BI&A Degree Offered?		Total
			0 (No)	1 (Yes)	
Within the College of Business?	0 (No)	Count	158	3	161
		% within College	98.1%	1.9%	100.0%
	1 (Yes)	Count	317	22	339
		% within College	93.5%	6.5%	100.0%
Total		Count	475	25	500
		% within College	95.0%	5.0%	100.0%

Table 2. Differences in BI&A degrees in Business and Non-Business Programs

Table 2 shows the relationship between those schools that offer BI&A degrees within the college of business as compared to those which offer BI&A degrees outside the college of business. The results show that the proportion of programs that offer BI&A degrees are 1.9% and 6.5 % for non-business and business schools respectively once again demonstrating that the proportion is higher for programs located in business schools.

In order to determine wither these figures held any significance we conducted Pearson's Chi-Squared ($\chi 2$) test on the data from Table 3 – which evaluated the relationship between schools that offer BI&A Degrees within the college of business and outside the college of business – and attained a value of 4.919 with an associated Asymptotic Significance of 0.027, signifying that there is a significant difference between the proportion of schools that offer BI&A degrees within the college of business versus those that offer BI&A degrees outside the college of business.

We believe the reason why a greater proportion of BI&A degrees are being offered within the college of business – as opposed to outside the college of business – is exactly the same reason why a significantly higher proportion of schools offer BI&A courses within the college of business. With an increase in both the recognition of the role that BI&A plays in an organization's decision-making-process and the demand for those individuals that have the necessary skills – as previously listed – that are required for an effective BI&A analyst, business schools have recognized that they are perhaps more favorably suited to meet these demands than any other school or college within their respective universities.

Hypothesis	Description	P- value	Supported
H1	The proportion of schools that offer BI&A courses for degree programs in the College of Business is higher than that in Non-College of Business.	.007	Yes
H2	The proportion of schools that offer BI&A as a degree program in the College of Business is higher than that in Non-College of Business.	.027	Yes

Table 3. Results of the Hypotheses testing

Discussion/Limitations and Future Research

The most prominent limitations with our research dealt with selecting one accreditation standard over the myriad of others. Also, even when we had selected our accreditation standard, the choice remained as to whether we would study schools within the U.S. or those beyond. We finally settled upon auditing those schools which are accredited by the AACSB and are located within the confines of the United States.

Although the results are interesting they should be viewed with care given the assumptions and limitations of the study. Given that we focused our study on those schools within the U.S. that are accredited by the AACSB, it would be interesting to see if future researchers could possibly replicate similar results within the international community of schools accredited by the AACSB – or, conversely, it would be of interest if researchers tested for similar results using different populations, such as U.S. schools accredited by the Accreditation Boards for Engineering and Technology (ABET), the Southern Association of Colleges and Schools (SACS) or other similar accreditation boards and comparing those results with international universities of equivalent accreditation.

The possibility then exists of comparing several accreditation standards against one another to determine if a particular population has a higher proportion of schools that offer both BI&A coursework and degrees within or beyond their respective colleges of business. The possibilities seem promising considering how little has actually been done concerning BI's actual place within the business school.

Also, these findings should be of particular interest to those which stand to benefit from an increase of a skilled BI&A workforce. Given our findings enterprises and organizations should take it upon themselves to partner with and encourage business schools to implement more BI&A and analytics related courses and degrees because, as we have found, despite the fact that a significantly higher proportion of AACSB accredited business schools offer these things, it is still – we feel – an insufficient amount. By demanding that more business schools offer BI&A coursework and degrees, then organizations stand to gain from an increase in output of those individuals with the necessary skills and knowledge to allow the organization to take advantage of the information they are continuously amassing which – as we have explained – has the potential to create value for the organization. This creation of value, however, is contingent upon the availability of those individuals that possess the necessary skills to successfully transform raw data into actionable intelligence, or knowledge. This knowledge is what facilitates the creation of value but, as we have already explained, if there is in fact too few of those individuals with the capacity to do this being produced, then the point is moot.

In short, business schools and the prospective employers of those school's students should not stand alone. Through cooperative partnerships they can ensure a quality of education and experience that future BI&A analysts will require in order to be successful.

Conclusion

Given what those CIOs surveyed by SIM for the past ten years have said and how highly they have ranked BI&A technologies, the number of schools actually offering BI&A degrees is quite surprising. Remember, BI&A is a set of tools which allow an organization to make sense of the massive amounts of information they are continuously producing. As we have stated, the analysis of this data allows most organizations to

make use of this information in a way that potentially creates value for the organization by improving the managerial decision making process through the addition of meaningful information. Realizing how important BI&A will continue to be it should become increasingly clear what business schools must do in order to meet the growing demand for skilled BI&A Analysts.

Our exploratory research has left us with the following results: There is significant differences in proportion of those schools that:

- Offer BI&A courses in a college of business vs. those that do not and,
- Offer BI&A degrees in a college of business vs. those that do not.

For the benefit of their students we hope to see the number of schools which offer either BI&A coursework and/or degrees to continue to rise. It is important to realize that in most instances when industries flourish society stands to benefit. We believe that the key to opening the door towards the next frontier of success is BI&A.

REFERENCES

Andoh-Baidoo, F.K. 2011. "Towards the Design of a Data Mart for Business Intelligence in Mineral Processing," in Proceedings of the Southwest Decision Sciences Institute, Houston, TX.

Chen, H., Chiang, R. H., and Storey, V. C. 2012. "Business Intelligence and Analytics: From Big Data to Big Impact," MIS Quarterly, (36:4), pp. 1165-1188.

Chiang, R. H., Goes, P., and Stohr, E. A. 2012. "Business Intelligence and Analytics Education, and Program Development: A Unique Opportunity for the Information Systems Discipline". ACM Transactions on Management Information Systems (TMIS), (3:3), 12, pp. 1-13.

Derksen, B., and Luftman, J. 2012. Key Issues for IT Executives 2012: Doing More with Less. MIS Quarterly Executive, pp. 207- 218.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011). "Big data: The next frontier for innovation, competition, and productivity," McKinsey Global Institute, pp. 1-137.

Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R., & Carlsson, C. 2002. "Past, present, and future of decision support technology," Decision support systems, (33:2), pp. 111-126.

Watson, H. J., & Wixom, B. H. 2007. "The current state of business intelligence," Computer, (40:9), pp. 96-99.

Wixom, Barbara, et al. "The Current State of Business Intelligence in Academia." Communications of the Association for Information Systems 29 (2011).

Zeleny, M. 2006. "From Knowledge to Wisdom: on Being Informed and Knowledgeable, Becoming Wise and Ethical," International Journal of information technology and Decision Making, (5:4), pp. 751-762.