Research Article

Improving Operational Effectiveness in Facilities Management at Colleges and Universities with use of Big Data and Data Analytics

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Abstract

This systematic review investigates current research in the studies of data collection and analytics on performance efficiency in facilities management departments at higher education institutions. This review will demonstrate that while research is limited it is clear that data collection and analysis will have a very important role and impact of the future on facilities management organizations. Thus, higher education institutions should move quickly to adopt data analytics in their everyday decision-making process.
Methods: A systematic review was conducted with research papers being selected between the years of 2010 and 2021 for relevancy.
Results: The results in this systematic review indicate that big data and data analytics are the future and would be beneficial for use in facilities management. While higher education research in facilities management in general is limited, it is evident that higher education is behind in the use of data collection and data analysis.
Conclusions: The findings concluded in this systematic review allow higher education institutions to make a well supported, evidence-based decision on why they should proceed with the use of data collection and analysis in facilities management.
Limitations: There was limited research on data analytics and its use in high education facilities management. The articles in the literature were authored by many of the same researchers.
Implications: There is a need in higher education facilities management to incorporate data collection and analysis in the decision-making process.

Keywords: Big Data; Data Analytics; Facilities Management; Performance; Operational Effectiveness

Introduction

Background

Over the past two decades it has become increasingly obvious that companies large and small are moving towards collecting big data and using data analytics to improve strategic decision making and their future position. This is happening for a number of reasons; companies want to see how they can improve financially, with overall production and performance, and even with retention of employees. How can they improve their business to ensure a successful future? Collecting data and using data analytics is a clear way to get these results. The old adage of "numbers don't lie" is easily applicable to this scenario. When companies start making decisions over facts and evidence rather than gut or the latest fad, they will be able to measure and chart real progress.

Problem Statement

Colleges and Universities, especially state-run higher education institutions run on extremely tight budgets. Facilities management (FM) has always been an area where higher education institutions often try to get every penny out of a dollar. Buildings and the staff that take care of them are often asked to "do more with less." For example, 30-year roofs get stretched to 40 years, HVAC systems with a lifespan of 25 years get stretched to 40 or 50 years. While a new system will save the school large amounts of money on energy, the schools only see the initial extremely expensive cost of replacement. Institutions often fail to factor in energy savings that new one-time investments bring and continue to repair aging equipment until equipment failure forces replacement. This can be applied to facilities management staff as well. While most private industries will pay staff higher premiums and bonuses for performance, colleges and universities often lean on benefits to help keep employees, with minimal raises, only seeing cost of living raises once in a while. With tight budgets, technology is often only used as a necessity and not utilized to its full potential. Data and data analytics could be a huge benefit to colleges and universities for a minimal upfront cost. There could be substantial savings in the future, both on people and equipment. However this brings up the point made earlier of the mentality to fix as cheap as possible for as long as possible.

TABLE 1.—RQ and CIMO Model

CIMO	Research Question Development
Context (C)	College and University Facilities Mgt.
Intervention (I)	Collection of Big Data
Mechanism (M)	Use of Data Analytics
Outcomes (O)	Improved Operational Effectiveness

Significance and Implications

This research is significant to facilities management departments at universities and colleges to assess the need to capture data and analyze it for future use. The data captured could be used to improve budgeting for future projects, equipment life cycles, preventative maintenance and replacement schedules, employee performance and retention and overall department process and procedures. All these items can help FM departments run more efficiently and administrators to better serve their department with future budgets and staffing.

Research Question

Dodgson (2020), states a quality research question defines "what will be studied, with enough specificity that there will be no ambiguity or confusion about exactly what variables (quantitative research) or phenomena (qualitative research) the researcher is seeking to study" (p. 106). A quality research question (RQ) should be evaluated and formulated for complexity, structure, clarity, focus, fitness for research, and analysis using a selected model. For the purpose of this research, the Context, Intervention, Mechanism, and Outcomes (CIMO) model was used to formulate the RQ in a structured manner, provide the basis for a systematic review, and guide what literature and data to consider. Use of CIMO helps the research question to move away from the prescriptive thoughts of an input-output to one that depends on the context of the outcomes (Denyer et al., 2008).

The research question for this paper is:

How does facilities management at colleges and universities use big data and data analytics to improve operational effectiveness?

Table 1 shows how the RQ fits the CIMO model

Theoretical Framework

While many theories and frameworks were explored, one theoretical framework stood out when it came to the research question that was developed for this systematic review: *The Theory of Action for Data-driven Decision Making in Education*. This theory involves three main steps that need to be done in sequential order. First, the FM department will need to assemble and gather high quality raw data, then they will need to analyze the data to ensure the data collected is relevant with the issue they are trying to improve, and finally they will use the data analyzed to inform and instruct operational decisions to ensure future success (Gill et al., 2014). This theoretical framework can be used as a tool for success for FM departments considering data analytics aid in the making future decisions in their departments. See figure 1 below.

Methodology

For the purpose of this research, a systematic review of current literature and previous research studies was conducted. Synthesizing results across studies to identify the similarities in findings to reach an overall understanding of a problem is a crucial part of a systematic review (Bertolaccini, & Spaggiari, 2020). Systematic reviews conducted by proven guidelines that can be reproduced by readers, have become a useful scientific tool in the synthesis of evidence. Rudnicka & Owen (2012) noted that systematic reviews are one of the most useful tools available to provide rapid synthesis of evidence on a given research question. It is important to be able to tell when a systematic review has been thorough and transparent and the summary of evidence can be trusted. A systematic review is a clear and transparent method for appraising well-formulated research questions. The review can then identify, select and critically appraise relevant research and analyze data from the studies to produce clear recommendations to the research question.

Search Strategy and Inclusion/Exclusion Criteria

Towson University Library OneSearch database and University of Maryland Global Campus OneSearch database were used to gather research. These databases contain over 170 different databases from which they pull articles related to the search strings entered by researchers. Key

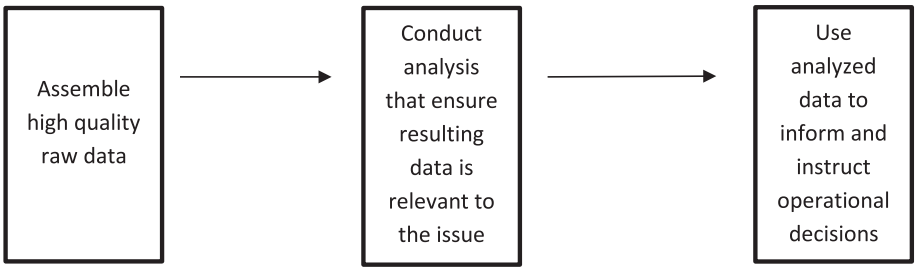

FIGURE 1.—

words from the research question were utilized to create search strings. The first search string consisted of "Facilities Management" AND colleges OR universities or higher education AND (data OR "data analytics") AND operation* AND effect*. This search returned 5,552 results. To reduce the search further, only full online articles, peer reviewed articles (vetted by other scholars in the field of study) ranging from 2010 – 2021 (most relevant and up to date research on a topic about data collection), in English (as researcher is not bilingual) with duplicates removed were used. This reduced the search to 1,356 results. The most important aspect of the research was the subject of "facilities management." To narrow the results even further, it was decided to include "facilities management" in the title of the articles chosen. This narrowed the search to 79 articles. A way to show, visually, the selection process is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses or PRISMA model in appendix A. Using a PRISMA diagram in a systematic review provides transparency and reproducibility for future research. It has also shown to have significantly more complete reporting than when it is not used, as well, publication guidelines for many publishers will be met (McGrath et al., 2019).

Each of the 79 articles was then evaluated for content that would be relevant to the current research question. Articles needed to pertain to facilities management as well as directly involving colleges/universities/education and data analysis and operational effectiveness. If the article's abstract did not mention any of those areas directly, they were excluded from the search. After reviewing the 79 articles, 17 articles remained and were included in this systematic review.

Data Extraction

The remaining 17 articles were thoroughly examined for their content in order to assess their use for this systematic review. Table B1 shows an example of the table used for documentation, the table for each individual article can be found in appendix C.

Example Data and Appraisal Chart

Each table contains important information for the researcher to use in the findings. Listed in the table are the article authors, the year of publication, the purpose of the article, the research question (if applicable), the methodology or research design with sample size (if applicable), the critical appraisal score, the main findings of the article, how the research is relative to the RQ and fit for purpose in facilities management.

Critical Appraisal

After the articles were selected they were reviewed thoroughly, specifically looking at the items listed above and using the documentation table, while also assessing articles for strengths and weaknesses using a proven appraisal tool. Gough et al, (2017) note that "appraisal tools provide a structured approach for assessing the methods of included studies. These usually consist of a list of questions with fixed response options which prompt the reviewers to make an evaluative judgement" (p. 262). For the purpose of this study, the TAPUPAS framework will be used for assessment. TAPUPAS is a proven assessment tool, which uses seven distinct areas to assess each article. The areas assessed are transparency, accuracy, purposivity, utility, propriety, accessibility and specificity. Each area of the TAPUPAS framework is given a rating of low, medium or high to reflect content of that area. An overall score of low, medium or high (numerical value of 1 for low, 2 for medium and 3 for high) is then given to each article to assess the article for both transparency, rigor and use for providing solutions to the research question. An article can score between 7 and 21 points, any article that scores below a 14 was not used in this systematic review. The complete TAPUPAS results for articles assessed can be seen in appendix B.

Results

After conducting a thorough review of all the chosen articles and critically appraising them for use, all articles were deemed to have some insight into the research question for which this systematic review was gathering information. The RQ for this systematic review was, *How does facilities management at colleges and universities use big data and data analytics to improve operational effectiveness?* While the research available on this research question was limited, three main findings were supported by the evidence collected.

- Big data and data analytics will be utilized in the future of facilities management to improve operational effectiveness.
- Higher education research in facilities management is limited, however it is evident from the research collected that higher education is lacking in the use of data collection and data analysis to improve operational effectiveness.
- Data collection and data analytics could be a useful tool for facilities management in higher education on performance effectiveness, however it is currently underutilized.

Data Analysis and the Future of Facilities Management in Higher Education

Over the last two decades the world's adoption of cloud-based programs and the collection of big data has skyrocketed. Companies are taking all the data they collect, analyzing it and using it to improve their business in ways that you would never think collecting data could take you (Yang & Bayapu, 2019). From issues with supply chain management, performance management, customer satisfaction and employee operation or behavioral, big data is changing how companies operate both internally and externally. Mawed and Al-Hajj (2016) state that "big data can provide more accurate and detailed performance data in real-time or near real-time, allowing managers to analyze

performance variability and understand its causes. More sophisticated analytics can be applied to big data to support decision makers in minimizing risks and finding new insights, thus improving the decision-making process" (p. 747). It is clear from the research, that data collection and data analytics are crucial for organizations to be successful in the future. The future of facilities management will be "based on a new wave of digitalization with intelligent data solutions for planning, design, monitoring, control and management in general" (Brochner et al., 2018, p. 376).

Lack of Research in Higher Education Facilities Management

While other companies have embraced the use of data collection and analysis for problem solving and company decision making, facilities management in general and in higher education has not embraced it as quickly. While most business are open to the possibility of change for the better, facilities management has been slow to make operational changes, often due to budget constraints and longevity of staff. The everchanging, fast-paced environment of data collection and data analytics is difficult for facilities managers to grasp and act on. "Big data is not just about having a huge store of data; it is concerned with being able to access, analyze and leverage the information in a timely manner to deliver real-world intelligence and business benefit" (Mawed & Al-Hajj, 2016, p. 749). While this may seem easy enough to make a priority, in facilities management, especially in higher education, departments are often understaffed and under budgeted. These issues cause departments to prioritize getting work done and not necessarily on how efficient they are getting the work accomplished. Campell (2016) states that facilities management "research is at an early stage of development and can perhaps best be described as a field of inquiry evolving towards becoming a discipline" (p. 357). The research on facilities management in higher education is extremely limited.

Improving Performance Effectiveness and Management in Facilities Management

Performance management is a practice successful companies are consistently monitoring. Performance management is a process of measuring and assessing the quality and effectiveness of an organization's operations. Amaratunga and Baldry (2013) state that "performance measurement is becoming increasingly important, both for reasons of justification to general management and to support management and practice with the facilities management organization" (p. 172). Performance measurement and management is a continued work in progress, without really achieving a termination point. However, the hope is to continue to learn and grow to ensure optimal performance. "Performance measures provide a mechanism to both learn from the past and evaluate contemporary trends in the use of facilities at universities. It is hoped that the collection, interpretation, and analysis of information about performance measures of facilities will provide the key to better planning and design for the future" (Amaratunga & Baldry, 2000, p. 294). Big data analytics is a strong tool to use for higher education institutions to incorporate into their performance management practices in facilities management. Data-driven management in leadership can improve employee relationships, company resource alignment, communication, and performance efficiency (Sullivan & McDonald, 2011).

Performance management in facilities management can take on a dual meaning. While traditionally, performance management concentrates on employees and their performance or output, in facilities management this can also mean performance of machinery and equipment. Not only can data be used to track employee performance, managers can also use data to track machinery and equipment performance. This allows facilities managers to look for patterns in equipment, study their history and understand how they best operate under optimal conditions. In addition, managers can track preventative maintenance schedules to ensure equipment is well maintained and at optimal operation levels. In facilities management the direct performance of equipment and machinery can influence the direct performance of employees and the entire company. Performance management of equipment and machinery can make or break a company's success if not monitored and given the attention it needs to perform.

Synthesis and Discussion

This research was designed to provide colleges and universities with evidence-based research to help their organizations make smart decisions about incorporating the use of big data analytics to improve performance efficiency in facilities management. The systematic review revealed three main findings in data collection and analytics in facilities management within higher education. First, data collection and analytics are the future in facilities management when it comes to performance and effectiveness. Second, there is limited research on this topic within facilities management in general and very limited within higher education institutions. Finally, data analytics is a very helpful tool for the use of performance effectiveness and management. "For facilities professionals to be successful leaders in their organizations in the next millennium and beyond, they must have a broader knowledge of performance measurement than ever before" (Amarantunga et al., 2000, p. 67).

This systematic review reveals that higher education institutions need to consider implementing data collection and analysis in facilities management in order to continue to improve their performance efficiency. Using data analytics can "help employers to create a better job design for FM workers to improve other areas such as work performance and the level of internal motivation, as well as to reduce turnover intention, rate of absenteeism and level of stress" (Ling & Wong, 2104, p. 65). Higher education

institutions need to push back on budget concerns and look to implement data collection and analysis programs in facilities management for future success.

Conclusion

The findings concluded in this systematic review allow higher education institutions to make a well supported, evidence-based decision on why they should proceed with the use of data collection and analysis in facilities management. This systematic review gave clear findings in the research of data analysis and benefits of use in facilities management. The research shows that facilities management departments that currently use data analytics can see a benefit in performance efficiency. While future research still needs to be conducted as current research is limited, the current evidence reveals that data collection and analysis can have a positive impact on facilities management organizations.

Limitations

The research for this systematic review included fully online articles, no grey literature, and only scholarly peer-reviewed research. This was an overall limitation to the research, as minimal scholarly research in the field of facilities management has been conducted, limiting the number of usable articles related to higher education. Another limitation to be noted is that the same authors appear in multiple articles. With all of that said, this systematic review provides a strong foundation for the need of future research in this area.

Implications for Practice

This systematic review has identified two recommendations for current facilities management departments and future research at higher education institutions. None of the following recommended implications for practice would put any departments in any kind of risk or have unintended consequences. At most a company could suffer minor financial loss on employee time spent on collection and analysis of data that is not put into practice. Possible rewards of successful implementation of new practices outweigh the minor potential risk.

1.) Higher Education facilities management should start small and build up to a more robust use of big data analytics. Most facilities management departments in higher education use some kind of work management information system that is collecting data daily. In theory, these institutions should be able to access certain information within the system and produce reports they can then utilize to make decisions on operational effectiveness and efficiency. Colleges/Universities should start small by utilizing current data that is already within their reach and start making small changes where they can to show the value of the data being collected and the possibility of more fully utilizing big data analytics in the future.

2.) More research needs to be conducted on the impact of big data analytics in facilities management at higher education institutions, as it could be a valuable tool if used properly. Currently, there is not much scholarly research done on facilities management in higher education. Higher education institutions are often like small cities. They have their own infrastructure including small power plants and all their own in-house utilities and staff. This is very true in state-run higher education facilities, as they are not profit driven, but budget driven. While higher education institutions do charge for residence and dining, this is often to offset their fiscal budgets for maintenance and renovations of buildings and equipment. It would be extremely beneficial for both higher education facilities management departments and researchers to use university campuses as research sites, as they are a small microcosm of larger municipalities and research implementations of big data analytics. As well, higher education institutions should look at well-run towns and cities of the same size as their institutions to compare best practices on operations and how these entities continue to meet budgets including necessary renovation and equipment maintenance needs. Learning from this research will allow facilities management departments to better forecast future expenses as well as become more efficient in overall organizational management and day-to-day maintenance practices and procedures. Additional research would be crucial to justification for future budgets and staffing.

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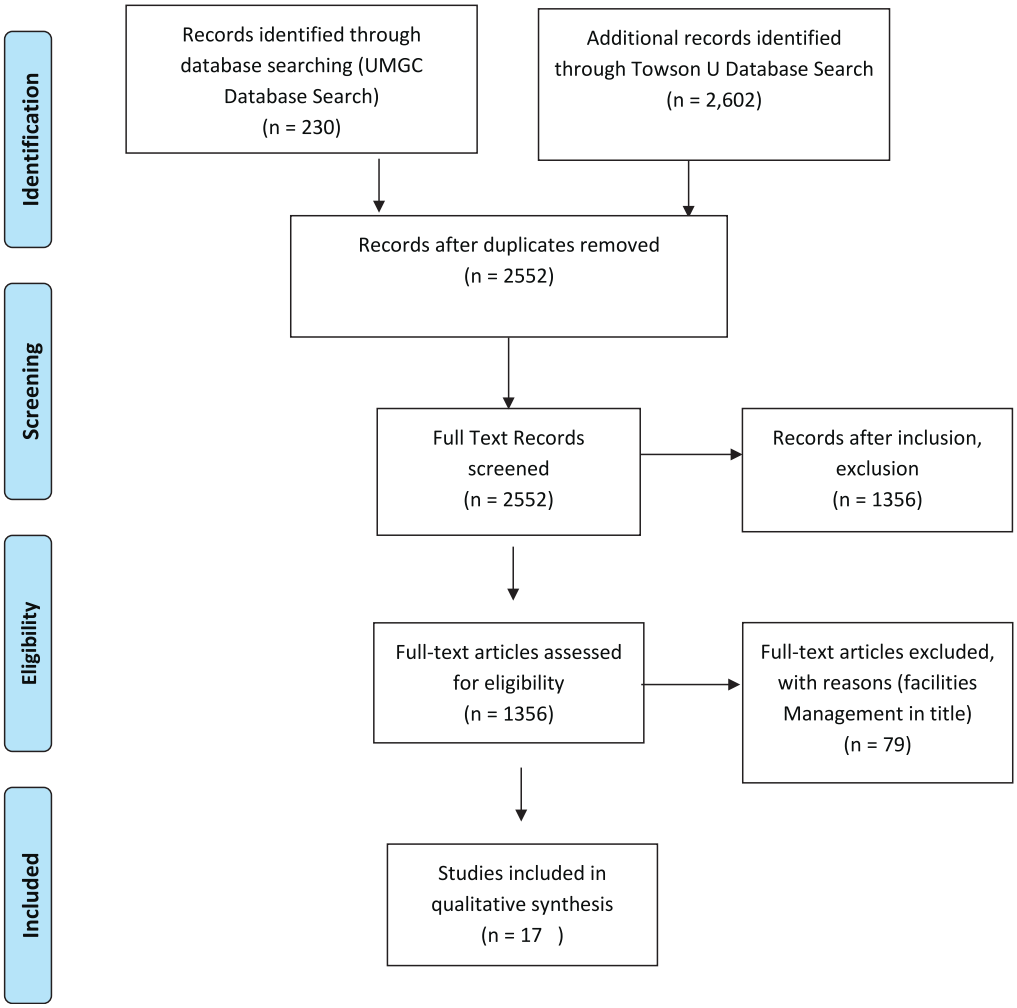
Appendix A

PRISMA Model



Appendix B

TAPUPUS

TABLE.—TAPUPAS Quality Assessment

	Transparency (T)	Accuracy (A)	Purposivity (P)	Utility (U)	Propriety (P)	Accessibility (A)	Specificity (S)	
	Is it open to scrutiny	is it well-grounded?	fit for purpose?	fit for use?	legal and ethical	Intelligible?	meets source-specific standards?	Score
Article 1 *Yang and Bayapu. (2019)*	H(3)	H(3)	H(3)	H(3)	M(3)	H(3)	H(3)	**21**
Article 2 *Ahmed, Tezel and Aziz, (2017)*	H(3)	H(3)	M(3)	M(3)	M(3)	M(3)	H(3)	**21**
Article 3 *Mawed and Al-Hajjl, (2016)*	H(3)	H(3)	M(3)	M(3)	M(3)	M(3)	H(3)	**21**
Article 4 *Ling and Wongr, (2015)*	H(3)	H(2)	L(2)	L(2)	M(3)	M(3)	H(3)	**18**
Article 5 *Beauregard and Ayer, (2018)*	H(3)	H(2)	M(2)	M(2)	M(3)	M(3)	H(3)	**18**
Article 6 *Amaratunga et all, (2000)*	H(3)	H(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 7 *Brochner et al, (2018)*	M(3)	M(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 8 *Sullivan and McDonald, (2011)*	H(3)	H(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 9 *Amaratunga and Baldryl, (2000)*	H(3)	H(2)	M(2)	M(2)	M(3)	M(3)	H(3)	**18**
Article 10 *Amaratunga and Baldry, (2003)*	H(3)	H(2)	H(2)	H(2)	M(3)	H(2)	H(3)	**17**
Article 11 *Brochner, (2016)*	H(3)	H(3)	M(1)	M(1)	M(3)	M(3)	H(3)	**17**
Article 12 *Roskams and Haynes, (2019)*	H(3)	H(3)	M(3)	M(3)	M(3)	M(3)	H(3)	**21**
Article 13 *Ogbeifun et al., (2015)*	H(3)	H(3)	L(2)	L(2)	M(3)	M(3)	H(3)	**19**
Article 14 *Amos et al., (2018)*	H(3)	H(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 15 *Karunasena and Muthmala., (2016)*	H(3)	H(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 16 *Campbell (2016)*	M(3)	M(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**
Article 17 *Lok and Baldry, (2014)*	H(3)	H(3)	M(2)	M(2)	M(3)	M(3)	H(3)	**19**

Article score H = High, M=medium, and L=Low; H=3, M=2, and L=1. A selected article should have a minimum of 14, which is an average TAPUPAS score (i.e., 2 across all seven dimensions of TAPUPAS)

Appendix C

Data and Appraisal Chart

TABLE B1.—*Article 1*

Article 1 *Yang and Bayapu. (2019)*	Purpose: Investigate the challenges to implement data analytics in FM	Research Question:	Methodology/Research Design: Case study through interviews
	Date of Publication: 2019	Sample size: 6 Interviews across FM department at GT	TAPUPAS Score: 21

Main findings: Big data and data analytics have been around, but have just recently started to be used in the FM field. "This study provides supporting evidence that data analytics is a promising endeavor for FM organizations by identifying data elements, transfer, gaps and challenges" (Yand & Bayapu, 2019, p. 268).

Management Implication: Collecting data and using data analytics in everyday FM setting can help organizations better understand internal process and use data for improvement.

TABLE B2.—*Article 2*

Article 2 *Ahmed, Texel and Aziz (2017)*	Purpose: Explore current use of big data, along with barriers, drivers, opportunities and perceptions in FM	Research Question: What are the current barriers, drivers and potential applications of big data in the FM industry?	Methodology/Research Design: Two workshops comprising of 200 key participants in the FM industry were held and Literature Review
	Date of Publication: 2017	Sample size: 200	TAPUPAS Score: 21

Main findings: Companies have plenty of data compiled, however do not have a process or the money to analyze the data into findings that will help them. Larger companies have the funding to use analytics, however medium and small companies do not yet see the return on investment.

Management Implication: More research needs to be completed on the important of data collection and analysis on a return on investment for medium and smaller companies. They need to see a positive impact on processes in order to invest in this kind of technology and research.

TABLE B3.—*Article 3*

Article 3 *Mawed and Al-Hajj. (2016)*	Purpose: Explores how bid data is stored and integrated into the FM work place	Research Question: How is data collected and used to increase functionality and effectiveness of FM services?	Methodology/Research Design: Lit review and interviews
	Date of Publication: 2016	Sample size: 5 interviews with "industry experts" and company employees from each level of hierarchy	TAPUPAS Score: 21

Main findings: The literature shows the benefits of the collection of and analysis of data, as well that the analysis turns into actionable items for improvement in the FM industry. "Big data can be the foundation for greater FM industry-wide innovation: managing and analyzing data is no longer an issue for IT departments alone, instead it is driving the overall industry's business agenda" (Mawed & Al-Hajj, 2019, p. 761).

Management Implication: Shows the value of data collection, analysis turning into usable methods for better FM service.

TABLE B4.—*Article 4*

Article 4 *Ling and Wong, (2015)*	Purpose: Recommend strategies to boost work outcomes in FM	Research Question: What can FM managers do to boost FM workers performance	Methodology/Research Design: Lit review and Survey through face to face interviews
	Date of Publication: 2015	Sample size: 42	TAPUPAS Score: 18

Main findings: Findings show that "FM workers have significantly high internal motivation, quality of work and job satisfaction" (Ling & Wong, 2015, p. 65). FM workers want to be challenged and perform at high levels in order to have job satisfaction.

Management Implication: Findings can help employers create working environments for FM workers that will lead to higher work performance and reduce turnover, absenteeism and worker stress.

TABLE B5.—*Article 5*

Article 5	Purpose:	Research Question:	Methodology/Research Design:
Beauregard and Ayer, (2018)	Understanding the relationship between FM and academic performance	Does good FM have a positive impact on academic performance in the facility being used?	Data collected from 200 academic districts over a 5 year period.
	Date of Publication:	Sample size:	TAPUPAS Score:
	2018	200 school districts	19

Main findings: No positive findings on impact of FM on academic performance, however did provide an in-depth look at how school districts prioritize FM

Management Implication: Management can look at prioritization in a more orderly and "need basis" fashion if they understand that FM does not have an impact on academic performance and can prioritize the most important issues first no matter what condition the current educational facility is in.

TABLE B6.—*Article 6*

Article 6	Purpose:	Research Question:	Methodology/Research Design:
Amaralunga et al. (2000)	To take a look at the future of FM performance assessment	What will the future of FM performance assessment look like?	Lit review
	Date of Publication:	Sample size:	TAPUPAS Score:
	2000	Lit review	19

Main findings: "The facilities manager's role, as an enabler and catalyst of change, must focus on how the strategy and service mechanisms for support services can assist the business to optimize its performance. The importance of performance assessment of facilities should also be looked at as part of a broader perspective of job satisfaction issues and with particular regard to theories of motivation" (Amaralung et al., 2000, p. 67).

Management Implication: How employees are measured needs to be studied, technology needs to be used in the future as it can show unbiased production and assessment of employees.

TABLE B7.—*Article 7*

Article 7	Purpose:	Research Question:	Methodology/Research Design:
Brochner et al. (2018)	A look at the future of FM	What will the future of FM look like?	Lit review
	Date of Publication:	Sample size:	TAPUPAS Score:
	2018	Lit Review	19

Main findings: "FM for tomorrow will be based on a new wave of digitalization with intelligent data solutions for planning design, monitoring, control and management in general" (Brochner et al., 2018, p. 376).

Management Implication: Talks a lot about using technology to monitor spaces, save energy as well as use data on employee management.

TABLE B8.—*Article 8*

Article 8	Purpose:	Research Question:	Methodology/Research Design:
Sullivan and McDonald. (2011)	Looks at the applied leadership attributes taught in the FM program at ASU	What change in leadership attributes can be applied after attending the FM program at ASU?	Lit review and observation
	Date of Publication:	Sample size:	TAPUPAS Score:
	2011	Lit review and observation	19

Main findings: "Performance measurement is a critical component in enabling facility management teams to quickly and clearly identify issues. If management provides more opportunity to engage technician content experts, technicians will be more effective in real-time performance" (Sullivan & McDonald, 2011, p. 308).

Management Implication: Management needs to track, and compile data on performance measurement to help front line employees become more effective.

TABLE B9.—*Article 9*

Article 9	Purpose:	Research Question:	Methodology/Research Design:
Amaratunga and Baldry (2000)	Looking at FM and efficiency management of people and processes	What can be done to optimize efficiency in FM in regard to people and processes?	Lit review
	Date of Publication:	Sample size:	TAPUPAS Score:
	2000	Lit Review	18

Main findings: "performance measures provide an essential feedback-loop in the process of strategic change. In order to achieve complete learning, a performance measurement system should reflect the value system of all the FM organizations stakeholders" (Amaratunga & Baldry, 2000, p. 300).
Management Implication: Performance measurement should be on going, tracked and managed.

TABLE B10.—*Article 10*

Article 10	Purpose:	Research Question:	Methodology/Research Design:
Amaratunga and Baldry (2003)	Measuring FM management performance	What theoretical theories and framework best fit FM performance management?	Lit review
	Date of Publication:	Sample size:	TAPUPAS Score:
	2003	Lit Review	17

Main findings: "Identified theoretical concepts and their practical validity need to be tested in real life contexts, in order to understand their contribution in developing performance measurement theories in FM by fully addressing the problems associated with current available systems and possible directions of performance measurement systems in order to address such associated problems" (Amaratunga & Baldry, 2003, p. 186).
Management Implication: Theory and theoretical frameworks can be used to look at employee performance

TABLE B11.—*Article 11*

Article 11	Purpose:	Research Question:	Methodology/Research Design:
Brochner (2016)	Identify measures of productivity of FM	What methods are appropriate for measuring the direct productivity of FM providers?	Lit review
	Date of Publication:	Sample size:	TAPUPAS Score:
	2016	Lit Review	21

Main findings: "If (companies) collect relevant data internally, FM companies are able to perform analyses of how efficiently they use resources, the possibilities for devising new measures multiply" (Brochner, 2016, p. 296).
Management Implication: FM companies should collect data, analyze and see how they can improve their productivity.

TABLE B12.—*Article 12*

Article 12	Purpose:	Research Question:	Methodology/Research Design:
Roskams and Haynes (2019)	Pilot study on integrating real time data	Can environmental FM be tested in real time and adjusted using real time data?	Observation and Assessment
	Date of Publication:	Sample size:	TAPUPAS Score:
	2019	15	17

Main findings: "The results of the study provide moderate support for the utility of using wireless sensors to effectively support occupant comfort" (Roskams & Haynes, 2019, p. 367).
Management Implication: Companies should consider putting in wireless sensors for energy savings.

TABLE B13.—*Article 13*

Article 13 *Ogbeifun et al, (2015)*	Purpose: Explores the role of effective communication in the role of FM and their customers	Research Question: What tools can be used for managing good relationships between FM and their customers	Methodology/Research Design: Lit review and interviews
	Date of Publication: 2015	Sample size: Lit Review and interviews of 2 university FM departments	TAPUPAS Score: 19

Main findings: The use of data and feedback will "bridge the existing gaps and improve customer satisfaction. The FM unit will earn the respect of its customer when the unit aligns its performance priorities along with the customer's perception and priorities" (Ogbeifun et al., 2015, p. 971).

Management Implication: Using feedback, and data analysis is key to customer satisfaction and continued improvement.

TABLE B14.—*Article 14*

Article 14 *Amos et al., (2018)*	Purpose: To present a comprehensive review of FM performance measurement over the past two decades	Research Question: How has FM performance measurement changed in the last couple of decades and what gaps have occurred?	Methodology/Research Design: Lit review
	Date of Publication: 2018	Sample size: Lit Review	TAPUPAS Score: 19

Main findings: "Descriptive statistics show a significant lag in FM performance research." As well there is "no one-size fits all solution" (Amos et al., 2018, p. 504) which leads to inconsistency among FM companies.

Management Implication: More research needs to be done and FM needs to be studied when it comes to performance management.

TABLE B15.—*Article 15*

Article 15 *Karunassena and Muthmala (2016)*	Purpose: Achievable service encounters in FM	Research Question: How can FM provide the best service encounters with customers?	Methodology/Research Design: Lit review and survey
	Date of Publication: 2016	Sample size: 46	TAPUPAS Score: 19

Main findings: "The findings revealed that each FM service encounter has links connecting the best combinations toward tangibility, reliability, responsiveness, assurance and empathy aspects of satisfaction. Therefore, the developed framework can be used as a FM services management tool. Further, it provides a guide to FM practitioners to map proactive measures for different service encounters over related satisfaction attributes to maximize tenant satisfaction" (Karunassena & Muthmala, 2016, p. 190).

Management Implication: Management needs to track service, analyze the data and consider a framework on response to ensure they are providing the best customer service depending on situation.

TABLE B16.—*Article 16*

Article 16 *Campbell (2016)*	Purpose: Looking at current potential and traditional trends in FM	Research Question: What are the current and future trends in FM?	Methodology/Research Design: Lit review
	Date of Publication: 2016	Sample size: Lit Review	TAPUPAS Score: 19

Main findings: "To aid the development of FM, researchers, funding bodies, organizations seeking FM research to be conducted on their behalf might consider sociological and psychological methods of research more. This can be challenging, given that FM is a support service, and often lacks adequate funding to conduct exploratory research focusing instead on more easily measurable, scientific hard FM research, with financially quantifiable research outputs" (Campbell, 2016, p. 363).

Management Implication: Organizations need to take a look at their groups socially and mentally as well and not just at what is seen in production and bank accounts.

TABLE B17.—*Article 17*

Article 17 *Lok and Baldry (2014)*	Purpose: Reviewing the concept of outsourcing in FM in higher education setting	Research Question: Does outsourcing FM have an impact on performance and impact on the client?	Methodology/Research Design: Case Study
	Date of Publication: 2014	Sample size: Case Study of Higher Ed in Hong Kong	TAPUPAS Score: 19

Main findings: "FM services will play a major role in the future of the higher education industry. Universities financial costs have recently increased, which means that the FM client-strategists must plan updated FM strategies to solve the current and future financial problems" (Lok & Baldry, 2014, p. 844).

Management Implication: While the cost of Universities rise, FM will need to look at more and outsourcing practices and their relationships with customers is very important to success.

APPENDIX D.—First Level Codes

Data
Data Analytics
Facilities Management (FM)
Higher Education
Evidence Based Decisions (EBD)
Data Management
Effectiveness
Challenges
Efficiency
Cost Savings
Opportunities
Process
Investment
Leadership
Barriers
Data Protection
Research
Benefits
Technology
Performance Management (PM)
Findings
Capabilities
Strategies
Work Performance
Budget
Expense
Future
Work Environment
Improvement
Key Concepts
Performance Measures
Change Management
Productivity
Interactions
Communication
Best Practices
Limitations

APPENDIX E.—First Level Coding Examples

Data, Data analytics, evidence-based decisions, data management, process, investment, data protection, research, technology, findings, capabilities	"Big data analytics is a cultural, technological and scholarly phenomenon that rests on the interplay of technology, analysis and mythology; the widespread belief that large data sets offer a brighter form of intelligence and knowledge that can generate insights that were previously impossible, with the belief of truth, objectivity and accuracy" (Tezel et al., 2016, p. 727).
Facilities management, Higher education, leadership, barriers, benefits, budget, expense, future, best practices, limitations	"The organizations can improve their revenue by increasing user satisfaction with FM services, thus attracting more students" (Lok & Baldry, 2014, p. 821).
Effectiveness, challenges, efficiency, cost savings, opportunities, performance management, work performance, strategies, work environment, improvement, key concepts, performance measures, change management, productivity, communication, interactions	"The customer's perception of the FM unit, obtained from customer satisfaction survey will change as the FM unit dramatically adapts the feedback information from the performance assessment to develop performance improvement strategies and then a performance management system" (Ogbeifun et al., 2015, p. 971).

APPENDIX F.—Category Coding

First Level Codes	Categories
Data, Data analytics, evidence based decisions, data management, process, investment, data protection, research, technology, findings, capabilities	Data and Data analytics in FM
Facilities management, Higher education, leadership, barriers, benefits, budget, expense, future, best practices, limitations	Higher Ed and FM
Effectiveness, challenges, efficiency, cost savings, opportunities, performance management, work performance, strategies, work environment, improvement, key concepts, performance measures, change management, productivity, communication, interactions	Performance Effectiveness and Management