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Research Article

Unlocking Student Success: A Comparative Analysis of Business Intelligence and Analytics in Higher Education Institutions

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Abstract – Business intelligence (BI) and analytics have emerged as critical tools for enhancing student success and improving institutional effectiveness in higher education. This study presents a comparative analysis of BI and analytics deployment and perceptions across different types of higher education institutions, including publicly funded universities and private universities. In the study, data from the Educause Core Data Services (CDS) questionnaire are utilized, supplemented by data from the National Center for Education Statistics (IPEDS). The findings reveal significant variations in BI deployment and perceptions among institutions, with private universities demonstrating higher levels of institution-wide deployment compared to public universities. Despite widespread recognition of the importance of analytics for strategic planning and decision-making, funding constraints and faculty acceptance emerge as key challenges hindering analytics maturity. However, there is growing momentum toward leveraging BI and analytics to drive transformative change in higher education, with strong leadership commitment observed for developing institutional effectiveness through analytics. The study underscores the need for ongoing research and collaboration to address funding constraints, improve faculty engagement, and foster a culture of data-driven decision-making across the sector. By overcoming these challenges and seizing opportunities for innovation, higher education institutions can harness the power of BI and analytics to improve student success outcomes, enhance operational efficiency, and drive institutional excellence in the 21st century academic landscape.

Keywords – Business Intelligence, Analytics in Higher Education, Student Success, Comparative Analysis, Institutional Effectiveness

I. INTRODUCTION

Higher education institutions are facing rising pressure to improve student outcomes and achievement in the face of ever changing academic, technical, and economic obstacles. As a result, a growing number of colleges are using business intelligence (BI) and analytics as tactical tools to support student success programs, enhance operational effectiveness, and inform decision-making.

The purpose of this study is to examine BI and analytics' role in higher education, specifically as it relates to enhancing student success. Universities may anticipate academic results, better understand student behavior, and customize interventions to meet the requirements of each person by utilizing data-driven insights. This study aims to clarify the disparate methods and perspectives on the implementation of information systems across various funding schemes by conducting a comparative analysis of publicly financed universities and private institutions.

Using information from the Educause Core Data Services (CDS) survey from 2002 to 2016, this study looks at patterns in institutional perspectives, BI and analytics technology investments, and deployments. The questionnaire offers a dataset covering multiple modules that address important aspects of IT infrastructure, services, and management within higher education institutions. It was compiled by Educause, a nonprofit association committed to advancing higher education through information technology.

This study aims to provide insights into the changing landscape of BI and analytics in higher education by examining the deployment status of analytics systems, assessing institutional attitudes toward analytics investment, and evaluating the readiness of universities to leverage data for strategic planning and decision-making. In addition, this paper examines the intersection of BI and analytics with student success initiatives, investigating how these technologies can be leveraged to enhance curricular design, academic support services, and student engagement strategies. By examining the deployment status of adjunct information systems designed to support student success, such as degree audit systems and advising management platforms, this study seeks to identify gaps and opportunities for further integration of BI and analytics into student support frameworks.

In summary, this study uses a nuanced analysis of survey data and empirical evidence to support strategic decision-making and resource allocation inside higher education institutions. Ultimately, we will have made progress toward the shared objective of raising student achievement and outcomes in the twenty-first-century academic environment.

II. Literature Review

In recent years, the use of business intelligence (BI) and analytics in higher education has garnered significant attention from scholars, practitioners, and policymakers alike. This field of study investigates how data-driven methods might improve operational effectiveness, guide decision-making, and ultimately lead to better student success results in higher education institutions.

The idea of data-driven decision-making, or DDDM, has become more well-known in the literature on higher education as colleges look to use data analytics to guide resource allocation and strategic planning. According to Bichsel (2012), BI and analytics are critical for delivering actionable insights that help organizations spot patterns, forecast results, and manage resources wisely. Furthermore, it has been demonstrated that DDDM makes evidence-based decisions easier in a variety of areas, such as academic program development, student support services, and enrollment management [1], [2].

To increase retention and graduation rates, predictive analytics has become a potent tool for identifying at-risk students and putting tailored interventions in place. Universities can create early warning systems that identify students who may be in danger of dropping out or falling behind academically by examining historical data on student performance, participation, and demographics [3], [4], [5]. Additionally, by determining each student's unique learning preferences, styles, and areas of strength and weakness, predictive analytics can help create individualized learning experiences [6].

Universities are depending more and more on BI and analytics to guide decision-making, therefore it is critical to take ethical issues pertaining to data protection, privacy, and transparency into account. Academics emphasize the significance of guaranteeing that student data is managed in an ethical and responsible manner, with suitable measures used to preserve confidential information [7], [8], [9]. Additionally, there is an increasing understanding of the necessity of accountability and transparency in BI and analytics processes to establish credibility and confidence with stakeholders [10], [11].

Yet, there are several obstacles in the way of BI and analytics in higher education to harness its potential. These include institutional capacity issues, data silos, and resistance to change. The necessity for colleges

to create strong data governance frameworks, make staff training and development investments, and promote a departmental culture of data literacy and cooperation has been underlined by academics [12], [13], [14]. Furthermore, multidisciplinary research and cooperation are becoming more and more important to tackle difficult problems and realize the full potential of BI and analytics in higher education [15].

The need to boost institutional effectiveness and increase student success has prompted higher education institutions to adopt business intelligence (BI) and analytics. Research shows that colleges are spending more money on BI tools and analytics platforms to gather, process, and display information about the demographics, academic standing, and involvement of their students [6], [13], [16], [18]. Universities have never had more opportunity to understand student behavior in real time, spot trends, and create focused interventions to help with student success efforts thanks to the technology.

A comparative analysis of BI and analytics implementation across different types of higher education institutions sheds light on the diverse approaches and attitudes toward information systems adoption. By examining the experiences of publicly funded universities and private institutions, researchers can identify similarities and differences in BI maturity, deployment strategies, and perceived benefits [15], [17]. The comparative study offers insightful information on the institutional agendas, financing sources, and organizational culture that affect BI adoption [18].

The literature on BI and analytics in higher education underscores the transformative potential of data-driven approaches to inform decision-making, enhance student success, and drive institutional innovation. By leveraging predictive analytics, ethical considerations, and interdisciplinary collaboration, universities can harness the power of data to address complex challenges and achieve their strategic goals in the 21st century academic landscape.

III. METHODOLOGY

The authors have separated the participating universities in the survey into three categories for the comparative analysis. Examining the distinctions between privately funded and publicly supported universities is the goal. Since public and private universities have distinct funding schemes, it is predicted that they will behave differently while implementing information systems. This is the reasoning behind the grouping.

To examine the similarities and variations in attitudes toward information systems while considering the various characteristics of these groups, a comparative analysis of the identified groups is crucial. There are summarizing techniques employed because the dataset is huge. Pivoting is the primary analytical tool that is utilized a lot in this part. This investigation made use of pivot table feature found in Microsoft Excel.

A survey carried out by Educause is employed. A nonprofit organization dedicated to advancing higher education, Educause is a family of IT leaders and professionals. The Educause questionnaire, which was assembled for the Core Data Services (CDS), aims to gather information from universities worldwide. It is divided into six modules, each of which has questions from a distinct subject area.

A. Educause Core Data Services (CDS) – Data Collection

The questionnaire was first conducted in 2002 and maintained the same format until 2009, comprising one module with several sections: IT Organization, Staffing and Planning (10 questions), IT Financing and Management (17 questions), Faculty and Student Computing (11 questions), Networking and Security (12 questions), and Information Systems (5 questions). Subsequently, in 2010, the survey expanded to include 8 modules, with the first module being mandatory. Each module contained more questions than in previous years. In 2016, the survey was redesigned with 9 modules, still requiring the first module for participation. Optional modules were rotated annually, allowing each institution to respond to only 5 modules per year while retaining access to previously contributed data. The summary of modules as of 2016 is provided in Table 1 below.

Table 1: Educause questionnaire modules

1-ITOSF: IT Organization, Staffing, and Financing (required, Previously M1)	6: IT Support Services (optional, Previously M2, not offered in 2016)
2-ISA: Information Systems and Applications (optional, Previously M8)	7: Research Computing (optional, Previously M4, not offered in 2016)
3-CTD: Capability and Technology Deployment (optional, new in 2016)	8: Data Centers (optional, Previously M5, not offered in 2016)
4-ETS: Educational Technology Services (optional, Previously M3)	9: Communications Infrastructure Services (optional, Previously M6, not offered in 2016)
5-IS: Information Security (optional, Previously M7)	

Source: Educause CDS modules

A growing number of universities have completed the survey: from 639 in 2002 to 1010 in 2007 and 784 in 2016. The number of participating universities has stayed constant over the past fifteen years, averaging about 800 a year. The Educause consortium comprises 3502 universities, the most of which are located in the United States, although some are from other nations as well.

B. Data Description

A portion of the 4. CTD-Capability and Technology Deployment and 5. ETS-Educational Technology Services Modules questions are used for this study in the comparative analysis section that follows. Table 2 contains a description of the questionnaire questions that were used in the study.

Table 2: Data Desription

Data	Question Nr.	Question Definition	Question Description and Use
Educause Questionnaire Data			
CDS	CTD, Q1	Analytics Maturity	Multiple choice grid with 6 categories (data efficacy, decision-making culture, investment, policies, technical infrastructure, and involvement) and sub-questions for each in the rows, and 5 levels of achievement (not achieved, slightly, partially, largely, fully) as columns.
CDS	CTD, Q2	Analytics Deployment	Multiple choice grid with 11 systems and technologies that relate to analytics as rows, and 5 categories of deployment (no, tracking, initial, partial, institution-wide) as columns.
CDS	ETS, Q8	E-Learning Technology Deployment	Multiple choice grid with 14 systems and technologies as rows, and 5 categories of deployment (no, tracking, initial, partial, institution-wide) as columns. Selected systems/technologies are used.

Source: Authors own description

Apart from the group comprising all institutions, two new groups were formed throughout the comparative analysis. Table 3 below lists the number of institutions in each group that participated in the survey.

Table 3: Number of participating institutions in all subgroups

Group of Institutions	Number of institutions
All Institutions	801
Public Institutions	462
Private Institutions	315

Source: Authors own database count

Most of the data used in the comparative study is summed up using functions like average, sum, and median before being handled using pivot tables and charts to provide the findings.

IV. RESULTS

Business Intelligence (BI) and analytics are increasingly being used by higher education institutions for strategic objectives outside of the classroom. Since 2012, BI and analytics have been among the top ten IT concerns, and their significance to institutions has only increased. As Grajek mentions, "Business intelligence (BI) and analytics are the keys to unlocking insights that are contained in the numerous institutional data stores" [19].

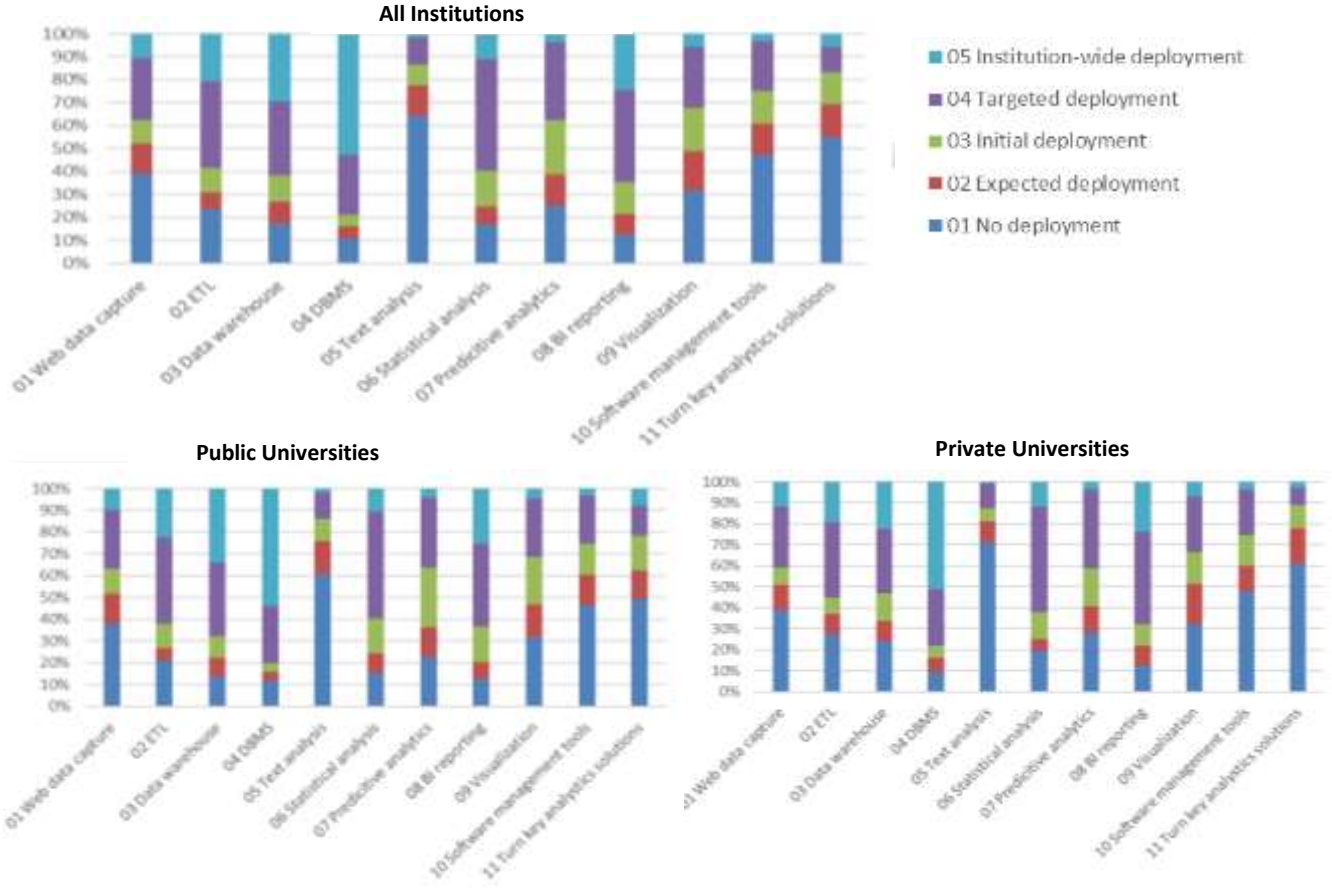

Figure 1: Analytics Deployment across different institutions types

Source: Authors own

There is an urgent need for increased funding for technologies that support and improve analytics, as seen in Figure 1. The database management system is the only one that is mostly implemented across institutions, but at moderate levels—roughly 50% across all institutions—according to Table 4 below, which is taken from the analytics deployment data.

Table 4: Analytics Deployment Systems implemented in HEIs.

Deployment Strategy	Analytics Maturity	Private Universities	Public Universities	All Institutions
No Deployment	Text Analysis	71%	61%	65%
	Turn Key Analytics Solutions	61%	49%	55%
	Software management tools	48%	46%	47%
Institution wide	DBMS	51%	54%	53%
Targeted	Statistical Analysis	50%	49%	49%
	BI reporting	44%	38%	40%
	Predictive Analysis	44%	38%	40%

Source: Authors own

Furthermore, data indicates that while many institutions believe that there should be more investment in analytics, their opinions are not entirely in agreement. Just 5% of the institutions think analytics is an investment, while the majority are indifferent or in agreement.

Table 5: Perception of Analytics as Investment by HEIs

Groups of Institutions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
All eligible institutions	8%	20%	37%	29%	5%
Private Universities	9%	25%	37%	24%	5%
Public Universities	8%	17%	37%	32%	5%

Source: Authors own

When asked if weather data is crucial for the strategic plan, the majority of universities indicated that they agreed.

Table 6: Perception of data as important for strategic planning

Groups of Institutions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
All eligible institutions	3%	9%	21%	51%	17%
Private Universities	3%	12%	25%	47%	13%
Public Universities	3%	6%	18%	53%	20%

Source: Authors own

The same holds true for whether or not the data is being used in the decision-making process. As Figure 2 below illustrates, the majority of institutions across all categories are neutral in this regard, with public universities slightly more likely to concur.

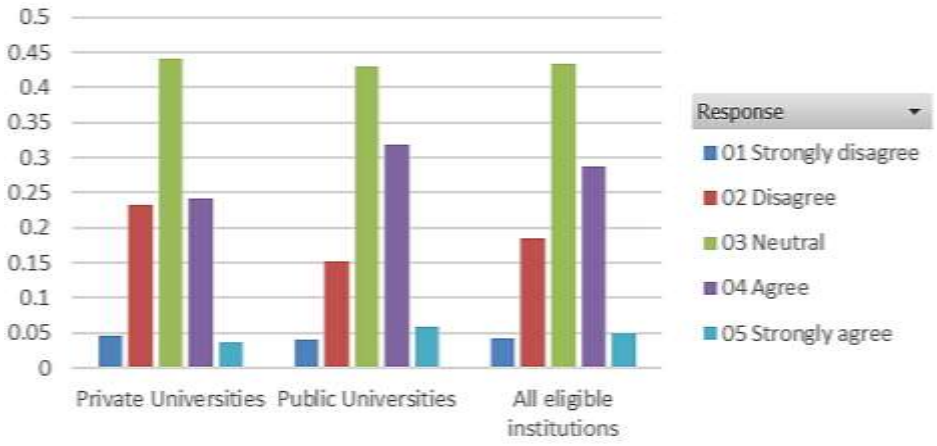

Figure 2: Data to Decisions

Source: Authors own

Higher education institutions' analytics maturity will increase as more and more universities come to understand the advantages of utilizing BI tools and analytics. According to data, most of the universities are dedicated to using analytics to help bring about revolutionary change within the institution. According to Figure 3 below, the top management of over 60% of institutions is dedicated to advancing analytics in order to increase institutional effectiveness.

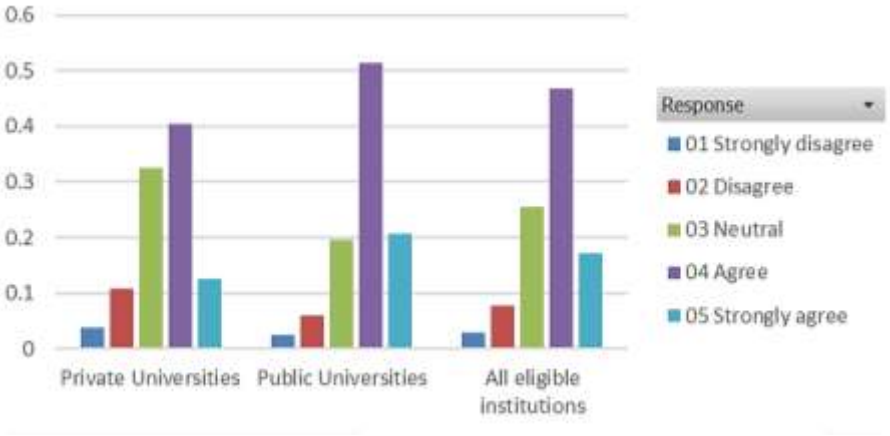

Figure 3: Leadership Commitment in supporting analytics in HEIs. Source: Authors own

But it appears that one of the main problems is a lack of funds. According to survey data, a major barrier preventing universities from reaching analytics maturity is a lack of funding. Figure 4 below shows that around 56% of private institutions and 49% of public universities agree that there is insufficient funding for higher education. Interestingly, both groups also think that the lack of funding for analytics is the cause of their academic shortcomings.

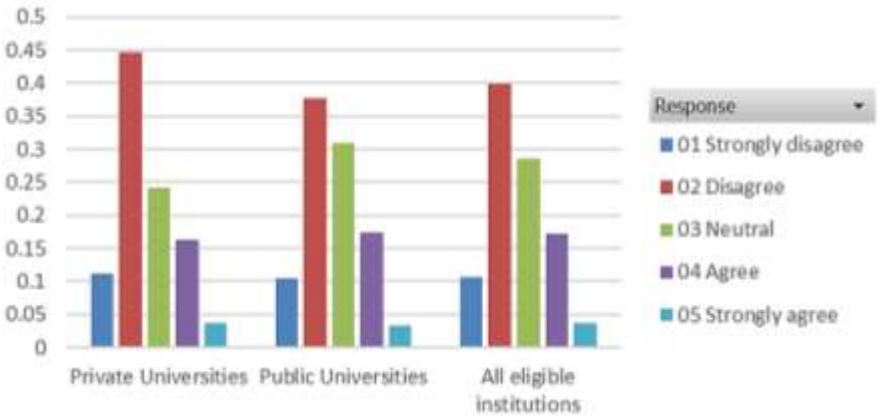

Figure 4: Is there sufficient funding for reaching analytics maturity. Source: Authors own

The significance that academic and administrative personnel have on analytics is another factor contributing to its relatively poor application. Data shows that while as few as 30% of academic members accept analytics, more than 60% of administrative staff members agree and employ them (see Figure 5). The question of whether the instructors use analytics is similarly relevant. Across all institutions, just 29% of people are in agreement.

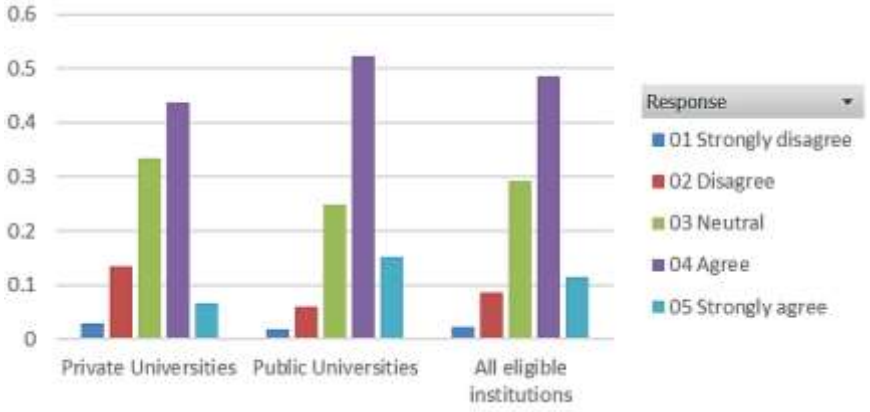

Figure 5: Administrative and Faculty acceptance of analytics.Source: Authors own

Nonetheless, for the institution, analytics is becoming more and more significant for a variety of reasons. In addition to helping the institution achieve its objectives, BI and analytics are crucial for providing reports and insights that are needed for the institution's aims to come first. Additionally, it improves the decision-making process by making it easily usable by all parties involved, including but not limited to teachers, staff, and students. Drawing from a study of 256 higher education institutions, Figure 6 below summarizes a few of the perceived benefits for a higher education institution.

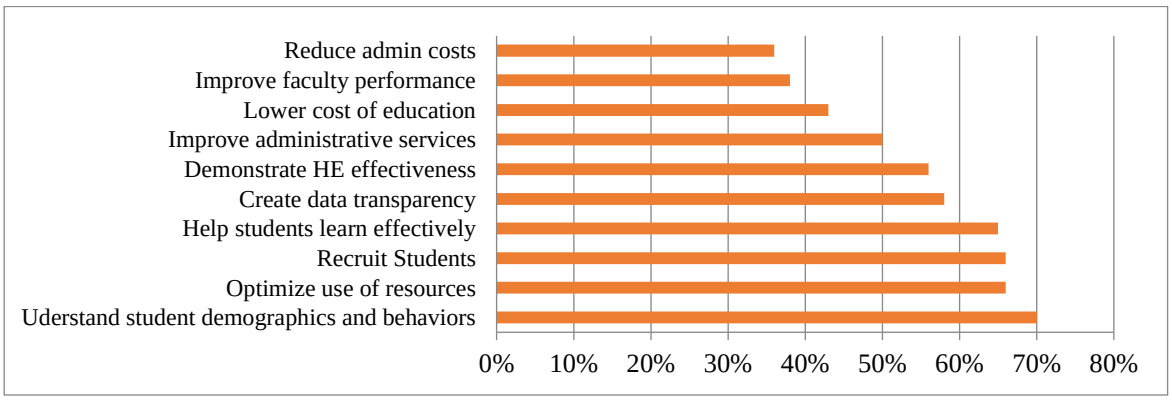

Figure 6: Benefits of analytics for HEI. Source: adapted from [17]

Analytics can play a key role in curriculum design and university priority setting when it comes to enhancing student achievement and success. Utilizing student spin data—that is, information regarding enrolling in and dropping out of courses, selecting majors, and switching institutions—to create curricula, academic programs, and hire and allocate academic staff is one method to achieve this. Additionally, utilizing student technologies can enhance student achievement. Student success technologies are those that are used to improve student outcomes in accordance with the institution's objectives by maximizing the utilization of available technologies. These technologies gather data and provide tools for analysing it to forecast student achievement, identify students who run the danger of failing, issue intervention warnings, and assess the efficacy of those warnings. Academic staff members have access to many tools and approaches, like decision trees, induction analysis, and genetic algorithms, that can be utilized to forecast the final grades of their pupils. The application of the clustering approach is demonstrated by mining student data to cluster to find patterns of user behaviour. Data clustering can be highly helpful in content management systems, staff and resource allocation, alumni management, and other adaptive and intelligent web-based educational systems. However, new technologies are only one part of the blueprint that improves the student outcomes. According to study, additional components are needed to have the desired effects. An attempt is made to summarize the various elements that make up the student technological maturity index depicted in Figure 7 below.

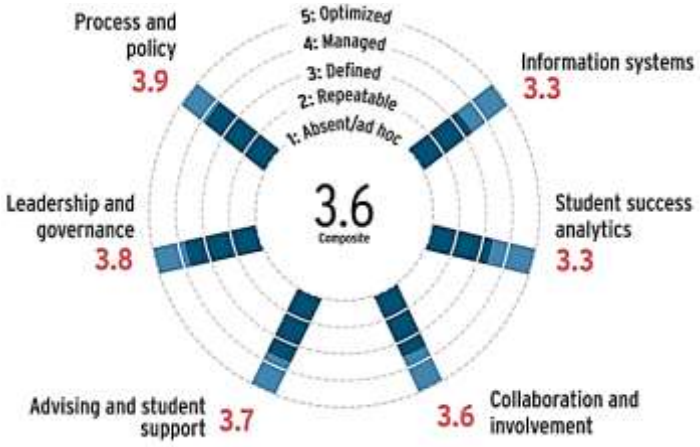

Figure 7: Student Success Technologies maturity index, Source: [19]

Even if advising and student support are ranked as high as 3.7 on this index, evidence indicates that not all schools are prepared to use data to improve student outcomes. The various adjunct information systems that are fully or partially deployed across all of the various subgroups are displayed in Table 7 below. The data indicates that less than 50% of universities or subgroups have mechanisms in place that recommend courses. Similar percentages, roughly 40% for public colleges and 70% for private universities, have not implemented student success data warehouses and dashboards.

Table 7: Adjunct Information System deployment in HEIs

Adjunct System/ Type of Institution		Degree Audit	Advising Center Management	Advising Case Management	Education Plan	Academic Early Alert	Course Recommendation	Credit Transfer	Student Success Dashboard	Student Success Datawareouse
No Deployment	All Institutions	9%	38%	39%	37%	32%	57%	34%	56%	52%
	Private Universities	10%	47%	43%	48%	37%	66%	46%	68%	69%
	Public Universities	7%	30%	34%	27%	27%	50%	25%	46%	41%
Partial Deployment	All Institutions	24%	29%	33%	30%	35%	24%	22%	34%	33%
	Private Universities	29%	26%	32%	27%	35%	21%	23%	26%	23%
	Public Universities	21%	31%	34%	34%	36%	27%	20%	40%	39%
Full Deployment	All Institutions	67%	33%	28%	33%	33%	18%	44%	11%	15%
	Private Universities	61%	27%	24%	25%	27%	13%	30%	5%	7%
	Public Universities	72%	39%	32%	39%	37%	22%	54%	14%	20%

Source: Authors own calculations

Furthermore, the data indicates that universities have primarily implemented degree audit systems (of which 67% of all institutions have fully deployed) and credit transfer systems (of which 44% have fully deployed) across all subgroups. When it comes to adjunct information systems, public institutions often have stronger implementation than private colleges, outperforming them by an average of 10% to 15%. For example, there is still a very low deployment rate of the education planning system, which provides, among other things, the option for facility planning, learning space design, and communication infrastructure where technology is integrated into teaching and learning (33% full deployment in all institutions, 25% for private, and 39% for public). The fact that 30% of institutions have just partial deployment, however, is encouraging since it means that they are either in the early stages of deployment or have targeted deployment and will soon have institution-wide deployment.

V. DISCUSSION

Looking ahead, the future of BI and analytics in higher education holds great promise for improving student success outcomes and driving institutional innovation. As universities continue to invest in BI tools and analytics platforms, there is a need for interdisciplinary research and collaboration to address complex challenges and unlock the full potential of data-driven approaches. By leveraging predictive analytics, ethical considerations, and comparative analysis, higher education institutions can harness the power of data to inform strategic planning, enhance student support services, and ultimately, foster a culture of continuous improvement and innovation in the 21st century academic landscape.

The comparative analysis of BI and analytics deployment across different types of higher education institutions reveals notable variations in adoption rates and strategies. Private universities exhibit a higher level of institution-wide deployment for database management systems (DBMS) compared to public universities. This disparity suggests that private institutions may have greater financial resources or a stronger emphasis on technology infrastructure investments. Conversely, public universities lag in DBMS deployment, indicating potential challenges or constraints in implementing comprehensive data management solutions.

The results shed light on the perceptions of analytics investment and strategic importance among higher education institutions. While there is widespread recognition of the importance of analytics for informing strategic planning and decision-making, there is a notable divergence in attitudes toward investment. Private universities and public institutions exhibit varying degrees of agreement on the need for increased

investment in analytics. This discrepancy suggests that while institutions recognize the value of analytics, there may be barriers such as budget constraints or competing priorities hindering investment in analytics initiatives.

The findings highlight several challenges and opportunities for BI and analytics implementation in higher education. Funding constraints emerge as a significant barrier to achieving analytics maturity, with most institutions citing insufficient funding as a primary reason for lacking behind. Moreover, faculty and administrative acceptance of analytics presents another hurdle, with lower levels of engagement observed among faculty compared to administrative staff. However, despite these challenges, there is growing momentum toward leveraging BI and analytics to drive transformative change in higher education institutions. Leadership commitment emerges as a crucial factor in supporting analytics initiatives, with a majority of institutions indicating strong executive support for developing institutional effectiveness through analytics.

VI. CONCLUSION

In conclusion, this study offers valuable insights into the adoption and impact of business intelligence (BI) and analytics in higher education institutions. The comparative analysis revealed significant variations in BI deployment and perceptions across different types of institutions, with private universities demonstrating higher levels of institution-wide deployment compared to public universities. Regardless of the widespread recognition of the importance of analytics for informing strategic planning and decision-making, funding constraints and faculty acceptance emerged as key challenges hindering analytics maturity.

Although there are challenges, there is growing momentum toward leveraging BI and analytics to drive transformative change in higher education. Leadership commitment plays a critical role in supporting analytics initiatives, with strong executive support observed for developing institutional effectiveness through analytics. However, addressing funding constraints and improving faculty engagement remain essential for realizing the full potential of BI and analytics in higher education.

Furthermore, the study highlights the need for ongoing research and collaboration to address complex challenges and unlock the full potential of data-driven approaches. Interdisciplinary research and collaboration are essential for developing robust data governance frameworks, investing in staff training and development, and fostering a culture of data-driven decision-making across departments. By addressing these challenges and seizing opportunities for innovation, higher education institutions can harness the power of BI and analytics to improve student success outcomes, enhance operational efficiency, and drive institutional excellence in the 21st century academic landscape.

Overall, this study underscores the transformative potential of BI and analytics in higher education and calls for concerted efforts to overcome barriers and foster a culture of data-driven decision-making and innovation across the sector.

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