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A Case Study on Sustainable Quality Assurance in Higher Education

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Abstract: In contemporary academia, accreditation stands as a vital process for universities to uphold their reputation and deliver quality education to students. Key Performance Indicators (KPIs) significantly contribute to this process by enabling institutions to assess their performance in crucial areas, such as student outcomes, faculty engagement, and research effectiveness. To achieve sustainable accreditation, universities necessitate a comprehensive data management system capable of handling extensive data and generating pertinent insights. High-quality education remains paramount for academic institutions to equip students with essential professional skills, thereby enabling societal economic advancement. A sustainable quality management system is an innovative approach emphasizing continuous improvement and long-term planning to enhance an organization's overall performance and maintain a competitive edge within the sector. This paper presents a case study on sustainable quality assurance in higher education, underscoring the importance of KPIs in accreditation and the need for a robust data management system to ensure sustainability. Additionally, it highlights the significance of delivering high-quality education and the role of a sustainable quality management system in realizing this objective.

Keywords: sustainable quality practices; quality assurance; higher education; quality management system

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1. Introduction

The concept of quality has experienced a remarkable transformation over time, developing from abstract notions to practical techniques and well-defined procedures [1]. Quality can be characterized in various ways, such as value, adherence to requirements, suitability for use, and meeting or exceeding customer expectations [1]. Researchers and practitioners concur that quality is a crucial determinant of an organization's long-term success. Al-Tarawneh and Mubaslat [2] posit that quality represents an ongoing process of improvement, resulting in consistent and enduring performance. Quality encompasses not only the product or service but also the organization's reputation and its quality management practices.

In today's fiercely competitive business landscape, quality serves as a key differentiator for organizations aiming to distinguish themselves from their counterparts [3]. By consistently offering high-quality products and services, organizations can cultivate a loyal customer base and bolster their reputation in the market. Quality management practices, such as Six Sigma and Total Quality Management, have gained traction as organizations endeavor to elevate their quality standards and achieve operational excellence. However, attaining and sustaining high levels of quality is no small feat. It necessitates a commitment to continuous improvement, a focus on customer needs and expectations, and a willingness to invest in the requisite resources and infrastructure. Organizations that prioritize quality and integrate it into their culture are more likely to thrive in the long run [4].

Higher education institutions (HEIs) must implement high-quality services to differentiate themselves from competitors and ensure long-term viability [4]. To enhance the

quality of services and procedures in higher education, an array of quality tools, methods, and models have been adopted. Total Quality Management (TQM), Quality Function Deployment (QFD), and, more recently, Lean Six Sigma (LSS), are examples of these approaches. While these techniques were initially developed for use in the private sector, they have since been successfully applied in public sector and not-for-profit organizations to improve efficiency, reduce costs, and enhance service quality [5]. HEIs have reaped substantial benefits from employing these tools and methods, such as cost savings, increased productivity, streamlined procedures, and improved customer satisfaction. However, conventional quality practices are expected to evolve to maintain their effectiveness. Elshennawy [6] suggests that quality professionals must adapt to a new era of advanced technology and innovation. Consequently, these professionals and their organizations are expected to refine quality-related practices and procedures by incorporating state-of-the-art technological tools, media, and strategies suitable for both manufacturing and service industries.

The primary objective of employing IT in university management of quality assurance (QA) is to enhance applicants' satisfaction with the educational process at HEIs through the utilization of software systems [7]. It is evident that this sector requires the application of sophisticated ICT [8]. The use of ICT enables more efficient and straightforward execution of tasks such as collecting, processing, and analyzing data necessary for monitoring quality and its adequate presentation.

Effective data exchange can be hindered by the incompatibility between software products developed by different developers [9]. Consequently, an increasing number of HEIs are opting to purchase or develop an integrated management system that facilitates the synchronization of all aspects of higher education quality assurance. Therefore, choosing an appropriate quality management system for the educational process is a pressing concern. This issue can be addressed by evaluating current automated educational process management systems, identifying their strengths and weaknesses, and assessing the outcomes of their implementation [10]. HEIs either employ pre-made software packages or develop their own systems to tackle the aforementioned challenges. Factors to consider when selecting a system include the HEI units subject to automation, the types of procedures to be automated, and the system components and structure.

Establishing a sustainable data warehouse for accreditation KPIs can assist higher education institutions in streamlining the data collection and analysis process while reducing costs and enhancing accuracy. This study presents a case study on a sustainable data warehouse for accreditation KPIs in higher education, emphasizing best practices, benefits, challenges, and future opportunities.

2. Literature Review

The importance of higher education institutions to meet the standards and requirements to achieve accreditation has increased significantly in recent years. Accreditation is the process of evaluating educational institutions and programs to ensure that they meet certain standards and requirements set by accrediting bodies [11]. Accreditation Key Performance Indicators (KPIs) are critical for higher education institutions to measure and demonstrate their compliance with these standards and requirements, as well as to improve the quality of education that they provide [12].

Educational establishments have been challenged to present themselves to the public in the most favorable light possible due to increased competition and the desire to attract students. The procedures for accreditation and quality assurance necessitate the collection, processing, and evaluation of a substantial amount of data. A significant advantage comes from having the appropriate software applications to support this procedure. However, there are no such commercial applications at this time. This is due to their limited use and the unique organization of quality systems in various educational establishments, which refers to various methodologies for evaluating various educational objects and subjects, procedures, and participants.

Different software tools are used by different educational establishments to support different activities and stages of the quality assurance procedures, either partially or completely. This includes applications for data processing and report generation, data aggregation and visualization, and various combinations of commercial and university applications for data collection, processing, and analysis for various educational subjects and objects.

Awino and Agolla [13] published a University of Botswana case study exploring sustainable quality assurance measurement for universities. The study offers a perspective on measurement-based assessment of learning at the university level, drawing on rich literature that informs what constitutes quality assurance in higher education. The study aims to develop a sustainable quality assurance framework that can be used to measure and improve the quality of education at the University of Botswana. The framework is designed to be flexible and adaptable to the changing needs of the university and to provide a basis for continuous improvement in the quality of education. The study highlights the importance of quality assurance in higher education and the need for universities to develop sustainable quality assurance frameworks that can be used to measure and improve the quality of education over time.

Holmab et al. [14] conducted a comparative analysis of quality assurance in education for sustainable development (ESD) in Nordic countries and China at both the policy and implementation levels. Their findings, which are worth paying attention to, were based on two stages of research. The first stage involved analyzing literature on the subject, while the second stage consisted of conducting a special survey in two provinces of China. The study aimed to identify opportunities for improving ESD in these regions by applying quality assurance methods. By examining the similarities and differences between the approaches taken in Nordic countries and China, the research sheds light on how ESD can be effectively implemented and improved in different contexts. Overall, the study provides valuable insights into the challenges and opportunities of implementing ESD and quality assurance practices in diverse settings.

Amalia et al. [15] provide a description of a conceptual model of an Internal Quality Assurance System, which includes the fundamental functional requirements and scenarios. The model can be modified to meet the particular requirements of educational establishments and utilized in the initial stages of software application design and development. Estil [16] presented their program-based quality assurance model with a decision support system design and development work. It is a web application for evaluating university programs that meet the quality standards of the Philippine Accrediting Association of Schools, Colleges and Universities (PAASCU) and the Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA), two accreditation bodies in the Philippines. The application stores, processes, and analyzes the information it collects to support the educational institution's management process and the preparation of accreditation-related documents.

In Indonesia, a program for evaluating academic quality was developed in 2013 [17]. It demonstrates Malcolm Baldrige University's accomplishments in terms of established quality standards. A service-oriented architecture model is used in both the design and the implementation, with a focus on business intelligence. The application makes use of services to collect, integrate, and extract data from a distributed information island. Alzoabi et al. present a model of a system for assessing a university's educational quality [18]. It is based on relevant indicators for the three main pillars of the education process: content, delivery, and assessment. Additionally, a Delivery Performance Indicator has been developed for performance evaluation.

An application has been developed by Shandong University to guarantee the quality of education [19]. The management of teaching, the management of student learning, and the visualization of data throughout the learning process are the three main aspects of the learning process that are distinguished. The application aggregates a variety of data, allowing for the identification of learning process flaws and the implementation

of enhancements. Odessa Polytechnic University researchers are working in the same direction [20]. They have created a decision support system that takes information from student surveys. It includes modules for defining deviations from recommended values and obtaining values for unobservable learning process characteristics. This makes it possible to identify the current state of the learning process and offer appropriate suggestions for its enhancement.

Gora et al. [21] used a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to provide empirical evidence of the impact of quality assurance in higher education on students' knowledge, skills, competencies, and employability in the context of sustainability. The study collected survey data from students' perspectives to test hypotheses regarding the relationship between key factors underlying management and quality assurance in higher education. The study's methodology is a quantitative research approach that uses statistical analysis to test the hypotheses and provide empirical evidence of the impact of quality assurance in higher education on students' outcomes. They tested hypotheses regarding the relationship between the key factors underlying management and quality assurance in higher education. The study's findings suggest that the quality of the educational process, infrastructure and technical equipment, practical activities, and students' research activities influence the knowledge/competencies/skills acquired by the students. Therefore, higher education institutions can use these findings to improve the quality of their educational process, infrastructure, practical activities, and research activities to enhance students' outcomes.

In Saudi Arabia, the higher education governance structure falls under the Ministry of Education and Education and Training Evaluation Commission (ETEC) [22]. Both entities require a set of data that are relevant to their needs. Having such a system made it easy to regularly send these data electronically, which is a sustainable way of dealing with such requests. The ETEC has several tasks, such as setting national standards for the evaluation of education and evaluating the performance of educational institutions.

The purpose of this article is to provide an overview of sustainable data warehousing for accreditation KPIs in higher education institutions. The article aims to help institutions in building an efficient and sustainable data warehouse to collect, analyze, and report the data needed for accreditation KPIs. The article also provides best practices and recommendations for the implementation of a sustainable data warehouse and highlights some of the challenges institutions may face during the implementation process.

3. Data and Quality Assurance

Any organization's decision making process must be efficient and accurate in order to be considered successful. Depending on the nature and type of the organization—whether manufacturing or service—data can come from a variety of sources. Up until the last ten years, it was difficult for some European HEIs to access data. Bonaccorsi et al. [23], for instance, looked into the lack of data in 12 higher education institutions in 12 European nations and offered methods for gathering and validating data from various national sources. In some of the countries studied, national statistical services collected data centrally from individual higher education institutions, while, in others, data were collected directly from individual universities. This revealed data transparency issues. Additionally, the authors identified issues with the uniformity and quality of the data, which have an impact on the data's veracity.

Collecting and analyzing accreditation KPI data can be challenging for higher education institutions [24]. The data are often scattered across various systems, and it can be difficult to ensure data accuracy and consistency. There are also challenges in managing data security, privacy, and access permissions, especially when dealing with sensitive information. Additionally, institutions often struggle with limited resources and budget constraints for data management and reporting.

Jacob [25] indicates that there are four types of data analytics: diagnostic, descriptive, prescriptive, and predictive. The most common method used in descriptive analytics is to

keep track of known or suspected correlations. To find bottlenecks, diagnostic analytics use metrics such as quality process cycle times. Metrics that are concerned with predicting the future include trend analysis and the application of trend rules to SPC data. Advanced analytics are prescriptive. They usually include some degree of autonomous behavior, indicate failure, and specify what actions should be taken to address or alter the outcome. When machine learning and/or artificial intelligence (ML/AI) are utilized, analytics processes that are descriptive, diagnostic, and predictive in nature can be carried out using conventional data in traditional quality settings.

Due to the difficulty of measuring and analyzing a large amount of data, many HEIs face significant difficulties in making strategic decisions [26]. Nguyen, Gardner, and Sheridan [27] indicate that data analytics helps higher education institutions (HEIs) understand the important educational processes that help them perform better. The creators expressed that there are three significant ways of dissecting information in HEIs:

- Learning Analytics: The learners and the learning processes are the focus of these analytics. To improve learning outcomes, this method collects learners' profiles and the teaching materials used and conducts descriptive analysis on them.
- Academic Analytics: Through the use of descriptive and predictive analyses, this method provides faculty members with a clear understanding of the most significant practices for enhancing learning and teaching methods.
- Data Mining for Education: To gain a deeper comprehension of students and educational systems, this strategy makes use of analytics to transform unstructured data into useful information.

Instead of being used as a stand-alone, unintegrated system within the organization, the quality management system must be operated at the enterprise level. Because quality is connected to every operational and managerial aspect of every process in the value chain [25], this is regarded as the center of value chain creation within any organization. In order to achieve the autonomy required to shift the high-value staff focus from mechanics of execution to innovation and improvement in traditional quality practices, Jacob [25] stated that these processes should be synchronized and software automated before being connected. The author stated that, despite the observed progress in adoption, only slightly more than 10% of organizations adopt an integrated system. Due to the fragmented core processes that exist in today's organizations, there has been a delay in adopting the high-quality technology that enables systems to become autonomous, a requirement for the adoption of an integrated system. As a result, organizations should align their quality processes in order for the software to automate them. All of an organization's quality processes can be connected to other systems and operations once they have been standardized and automated. Such a connection would boost collective analytics and learnings to continuously enhance system autonomy.

The system's central repository of data is used to monitor quality indicators and generate reports at the university or organizational unit level. The integration of existing data from individual organizational unit databases is one of the system's main functions. The ability to record data for which there is currently no electronic record is yet another important feature. At the university level, the functionality for extracting, transforming, and loading a central data warehouse is implemented by a subsystem for the integration of existing data. Data about students, teaching staff, programs, and courses are all stored in the data warehouse. In addition, the results of student surveys are stored in the data on teaching staff for evaluation of teaching quality. Programming apparatuses in light of the utilization of business knowledge are utilized for the examination and showing of this information.

Several quality indicators are coming from several surveys. Automated and streamlining these surveys in existing systems help a great deal in making the data ready when needed. These steps are essential in any digital transformation or automation of quality aspects. Placing these surveys in the right system with a clear process that ensures the right response rate is achieved is a very important aspect of these efforts' success. Prince Sultan

University has more than nine surveys related to students, faculty, services, etc. These systems were placed in the existing system with a suitable mechanism to enforce a certain response rate.

4. Data Warehouse and Quality Assurance

Data warehousing is a crucial process that involves collecting and storing data from various sources in a centralized repository. This repository is designed to support the analysis and reporting of data, making it an essential tool for higher education institutions seeking to improve their accreditation KPIs.

A sustainable data warehouse for accreditation KPIs can help institutions collect, analyze, and report data efficiently and accurately. This is achieved through the key components of data integration, data modeling and architecture, data quality management, data governance, and reporting and analysis. These components ensure that the data collected and reported are consistent, accurate, and reliable.

To build a sustainable data warehouse for accreditation KPIs, it is essential to follow best practices. These include creating a clear data governance policy, implementing data security measures, establishing a data quality management program, ensuring data accuracy and consistency, and providing tools for reporting and analysis. By following these best practices, institutions can ensure that their data warehouse is effective and reliable, leading to improved accreditation KPIs and overall success.

There are three main layers to the traditional Business Intelligence architecture, which is based on data warehouses: the information source layer; the processing, storage, and movement of data layer; and the reporting and visualization layer. All of the system's data sources are included in the data source layer. The Extract Transform Load (ETL) layer is in charge of extracting data from the data sources, cleansing and loading it into a staging area or other location, and finally loading it into the data warehouse. Data are presented to the decision maker in a variety of formats in the presentation layer to aid in data comprehension and decision making.

A fundamental shift in the orientation of analytics functions, particularly Institutional Research (IR), is the transformation of data into insight that drives action in more prospective and prescriptive ways. IR will be asked to guide the maturation of data use across the entire campus as analytics permeate the community. Fortunately, institutional researchers are uniquely qualified to do so because of their combination of analytical skills and a thorough understanding of their institution's history and culture. Through the use of data analytics, IR will facilitate organizational transformation and build networks of data analysts throughout the institution.

Despite this, colleges and universities do not care about the volume of data or the variety of analysis tools unless the conditions are right for their effective use. A solid foundation of data based on accuracy, timeliness, relevance, integration, and security can be very beneficial to institutions. In order for decision makers to gain insights in close to real time, the steps of acquiring, processing, and analyzing data must be completed quickly. A lack of integration is a major obstacle to providing insight that is accurate, timely, and pertinent. Differences in storage, definition, structure (or lack thereof), and intended use are just a few of the obstacles that must be overcome when combining data from various sources. In a time when unstructured data, which can be extremely rich, account for 90% of enterprise data, connecting them to other data sources frequently entails finding ways to extract value from them [28]. As a result, effective integration becomes an even more crucial step in the process of generating dynamic data and insights.

In order to securely acquire, process, and analyze data from a variety of sources, the appropriate infrastructure is required. Over half (57%) of respondents to the most recent survey conducted by the Higher Education Data Warehousing Forum regarding the most pressing issues that its members face selected data governance as the most pressing issue. Technology was mentioned in six of the top twelve categories. Data quality

accounted for 45%, metadata and data definitions for 42%, predictive analytics for 35%, data visualization for 34%, integration for 33%, and self-service for 30% [29].

Campuses must reorient their cultures toward a collaborative model of data-informed decision making in order to make investments in high-quality data, insights, and the infrastructure that supports them. In the absence of a culture of analytics, efforts to embed analytics may raise concerns about reducing quality, removing choice, tracking students, cutting programs and jobs, and destroying the identity of the institution. Data analytics must be integrated into a future vision that is centered on student success and institutional sustainability [30], and leadership must promote the use of data. Campuses willing to invest in their culture and infrastructure—two essential elements for safely and effectively harnessing the analytics revolution—will reap significant benefits.

5. PSU Case Study

This study utilized a case study research approach to investigate the implementation of a sustainable quality assurance system at Prince Sultan University (PSU). According to Yin [31], a case study research approach is appropriate for investigating a phenomenon within its real-life context and when the boundaries between the phenomenon and its context are unclear. In this study, the case study approach enabled an in-depth analysis of the development and implementation process of the quality assurance system within the specific context of PSU, including the roles of the Information Technology Center (ITC) and the Deanship of Quality Assurance (DQAD).

The close collaboration between ITC and DQAD was essential to the success of the implementation. This study documents the process of the implementation, reflecting on the experience and challenges faced throughout the process. The case study approach allowed for a comprehensive investigation of the implementation process and provided insights into the factors that contributed to the success of the quality assurance system at PSU.

The methodology followed at Prince Sultan University to establish a sustainable university data warehouse for accreditation KPIs calculations that will provide valuable insights and support data-driven decision making is as follows:

1. Define the scope of the data warehouse: Determine the data sources that will be included in the data warehouse, the types of data that will be collected, and the specific KPIs that will be calculated. These include existing systems and suggested systems, such as Student Information System, (SIS), Library Information System, and survey engine.
2. Identify the data integration requirements: Determine the data integration requirements for the data warehouse. This includes identifying the software and systems that will be integrated with the data warehouse, as well as the processes that will be used to extract, transform, and load the data. We mainly focus on building an integration layer, such as web services and APIs.
3. Develop a data model: Develop a data model for the data warehouse. This includes defining the tables, columns, and relationships that will be used to store and organize the data. We mainly focus on ETL (Extract, Transform, Load) to deal with data.
4. Design the data warehouse architecture: Determine the architecture for the data warehouse. This includes deciding on the hardware and software components that will be used, as well as the network infrastructure that will be required.
5. Implement the data warehouse: Begin building the data warehouse by setting up the hardware and software components, creating the necessary databases and tables, and implementing the data integration processes. We employ facts and dimensions in the data warehouse to ensure consistency. A fact is a piece of quantitative data that is kept in fact tables and has a foreign key relationship with several dimension tables. Facts and dimensions work together to explain the items in a fact table.
6. Populate the data warehouse: Once the data warehouse is set up, begin populating it with data from the various sources identified in Step 1. This may involve extracting

data from existing systems, cleaning and formatting the data, and loading them into the data warehouse.

7. Test the data warehouse: Conduct thorough testing and validation of the data warehouse to ensure that it is functioning as expected. This may involve running queries and reports to verify that the data are accurate and that the KPI calculations are working correctly.
8. Train users: Provide training to users who will be working with the data warehouse. This may include training on how to access and query the data, as well as training on how to interpret the KPIs that are calculated.
9. Visualize the KPIs: We use Microsoft Power BI to visualize KPIs at different levels. Each level has its dashboard. Levels are institutional, college, department, and graduate programs. Dashboards contain actual KPIs, targets, and benchmarks.
10. Maintain and update the data warehouse: Once the data warehouse is operational, it is important to maintain it and keep it up to date. This may involve adding new data sources, updating the data model, and modifying the KPI calculations as needed.

The project started at the beginning of September 2018. The start was about studying all related KPIs and their data sources. After identifying different levels of KPIs, namely strategic, institutional, and program KPIs, and after identifying these KPIs' levels, a wiki website was developed to document these KPIs, their data sources, and their calculation methods. The KPIs' details were documented using the KPI card approach.

After documenting the needed KPIs, the next task is to map out the sources of the data. The sources of data were different by nature. Some of these data are transactional and can be extracted from existing systems. The included systems are Student Information System (SIS), Human Resource Management System (HRMS), Faculty Portal, Student Portal, Learning Management System (LMS), and Library Management System. Figure 1 shows these systems.

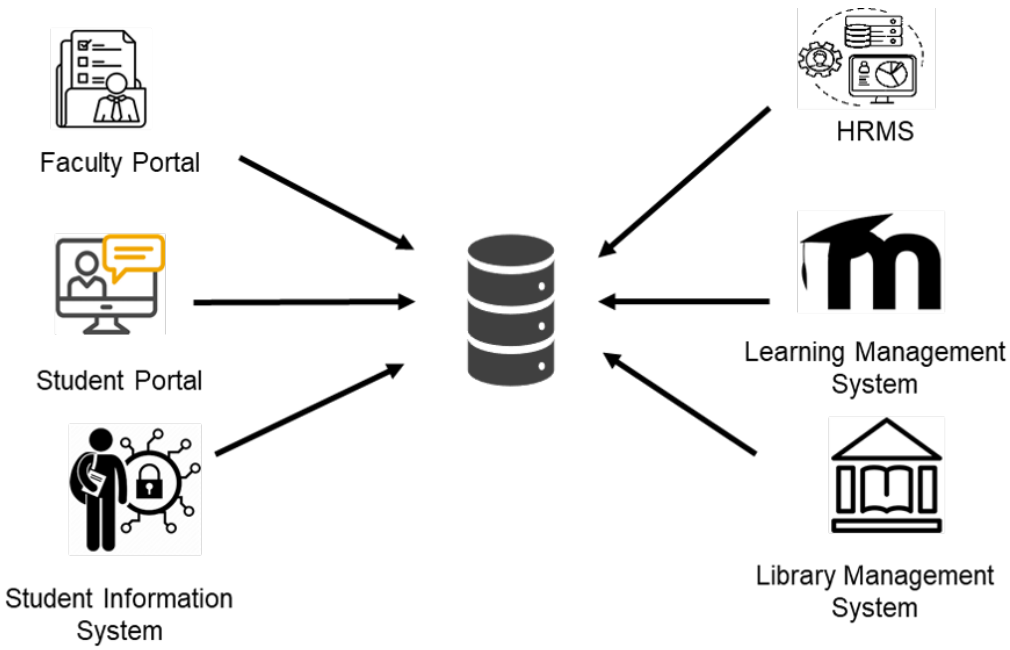

Figure 1. Prince Sultan University data sources.

The SIS automatically pulls information about courses, registrations, and other information. These data were extracted using web services that were built on top of the system at a specific time, which was referred to as the consensus date. In a similar manner, data about faculty members and their ranks are retrieved from the HRMS. Research data, professional development, and community service are available to faculty members through

the faculty portal. To streamline the collection of data, the portal is integrated with the Scopus database.

Other types of data are primarily collected through surveys. The team decided to automate the surveys and build a clear mechanism to ensure obtaining the needed response rate, which is a very common issue with surveys. After optimizing and automating these needed surveys, they were placed in existing systems to streamline the process of collecting and validating the data. Course Evaluation Survey (CES) is automated in SIS and is conducted every semester. The response rate is always more than 90%. Other surveys that are automated in SIS are Midway Survey and Program Exit Survey. Faculty and employee satisfaction surveys were automated to be part of HRMS. All other surveys related to students are placed in the student portal, such as the Alumni survey.

After mapping these data sources and automating the surveys, a conceptual diagram was designed to capture the architecture of the system. The team decided to adopt the best practices in building such a system. A data warehouse approach was built with all related methods, such as Extract, Transform, Load (ETL), Staging, Data Cubes, Data Marts, etc. For the visualization of the data and building Dashboards, Microsoft PowerBI was chosen. Several Dashboards were built for different purposes, such as Strategic, Institutional, College, and Programs dashboards. Figure 2 shows a conceptual diagram of the data warehouse.

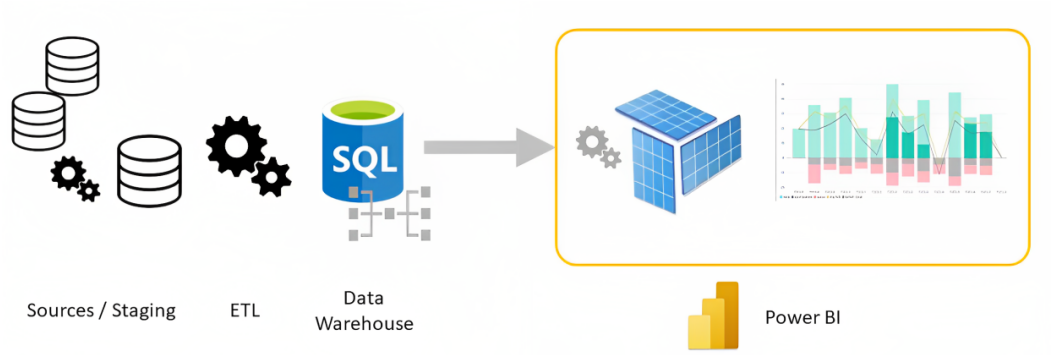

Figure 2. Prince Sultan University data warehouse.

6. Digital Transformation and Quality Assurance

The QA objectives and criteria for education and the evaluation of teaching quality have changed because of the digital era [32]. QA in teaching and learning undergoes a digital transformation as a result, taking on new aspects. These changes include the following features:

- Goals—from a single set to more varied objectives: Talents with a wider range of skills are required in the digital age. This forces a shift in emphasis from students' knowledge acquisition to well-rounded development, including capacity building and value nurturing, as well as away from the prior standard QA aims in education.
- Functions—from rating to early warning: The typical method of quality assurance (QA) in education involves assessing how well instruction is delivered and how well students are learning, and then optimizing the subsequent QA activities. QA in education is now able to gather and evaluate real-time data on student learning, teaching delivery, course implementation, and other topics because of big data and AI prediction technology. These, in turn, provide timely presentations of how teaching and learning are progressing and trend analysis of the entire process. Hence, they serve as a function for early warning.
- Objects—from scattered to integrated: Following the digital revolution, QA teaching and learning objects switch from structured data analytics of a single information system to unstructured data comprehensive analytics across information systems and enterprises. Information is dispersed, links lack any meaningful relationship,

and many departments only pay attention to their respective areas of responsibility in the original QA system. A QA system that has been digitally altered, however, does not face these problems because it integrates all QA components in a methodical way.

- Coverage of standards—from partial and one-sided to complete and all-sided: The standards for QA in teaching and learning have changed from targeting only some instructional stages and certain aspects of instructional objectives to covering the entire educational process and all dimensions of instructional objectives as quality goals take on more dimensions and measuring and statistics are digitalized.
- Teaching quality assessment—from periodic to normalized, and from sampling to total size: According to the traditional method of quality assurance in education, only a sample of the students, teachers, courses, and academic programs are evaluated, often once every two semesters. This results in insufficient influence on instruction due to inefficient assessment feedback time management and inaccurate assessment results. The data-driven intelligent teaching assessment, in contrast, increases the efficiency of measuring, assessing, and providing feedback, enabling standardized and full-size quality assessment.
- Teaching quality assessment flow—from closed to open: Data were sent between several assessors under the former assessment procedure, which had limited transparency and efficiency at a high expense. The idea of data sharing and the support of digital technology has allowed for the inclusion of more items and stakeholders in the digital age. Many stakeholders can use the same database for assessments. Additionally, this facilitates communication and cooperation between university departments and outside organizations as well as within the university. It also increases the openness, transparency, and participation of the evaluation process.

Figure 3 illustrates how consolidating data onto a single platform and automating data collection processes can have a positive impact on educational environments. By enabling the blend of learning and bridging communication gaps, educational services can be provided more efficiently. Reflective monitoring of Key Performance Indicators (KPIs) through dashboards and alerts can also help to improve the quality of education.

When faculty information, student information, and learning management systems are systematized, they can jointly contribute to the achievement of UN Sustainable Development Goal 4, which is focused on quality education. Additionally, when combined with the Library system, these systems can enable the same content to be delivered, accessed, and assessed for all genders. The automated assessment system can also eliminate biases, which is aligned with UN Sustainable Development Goal 5.

These systems are designed to communicate with each other and provide real-time information regarding various KPIs. This allows for quick decision making in response to any component that needs to be addressed. Furthermore, these systems can provide access to valuable resources for students and individuals in need, which aligns with UN Sustainable Development Goal 9.

Building a single system capable of performing all tasks at the same time presents many challenges, which requires a re-evaluation of the entire education system. To address this, a Publisher–Subscriber architecture that uses web services allows different systems (both proprietary and open source) to communicate with each other. Agile methodologies can be used to construct these systems, enabling in-time fixes and actions to be taken.

By using these quality systems, educational support can be provided to all genders, and the qualification of instructors can be improved. This aligns with the goals of a 21st-century education that is agile, reflective, and responsive. These quality systems can become the foundation of 21st-century education, enabling us to accelerate development and achieve milestones, which aligns with UN Sustainable Development Goal 17.

Figure 3. Effect on SDG with taken actions.

In summary, the integration of various systems and processes can have a positive impact on education, enabling more efficient services, better communication, and improved decision making. By aligning with UN Sustainable Development Goals, these quality systems can help to improve education for all genders and enable a more agile and responsive education system.

7. Reflections on Lessons Learned

The case study conducted at PSU has yielded valuable insights into the implementation of continuous improvement processes in higher education institutions. These findings can serve as a practical guide for institutions looking to adopt similar strategies. To ensure the successful automation of processes, it is crucial to develop a comprehensive implementation plan. The DevOps model is an effective approach to automation, starting with the most critical component and continuously improving the system using the Agile methodology.

It is advisable to consolidate the data collection process and avoid implementing new systems for existing ones, if possible. The Publisher–Subscriber model is recommended to ensure data unification and system security. By following these recommendations, higher education institutions can streamline their processes and achieve greater efficiency and effectiveness.

Furthermore, the researchers have made a noteworthy observation that this model has successfully avoided employee resistance to data sharing. This is because employees remain the owners of the data, which has resulted in a more cooperative and collaborative work environment. Additionally, this model has also eliminated duplication of effort, which has led to increased efficiency and productivity.

To ensure that the system is entirely fault-proof, it is recommended to make incremental changes to the process rather than changing it all at once. This approach will allow for a

more thorough and comprehensive review of the system, which will ultimately result in a more robust and reliable system.

However, the case study has identified several challenges that need to be addressed. These challenges include a lack of cooperation from system heads and staff, budgeting issues, the consolidation of different systems, the unification of data, and changing requirements from education officials and accreditation bodies.

To overcome these challenges, it is recommended to follow a DevOps model for development and integration, a Publisher–Subscriber model for data sharing, an XML-based common data language for communication, incremental system development, and incremental policy implementation based on feedback. By adopting these strategies, organizations can ensure that their systems are efficient, reliable, and meet the changing needs of their stakeholders.

In conclusion, it is essential to adopt a proactive approach to address the challenges faced by organizations in the development and integration of their systems. By following the recommended strategies, organizations can overcome these challenges and ensure that their systems are fault-proof, efficient, and meet the needs of their stakeholders.

8. Conclusions

The development of a software system for quality assurance in higher education poses significant challenges. Accreditation agencies establish indicators and quality criteria for qualitative and quantitative evaluations, complicating the process for educational institutions to adhere to such standards. Nonetheless, institutions can create their own internal quality systems to comply with these requirements. Employing software tools to automate quality assurance processes proves essential in achieving this aim. To simplify compliance with these standards and indicators, we advocate for abstraction and operation at a higher level, facilitating adaptation to changes in the standards and indicators.

This paper examined Prince Sultan University's experience constructing its quality assurance system and the lessons gleaned throughout the process. Drawing from our successful implementation of automation concepts at PSU, we endorse the adoption of modern software development methods, such as agile methodology, for the development of a comprehensive system. We further propose implementing development incrementally and employing DevOps methodology for system integration. For data consolidation, we strongly recommend utilizing a Publisher–Subscriber-based model, which allows for rapid integration, a common data language, secure access, and reduced resistance from existing employees. By adhering to these recommendations, educational institutions can develop a robust quality assurance system that meets accreditation standards and ensures the delivery of high-quality education.

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