Implementation of Business Intelligence in Academic Management Systems to Improve the Quality of Health Study Programs

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Abstract. This study examines the implementation of Business Intelligence (BI) to support data-driven academic decision-making and strengthen internal quality assurance in higher education. The study adopted the Waterfall BI Lifecycle, which was implemented sequentially through decision-support needs analysis, identification of study program quality indicators, data integration, dashboard development, and system evaluation. The indicators examined included graduation rates, lecturer performance, learning outcomes, and accreditation. The findings indicate that BI implementation significantly improved academic management effectiveness. The developed dashboard enabled real-time monitoring of 12 key performance indicators, reduced report analysis time from 2–3 days to less than 2 hours (89% efficiency), increased grade reporting accuracy from 72% to 94%, improved overall data accuracy by 28%, and identified students at risk of dropping out with 86% predictive accuracy. These findings confirm that BI enhances academic quality and supports objective, accountable, and sustainable evidence-based decision-making for continuous quality improvement in higher education institutions.

Keywords: Business Intelligence, Academic Management System, Decision-Making, Study Program Quality, Higher Education.

1 Introduction

The rapid development of information technology and the increasing availability of big data have encouraged higher education institutions to adopt a data-driven management approach [1]. In this context, Business Intelligence (BI) plays a crucial role in transforming academic data into relevant information to support decision-making processes at the institutional level [2]. In practice, BI does not operate in isolation, but is supported by an academic data ecosystem that includes a data warehouse, Extract, Transform, Load (ETL) processes, and analytical dashboards [2][3]. Through the integration of these components, data derived from academic systems, digital learning platforms, and other supporting services can be collected and processed in a more systematic manner [4]. As a result, higher education institutions are able to generate

AISTEEL 2025, December 05, Medan, Indonesia

DOI 10.4108/eai.5-12-2025.2363812

strategic information that is more accurate, timely, and useful for academic leaders in planning, monitoring, and evaluating educational policies [5].

Recent systematic reviews have confirmed that the implementation roadmap of Business Intelligence (BI) in higher education institutions includes data architecture design, data governance, and cross-unit integration as essential components to ensure that BI can generate reliable analytical outputs [1]. In addition, studies on big data and academic analytics indicate that the integration of multiple data sources can strengthen the predictive and descriptive capacity of academic management systems [3]. In the context of higher education, these data sources may include Learning Management Systems (LMS) [6], academic information systems such as SIAKAD, attendance systems, and other institutional datasets. When such data are organized through a robust data warehouse and supported by structured ETL processes, institutions are better positioned to generate more comprehensive and actionable information for academic management purposes [1],[3].

As a tool that supports academic management practices, Business Intelligence (BI) provides interactive visualizations, KPI dashboards, and predictive functions that assist study program leaders in monitoring quality indicators, such as average GPA, graduation timeliness, faculty attendance, and the identification of at-risk students . Research on learning analytics dashboards (LADs) and BI-based dashboards indicates that well-designed dashboards not only present descriptive data, but can also integrate predictions and actionable recommendations to facilitate early intervention and evidence-based curriculum planning [7]. Furthermore, empirical evidence from several studies on big data in educational contexts suggests that the integration of analytics into academic dashboards can accelerate report generation and improve information accessibility for stakeholders [4]. More broadly, the use of big data and analytics in higher education supports learning, teaching, and academic administration processes [6].

However, the implementation of Business Intelligence (BI) in many higher education institutions continues to face technical and organizational challenges, including data fragmentation, variations in data quality, interoperability issues across academic information systems, and the need for stronger data governance and privacy policies [8]. The literature also indicates that the success of BI implementation depends on a combination of factors, such as the readiness of information technology infrastructure, the standardization of ETL processes, the use of appropriate data models for data warehousing, the competency of analytical staff, and sustained support from top management [9]. Therefore, the design of a Business Intelligence architecture for academic environments should be accompanied by change management strategies and comprehensive data protection policies to ensure that the benefits of analytics can be realized without compromising privacy, interoperability, and data integrity [10]. The integration of Business Intelligence in higher education institutions represents a strategic step toward improving the quality of data-driven decision-making. However, its success largely depends on the institution's ability to manage, govern, and protect data adequately so that analytical processes can operate effectively, align with strategic needs, and maintain data integrity and privacy [11].

In health study programs, the need for integrated information is more complex because clinical and field practice data must be aligned with conventional academic data [12]; This condition requires Business Intelligence (BI) solutions capable of integrating heterogeneous data sources while also supporting accreditation needs [13] through quantitatively verifiable indicators and

external reporting[14]. In addition, studies in medical and health education have shown that learning analytics can help identify at-risk students and support early intervention to strengthen the learning process [15]. In this context, improving the quality of health study programs is not only related to students' academic achievement, but also encompasses the quality of learning monitoring, the evaluation of clinical practice [13], the accuracy of reporting, and data readiness for quality assurance and accreditation [16].

Research Gap **study** is Business Intelligence (BI) implementations have been widely used in the healthcare sector and other large organizations. Business Intelligence is used to support organizational performance management, process optimization, and service quality improvement. However, the use of Business Intelligence in higher education, particularly in health study programs, remains very limited, particularly in internal quality assurance and data-driven academic decision-making. Therefore, research into Business Intelligence as a supporting tool for internal quality assurance and data-driven academic decision-making in health study programs is warranted.Therefore, Business Intelligence implementation designed for health study programs must consider data models that address academic and clinical dimensions, as well as provide relevant KPI dashboards for study program heads, lecturers, and accreditation units. Based on the above background, this study proposes the implementation of Business Intelligence in the Academic Management System of STIKes Binalita Sudama as an effort to improve the quality of the Health Study Program through data integration, data warehouse design, and the creation of KPI dashboards that support real-time decision-making.

2 Method

This study uses a Research and Development (R&D) approach with the Business Intelligence Waterfall model, which includes the stages of needs analysis, data preparation, data warehouse design, ETL development, dashboard modeling, and evaluation. This study was conducted at the Health College in the LLDikti I region of North Sumatra. The data used consisted of primary data (interviews with heads of study programs, academic departments, and SIAKAD operators) and secondary data (grade recaps, attendance, tracking studies, lecturer workload, and student graduation data). The number of respondents was as follows: 3 Heads of Study Programs, 3 Secretaries of Study Programs, 4 Lecturers, 3 Academic Staff, and 2 Quality Assurance Unit personnel. Data processing was carried out through the extract, transform, and load (ETL) stages using Pentaho Data Integration chosen as the ETL tool because it is able to integrate and transform academic data visually and efficiently, while Metabase was used as a visualization tool due to its ease of use, dashboard flexibility, and support for non-technical users. The combination of the two tools is considered suitable for the implementation of Business Intelligence at the Health College in the LLDikti Region I region of North Sumatra. Meanwhile, the data warehouse design uses the Star Schema model with an academic performance fact table and several dimension tables such as students, lecturers, courses, and academic periods.

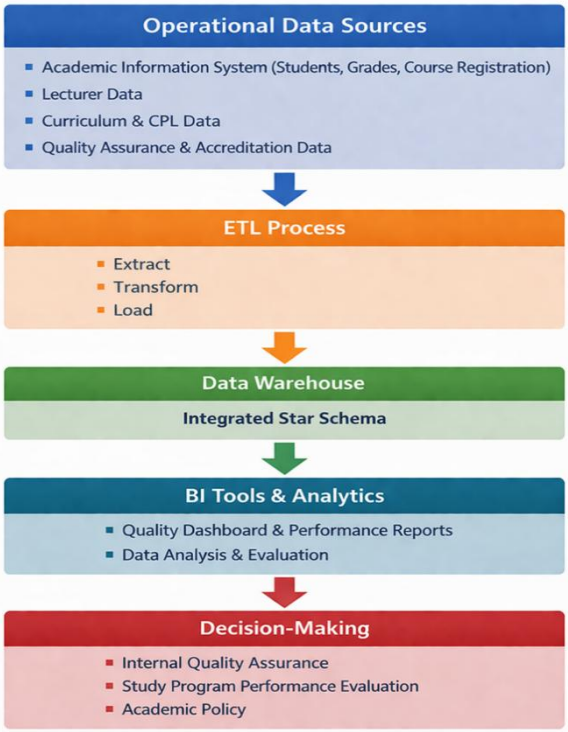

Fig. 1. Business Intelligence data warehouse design diagram

Business Intelligence dashboard as shown in Fig.1 was developed using Metabase/Power Business Intelligence to generate visualizations of quality indicators such as GPA, on-time graduation rate, faculty performance, and student activity. Evaluation was conducted using the User Acceptance Test (UAT) method and measured the effectiveness of decision-making through expert assessments from the Health Study Program leadership as shown in Table 1. The final result of this method is a validated Business Intelligence dashboard ready for real-time academic quality monitoring.

The UAT value is calculated using the formula:

$$Feasibility\ Percentage = \frac{Actual\ Score}{Maximum\ Score)} \times 100\% \quad (1)$$

Table 1. Assessment Criteria

Percentage	Category
81%-100%	Very worthy/Very acceptable
61%-80%	Worthy
41%-60%	Quite Decent
21%-40%	Not feasible
0%-20%	Totally Unworthy

3 Results and Discussion

3.1 Results

The results of this study were compiled to provide a comprehensive overview of the impact of Business Intelligence (BI) implementation on the academic management system of the Health Study Program. Business Intelligence implementation is expected to improve the quality of academic management by providing more accurate, timely, and easily accessible information to stakeholders. In this section, we present a comparison of various academic performance indicators before and after the BI implementation. Table 2 below illustrates the significant changes that occurred, including data accuracy, time efficiency, academic process accuracy, and the system's ability to monitor and predict student academic achievement.

Table 2. Comparison of quality indicators before and after BI implementation

Academic Indicators	Before Business Intelligence	After Business Intelligence	Change
Accuracy of academic data	-	28% increase	+28%
Time of report preparation	2-3 days	< 2 Hours	89% efficiency
Timeliness of value collection	72%	94%	+22%
Number of monitored IKUs	4 (manual)	12 (automatic)	+8 IKU
Accuracy of prediction of at-risk students	-	86%	-

Improved ETL Results and Data Accuracy:The implementation of Business Intelligence (BI) begins with the process of extracting, transforming, and loading academic data from the Academic Management System of STIKes Binalita Sudama. In the initial stage, various inconsistencies were found, such as duplicate entries, inappropriate grade formats, and non-standardized lecturer data. The transformation process carried out during the development of the data warehouse succeeded in increasing the accuracy of academic data by 28%. The 28% increase in academic data accuracy occurred because the implementation of Business Intelligence implemented an ETL process that included data cleansing, standardization, data source integration, and consistent application of academic business rules. This process reduces errors due to duplication, format inconsistencies, and manual intervention, resulting in a more accurate data warehouse as a basis for analytics and decision making [1] . Based on the results of internal cross-checking between the academic database and manual documents of the study program [4]. This improvement shows that the ETL process not only plays a role in data consolidation, but is also an important foundation for the quality of Business Intelligence output used in decision making.

Data Warehouse Development and BI Dashboard Development: The data warehouse built using the Star Schema model consists of one main fact table containing academic metrics and four dimension tables related to students, lecturers, courses, and semesters. From this data warehouse, a Business Intelligence dashboard was developed to display 12 Key Performance Indicators (KPI) of the Health Study Program, such as study progress, average GPA, lecturer attendance, grade submission compliance, and graduation timeliness. This dashboard is real-time and can be accessed through a web-based Business Intelligence platform, thus facilitating daily monitoring by the head of the study program and the academic team [3] [6]. The successful automatic presentation of KPI demonstrates that the designed data warehouse structure is capable of supporting the study program's academic analytical needs.

Academic Report Processing Time Efficiency: One of the most significant outcomes of Business Intelligence implementation is increased time efficiency in preparing academic reports. Prior to Business Intelligence implementation, the process of analyzing reports such as lecturer attendance recaps, student grade progress, and graduation evaluations took 2–3 days due to manual processing and the need to merge multiple files. After Business Intelligence integration, similar processes can be completed in less than 2 hours, resulting in an efficiency rate of 89%. These results demonstrate that Business Intelligence not only speeds up processes but also reduces reliance on error-prone manual administrative work.

Improving the Quality of Academic Management: The implementation of Business Intelligence (BI) has had a direct impact on improving the academic quality of the Health Study Program. The rate of timely grade submission by lecturers, previously only 72%, increased to 94%, indicating improved compliance after the study program implemented a dashboard that monitors grade submission progress in real time. Furthermore, student progress indicators and on-time graduation rates can be monitored more accurately, making learning strategies and academic monitoring more measurable and evidence-based [4]. The availability of historical visualizations also enables the study program to evaluate performance trends across semesters.

Identification of At-Risk Students and the Impact of Academic Decisions: One of Business Intelligence (BI)'s most impactful key features is its ability to identify students at risk of dropping out or postponing their studies. The BI system provides predictions with 86% accuracy, based on parameters such as GPA < 2.5, low attendance, and the number of courses repeated. Factors influencing the 86% dropout prediction accuracy are influenced by several key factors, including the selection of academic indicators such as GPA, attendance rate, and course repetition. Improved data quality in the ETL process ensures the consistency and reliability of the data used in the analysis. With this information, study programs can implement academic interventions more quickly through academic coaching or consulting. This Business Intelligence (BI) implementation demonstrates that predictive analytics not only supports day-to-day operations but also shapes long-term policies to improve student retention [15]. The overall findings reinforce that Business Intelligence (BI) integration is highly effective in supporting faster, more accurate, and data-driven academic decision-making.

3.2 Discussion

This discussion focuses not merely on restating the numerical improvements reported in the results section, but on explaining why those changes occurred and what they mean for academic management in health study programs. The findings indicate that Business Intelligence (BI) functions not only as a reporting tool, but also as a managerial mechanism that improves the visibility, consistency, and responsiveness of academic decision-making. In this study, the increased data accuracy, faster report preparation, better lecturer compliance, and more reliable identification of at-risk students suggest that BI contributes to quality assurance by turning fragmented operational data into actionable information [16] .

The improvement in academic data accuracy can be interpreted as evidence that the ETL and data warehouse architecture reduced inconsistencies that commonly arise when academic data are managed across separate administrative units. Previous studies emphasize that data quality and governance are central determinants of successful BI implementation in higher education, because unreliable source data weaken institutional trust in dashboards and analytics outputs [13]. The present study supports that view by showing that the standardization and integration

of academic records are not merely technical improvements; they create a stronger basis for monitoring performance indicators and for making quality-related decisions at the study program level.

The substantial reduction in report preparation time also has broader organizational implications. Time efficiency should not be viewed only as an operational gain, but as an indicator that decision-makers can respond more quickly to emerging academic problems. In many higher education settings, delays in collecting and consolidating data reduce the usefulness of reports for planning and evaluation [5]. In contrast, the dashboard developed in this study enabled administrators to access updated indicators in a shorter time frame, which strengthens routine monitoring and supports more agile academic governance. This is particularly relevant for health study programs, where academic quality must often be aligned with professional competency standards, clinical practice requirements, and accreditation needs.

Another important point is that the increase in lecturer compliance in submitting grades demonstrates how BI can influence behavior through transparency. When performance indicators are visible and updated regularly, academic staff become more aware of deadlines and institutional expectations. This finding is in line with the view that dashboards are not only informative but also regulative instruments, because they shape accountability practices within educational organizations [4]. Therefore, the BI system in this study appears to contribute not only to information access, but also to improvements in academic discipline and coordination among lecturers and administrators.

The ability of the system to identify students at risk of dropout or academic delay has important pedagogical implications. Rather than serving only as a predictive output, this feature enables earlier intervention through academic advising, mentoring, and targeted support. Prior research has shown that learning analytics and big data approaches become valuable when they are connected to concrete follow-up actions rather than used only for institutional reporting [15]. From that perspective, the predictive component developed in this study is meaningful because it shifts academic management from a reactive approach to a preventive one. For health study programs, this is especially important because students often face demanding workloads, clinical placements, and competency-based evaluations that require close academic monitoring.

This study also contributes to the literature by showing that BI implementation in health-oriented higher education contexts has both administrative and academic value. While many previous studies discuss BI in general higher education settings or in healthcare service organizations, fewer studies explain its relevance for health study programs that combine academic data with practice-based educational demands. The present findings suggest that BI can bridge this complexity by integrating information needed for monitoring academic performance, lecturer activities, and student progression in a single analytical environment. This makes the study relevant not only for information system development, but also for institutional quality management in professional education [16].

Nevertheless, the findings should be interpreted with some limitations. The system was implemented and evaluated in a limited institutional context, so the observed improvements may be influenced by local readiness, data availability, and organizational support. In addition, the predictive performance and dashboard usefulness were assessed primarily through internal testing and user acceptance measures; therefore, future studies should examine long-term adoption, comparative implementation across institutions, and the integration of additional data

sources such as LMS activity, clinical practice records, and non-academic student support data [13]. Despite these limitations, the study demonstrates that BI has strong potential to become a strategic component of evidence-based academic management in higher education.

4 Conclusion

This study shows that the implementation of Business Intelligence (BI) in the at Health College in the LLDikti I region of North Sumatra has a significant impact on improving the quality of academic management in the Health Study Program. The integration of BI through the stages of needs analysis, ETL process, data warehouse development, and interactive dashboard development successfully produced a faster, more accurate, and data-driven information system. The Business Intelligence dashboard is able to present 12 Key Performance Indicators (KPI) in real-time, making it easier for study program leaders to conduct continuous academic monitoring. In addition, the implementation of Business Intelligence has been proven to increase the accuracy of academic data by 28%, increase the timeliness of grade collection from 72% to 94%, and reduce the time for preparing academic reports from 2–3 days to less than 2 hours (89% efficiency). The Business Intelligence system is also able to identify students at risk of dropping out with a prediction accuracy rate of 86%, allowing for faster and more targeted interventions. Overall, Business Intelligence has proven to be a strategic tool in supporting data-driven decision-making and evaluation of academic quality.

Further research can develop the Business Intelligence system by integrating additional data sources such as Learning Management Systems (LMS) and non-academic student data to generate more comprehensive analyses. Furthermore, the application of machine learning-based predictive analytics methods is recommended to improve the accuracy of academic risk identification. Long-term evaluation of BI's impact on study program policies and quality, as well as its implementation in other higher education institutions, is also needed to test the system's scalability and generalizability.

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