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CONCEPTUAL FRAMEWORK OF PREDICTIVE STUDENT RELATIONSHIP MANAGEMENT (PSRM) USING BUSINESS INTELLIGENCE FOR UNDERGRADUATE STUDENT RETENTION

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Abstract— This research proposes a conceptual framework of Predictive Student Relationship Management (PSRM) Using Business Intelligence (BI) to improve undergraduate student retention. A qualitative approach, including document analysis and thematic synthesis, identified SRM processes aligned with BI strategies. The SRM framework follows the student journey across three phases: 1) Pre-enrollment, focusing on attracting prospective students and sharing institutional information; 2) Enrollment, the critical phase, involving four processes: student lifecycle management, personalized counseling, academic support, and managing expectations; and 3) Post-graduation, emphasizing alumni networks and career development. The enrollment phase is pivotal, leveraging BI foundational components, including predictive analytics, to enhance the framework's capacity to analyze historical and real-time data. Techniques such as data preparation, feature engineering, model development, and validation provide actionable insights for identifying at-risk students. Predictive models based on performance and engagement metrics enable institutions to implement timely interventions, such as academic support and counseling, improving student retention and fostering academic success. This research offers a structured approach for institutions to proactively address student needs, enhance retention, and ensure academic success through predictive modeling.

Index Terms— predictive student relationship management, business intelligence, student retention

I. INTRODUCTION

Student retention, defined as an institution's ability to guide students from enrollment through graduation, remains a critical challenge in higher education. Effective retention strategies significantly influence institutional reputation, financial stability, and resource optimization while ensuring students achieve academic success, alleviate financial stress, and acquire essential lifelong skills [1]. These objectives closely align with Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education and lifelong learning opportunities for all [2]. Additionally, leveraging innovative technologies to address retention aligns with Sustainable Development Goal 9 (SDG 9), which promotes resilient infrastructure, inclusive industrialization, and innovation [3].

Predictive Student Relationship Management (PSRM), supported by Business Intelligence (BI), has emerged as a transformative strategy to address retention challenges. BI-powered PSRM utilize predictive analytics to analyze student data, identify at-risk individuals, and implement personalized interventions. These systems enhance retention rates, reduce disparities in education, and foster equitable learning environments, thereby supporting SDG 4 [4]. Concurrently, adopting BI technologies in education exemplifies SDG 9's vision for integrating advanced technologies into institutional processes, driving innovation and adaptive infrastructure [5].

Recent studies have demonstrated the effectiveness of predictive analytics in identifying patterns in student performance, engagement, and behavior [6]. Proactively addressing these factors enables institutions to create supportive learning environments, improve educational access, and strengthen institutional resilience. This not only advances equity and success rates but also contributes to the development of innovative and sustainable educational infrastructures [7].

This paper proposes a conceptual framework for a Predictive Student Relationship Management (PSRM) using business intelligence concepts. It highlights the integration of data-driven methodologies to enhance institutional capacities, align with global sustainability goals, and promote sustainable practices in higher education.

II. LITERATURE REVIEW

A. Student Relationship Management: SRM

Student Relationship Management (SRM) is a pivotal strategy in higher education for enhancing student retention by fostering stronger relationships between institutions and students. Adapted from Customer Relationship Management (CRM), SRM employs data-driven approaches, predictive analytics, and tailored strategies to meet

students' diverse needs, ensuring academic success and satisfaction throughout their journey [9].

By leveraging technology, SRM personalizes experiences, improves communication channels, and supports timely interventions. Kumar et al. [10] emphasize that tailored communication and feedback mechanisms significantly enhance retention by creating positive student experiences. Similarly, Chen et al. [5] highlight the role of artificial intelligence (AI) in predicting at-risk behaviors, enabling proactive interventions to prevent dropouts.

Beyond technology, SRM aligns institutional goals with student needs, ensuring inclusivity and adaptability in dynamic educational landscapes [11]. Its flexibility is essential for addressing challenges such as online learning and diverse student populations, making SRM a critical tool for retention strategies [12]. The primary goal of SRM is to build strong relationships between institutions and students through data-driven strategy, technology, and personalized communication. SRM enhances student engagement by fostering belonging and motivation [12] and improves academic success through timely support tailored to individual needs [11]. It boosts retention rates by identifying at-risk students and implementing targeted interventions [10]. Additionally, SRM increases student satisfaction by addressing expectations and creating positive experiences [5] while nurturing lifelong loyalty, and encouraging alumni contributions to institutional growth [9].

The primary goal of SRM is to build strong relationships between institutions and students through data-driven strategies, technology, and personalized communication. SRM enhances student engagement by fostering belonging and motivation [12] and improves academic success through timely support tailored to individual needs [11]. It boosts retention rates by identifying at-risk students and implementing targeted interventions [10]. Additionally, SRM increases student satisfaction by addressing expectations and creating positive experiences [5] while nurturing lifelong loyalty, and encouraging alumni contributions to institutional growth [9].

B. Business Intelligence: BI

Business Intelligence (BI) refers to the use of technologies, applications, processes, and practices for collecting, integrating, analyzing, and presenting business information. BI systems enable organizations to transform raw data into actionable insights that support strategic decision-making. In education, BI is utilized to analyze student data, predict outcomes, and develop strategies to improve institutional effectiveness and student success [13].

The primary goal of BI in student retention is to leverage data-driven insights to proactively identify at-risk students and implement targeted interventions. BI enables institutions to analyze academic, behavioral, and engagement data to flag potential dropouts [14] and develop personalized support strategies to enhance academic outcomes [15]. It also provides real-time insights for informed decision-making [16], optimizes resource allocation for impactful retention activities [17], and tracks the effectiveness of initiatives to refine strategies [18]. BI fosters student success and institutional sustainability.

C. Student Retention

Student retention refers to an institution's ability to ensure students remain enrolled from admission to graduation, distinguishing it from student persistence, which focuses on a student's determination to continue their education [19]. Retention is critical for maintaining institutional stability and educational quality, as well as ensuring student success. Recent advancements in technology, such as machine learning and artificial intelligence, have proven effective in identifying at-risk students and enabling personalized interventions to improve retention [20].

Additionally, factors like mental health and protective mechanisms have been shown to play a significant role in academic persistence and retention, particularly during global crises [21]. Systematic reviews have highlighted key contributors to student dropouts, emphasizing the importance of engagement, support services, and the quality of the learning environment, especially in online education [22].

In summary, student retention is a multifaceted concept involving institutional strategies to support students throughout their academic journey. Ongoing research underscores the need for holistic approaches, incorporating technology and mental health support, to address the challenges of retention and improve outcomes across diverse educational settings.

III. RESEARCH METHODOLOGY

The objective of this study is to develop a conceptual framework for predictive student relationship management (SRM) using business intelligence (BI) concepts to enhance undergraduate student retention.

A. Research Approach

This research employed a qualitative approach, specifically document analysis, to construct a comprehensive conceptual framework. The qualitative method was chosen for its ability to analyze existing literature and synthesize knowledge from multiple theoretical and practical perspectives. The methodology was designed to explore the intersection of SRM, BI, and predictive analytics to effectively address challenges in undergraduate student retention.

B. Methodological Steps

The research process was divided into the following phases:

1) Studying Foundational Concepts of SRM:

The study reviews SRM principles, strategies, and their applications in higher education to understand their role in enhancing student retention.

2) Examining BI Fundamentals:

Foundational concepts and applications of BI in decision-making processes are explored to identify its potential

in educational settings.

3) Investigating Predictive Analysis for Retention:

The study examines principles of predictive analytics and their application in identifying at-risk students and supporting retention strategies.

4) Synthesizing Processes for PSRM Using BI:

A synthesis of SRM and BI concepts is conducted to create a unified process framework tailored for predictive retention strategies.

5) Developing the Conceptual Framework:

The findings are consolidated into a conceptual framework integrating PSRM and BI concepts to enhance undergraduate student retention.

C. Data Collection Methods

Data collection focuses on analyzing relevant documents, research studies, and theoretical frameworks related to SRM, BI, and predictive analytics. The steps involved are:

1) Reviewing Relevant Documents:

Literature on SRM, BI, and student retention is systematically reviewed.

2) Analyzing Data from Documents and Studies:

Key insights from reviewed literature are analyzed for their relevance to the study's objectives.

3) Synthesizing and Summarizing Information:

Data from the reviewed literature is synthesized and summarized to identify patterns and insights critical to the conceptual framework.

D. Research Instrument

A structured content synthesis form is used to systematically capture and analyze key findings from the reviewed documents.

E. Data Analysis Methods

Thematic analysis is employed to interpret and organize qualitative data. The analysis includes the following steps:

1) Reading and Coding Data:

Key information from analyzed documents is coded to identify significant patterns and insights.

2) Reviewing and Refining Codes:

Codes are reviewed for clarity, redundancy is eliminated, and additional codes are added if needed.

3) Grouping Codes into Themes:

Related codes are grouped into meaningful categories, and overarching themes are identified to align with the research objectives.

4) Integrating Findings with Theoretical Frameworks:

The final analysis integrates themes with existing theories to construct a cohesive conceptual framework.

This systematic methodology ensures that the developed framework is grounded in rigorous qualitative analysis and aligns to enhance undergraduate student retention through predictive SRM and BI concepts.

IV. RESULT

The analysis of relevant documents and literature revealed that the ability to predict undergraduate student retention relies on two major components: SRM through Student Journey Framework and BI fundamental components.

By integrating these components, the framework for a PSRM System is designed to enhance undergraduate retention rates. This comprehensive approach combines the identification of key factors with advanced analytical capabilities, providing actionable insights to mitigate dropout risks and promote academic success.

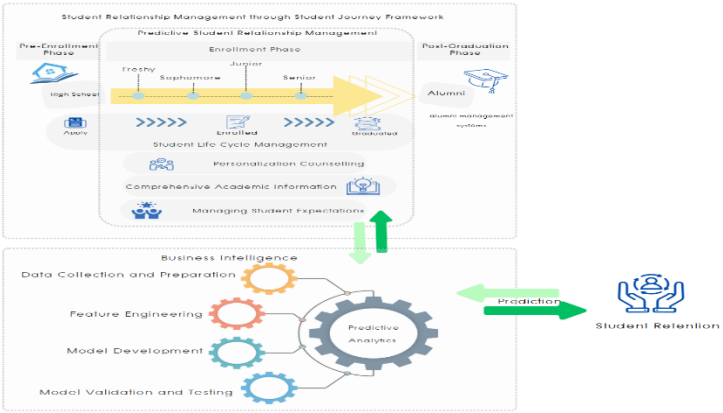

Figure1: Conceptual Framework of the PSRM Using BI Concepts to Enhance Undergraduate Student Retention

A. SRM through Student Journey Framework

SRM has become a strategic framework in educational institutions, aiming to foster meaningful relationships with students throughout their academic lifecycle. This research explores SRM through the three phases of the student journey: pre-enrollment, enrollment, and post-graduation. These stages provide a comprehensive structure to

optimize student engagement and satisfaction, enhancing institutional outcomes.

1) Pre-Enrollment Phase

The pre-enrollment phase involves activities aimed at attracting potential students and disseminating critical information about the institution. This phase is pivotal for establishing initial impressions, which directly influence a prospective student's decision-making process. Institutions employ marketing campaigns, online platforms, and personalized communications to highlight programs, scholarships, and campus life. Effective SRM during this phase ensures accurate, accessible, and engaging information delivery [5] [8] [9] [11] [16] [22].

2) Enrollment Phase

The enrollment phase focuses on the active academic lifecycle of students, from admission to graduation. This stage encompasses four key processes:

2.1) Student Lifecycle Management

2.1.1) Application: Institutions manage applicant data, monitor application statuses, and provide timely updates on examination schedules, admission results, and deadlines [5] [8] [9] [11] [16] [22] [23] [24].

2.1.2) Enrollment: This process ensures seamless course registration, including course selection, add/drop options, and access to class schedules. Effective enrollment management supports timely student decision-making and reduces administrative errors [5] [8] [9] [11] [16] [22] [23] [24].

2.1.3) Graduation: Institutions must facilitate tools for students to track academic progress, ensuring all graduation requirements are met. Additionally, providing visibility into the status of graduation approval processes promotes transparency [5] [9] [11] [16].

2.2) Personalized Counseling

Personalized guidance addresses the unique strengths, weaknesses, and career goals of each student. Tailored academic advice significantly improves student success rates and retention while minimizing the risk of academic disengagement [25] [26] [27].

2.3) Comprehensive Academic Information

Providing complete and timely information, including important academic deadlines, procedural guides, and institutional services, is vital for reducing confusion and improving the student experience [25] [26] [27].

2.4) Managing Student Expectations

This process involves understanding and aligning institutional offerings with the diverse expectations of students. By leveraging surveys and focus groups, universities can design programs that meet both individual aspirations and institutional goals, ultimately fostering satisfaction and success [22] [28].

3) Post-Graduation Phase

The post-graduation phase emphasizes maintaining relationships with alumni through dedicated alumni management systems. These systems function as centralized databases for alumni contact information, supporting networking, mentorship opportunities, and institutional fundraising initiatives [7] By sustaining meaningful connections, institutions can reinforce their reputations and inspire future student cohorts.

SRM across the student journey framework ensures consistent engagement, satisfaction, and success for students while aligning institutional operations with their needs. From targeted pre-enrollment strategies to lifelong alumni relations, SRM is a comprehensive approach to fostering academic and personal development.

B. PSRM within the SRM Framework

An in-depth analysis of the Student Relationship Management (SRM) framework highlighted that the most impactful processes for predicting student retention are concentrated within Phase 2: Enrollment Phase. This phase, which represents the core of the academic lifecycle, plays a pivotal role in collecting comprehensive data and implementing targeted interventions to maintain and enhance student engagement and persistence.

Key Factors in Phase 2 Influencing Student Retention Prediction:

1) Student Lifecycle Management

1.1) Application: Early engagement through application tracking and personalized communication establishes a foundation for understanding student intent and commitment. These factors serve as significant indicators of retention [9] [16] [22].

1.2) Enrollment: Efficient and error-free enrollment processes, including timely course registration and access to academic schedules, are strongly correlated with institutional satisfaction and student persistence [23].

Graduation: Tools that allow students to monitor their academic progress and ensure they meet graduation requirements foster transparency and a sense of accomplishment, thus supporting retention [22] [24].

2) Personalized Counseling

Tailored academic guidance identifies individual challenges and aligns support with student goals. This personalized approach reduces academic disengagement and improves retention outcomes [25] [26].

3) Comprehensive Academic Information

Providing clear and timely access to institutional information, including deadlines, procedural guides, and services, minimizes confusion and enhances the student experience [29] [30].

4. Managing Student Expectations

Institutions that actively assess and align their programs with student aspirations through surveys and focus groups foster higher levels of satisfaction and loyalty, contributing to retention [22] [28].

The findings highlight the pivotal role of Phase 2: Enrollment Phase within the Student Relationship Management (SRM) framework, emphasizing its significance in enhancing student retention through targeted, data-driven strategies. The integration of predictive analytics into this phase significantly amplifies its effectiveness, enabling

institutions to proactively address retention challenges and foster student success.

The Enrollment Phase encompasses critical academic lifecycle touchpoints where student engagement and satisfaction are directly influenced. By utilizing data on academic performance, behavioral patterns, and counseling interactions, institutions can develop predictive models powered by advanced analytics and machine learning techniques. These models facilitate the early identification of at-risk students, enabling institutions to implement timely and personalized interventions aimed at preventing dropout and improving retention rates [14][23].

This phase serves as the foundation of the Predictive Student Relationship Management (PSRM) approach within the SRM framework. Through data-driven methodologies, it provides actionable insights that empower institutions to promote student persistence, satisfaction, and long-term academic success. Furthermore, these strategies contribute to institutional excellence by fostering a culture of proactive student support and optimizing resource allocation to address retention issues effectively.

In summary, the Enrollment Phase within the PSRM framework demonstrates the transformative potential of predictive analytics in achieving sustainable retention outcomes and advancing the overall quality and equity of higher education.

C Business Intelligence (BI) as a Predictive Analytics

Predictive analytics, a cornerstone of modern BI, has transformed the way organizations approach decision-making. By leveraging historical and real-time data, predictive analytics addresses the fundamental question, "What will happen?" Through mathematical and machine learning models, this field provides actionable insights that guide strategic decisions across industries such as healthcare, finance, marketing, and logistics. In recent years, its applications in higher education have emerged as a pivotal area for enhancing student outcomes and institutional efficiency [31][32][33][34].

Predictive analytics offers a unique advantage by enabling proactive decision-making. Unlike traditional methods that focus on retrospective analysis, predictive analytics equips institutions with the tools to anticipate challenges, identify opportunities, and devise strategies to address them effectively. In higher education, predictive analytics serves as a catalyst for improving student retention, optimizing course offerings, and forecasting enrollment trends. For example, predictive models can identify at-risk students based on attendance records, grades, and engagement metrics, allowing institutions to intervene before students drop out [31][32][33][34][37][38].

The Process Predictive Analytics

Predictive analytics relies on a structured process to ensure that its forecasts are evidence-based and actionable. The following steps outline this systematic approach:

1) Data Collection and Preparation

The foundation of predictive analytics lies in the quality of its input data. In higher education, data is collected from a wide array of sources, including student information systems, learning management platforms, and survey responses. Preparing this data involves cleaning, integrating, and structuring it to eliminate inaccuracies, such as missing values or inconsistencies. Example in Higher Education: Universities collect historical data on students' academic performance, extracurricular participation, and socioeconomic backgrounds. By preparing and integrating these datasets, institutions can create comprehensive profiles to predict student success [9] [11] [14] [16] [22] [39] [40] [41].

2) Feature Engineering

Feature engineering focuses on identifying the most relevant variables and transforming them into formats suitable for modeling. In higher education, features might include GPA trends, course attendance rates, and digital engagement metrics. Effective feature engineering reduces noise, enhances model performance, and ensures that predictions are based on significant factors. Example in Higher Education: Features like the number of login sessions in a learning management system (LMS), participation in discussion forums, and submission of assignments can be used to predict students' risk of failing a course [31][32][33][34][37][38].

3) Model Development

Developing predictive models involves selecting and implementing suitable mathematical and machine learning techniques. Common models include logistic regression for binary outcomes, decision trees for classification tasks, and neural networks for complex patterns. Example in Higher Education: Logistic regression can predict whether a student is likely to graduate within four years, while neural networks can analyze large-scale patterns to recommend personalized learning paths for students [31][32][33][34][37][38].

4) Model Validation and Testing

Ensuring that predictive models are accurate and reliable requires rigorous validation and testing. Models are typically evaluated using techniques like cross-validation and are assessed using metrics such as precision, recall, and F1 score. Example in Higher Education: A predictive model designed to identify at-risk students is validated against historical data to determine its accuracy. Misclassifications are analyzed to refine the model further [31][32][33][34][37][38].

The potential of predictive analytics in higher education extends across various domains, including student success, resource allocation, and administrative planning. It also improves student retention rates. Predictive analytics identifies at-risk students early, enabling institutions to implement targeted interventions. For instance, students exhibiting a decline in grades or low engagement levels can be flagged for academic counseling or mentoring programs [39] [40] [41].

D Student Retention

Academic performance, often measured through grades, is a critical factor influencing student retention, serving as both a predictor of persistence and a reflection of academic engagement. Students with consistently low grades are at a higher risk of dropping out due to discouragement and disengagement [14]. Grades act as early indicators, enabling institutions to identify at-risk students and provide interventions like tutoring or counseling [42]. Positive academic performance enhances self-efficacy and motivation, reinforcing commitment to completing studies, while poor grades can diminish confidence and increase dropout risks [43].

Institutional policies also tie retention to grades. Academic thresholds for financial aid and scholarships can pressure students to leave if they fail to meet requirements [44]. However, remedial programs designed to improve grades can boost [16]. Additionally, grades reflect engagement levels; high grades often correlate with active participation in coursework and institutional activities, while low grades indicate disengagement, further increasing attrition risks [6].

While grades are not the sole determinant of retention, monitoring them allows institutions to identify challenges early, offer targeted support, and foster student success, significantly enhancing retention outcomes.

V. DISCUSSION

This research highlights the integration of Student Relationship Management (SRM) and Business Intelligence (BI) to form a Predictive Student Relationship Management (PSRM) framework aimed at enhancing undergraduate student retention. The analysis underscores the importance of two critical components: the SRM through the Student Journey Framework and the BI foundational components**,** with a particular focus on the enrollment phase as the central point for predictive interventions.

The SRM through the Student Journey Framework emphasizes fostering meaningful relationships with students across three phases: pre-enrollment, enrollment, and post-graduation. While the pre-enrollment phase focuses on attracting students through strategic communication, and the post-graduation phase fosters alumni relationships, the enrollment phase emerges as the most pivotal [7] [9]. Processes such as student lifecycle management, personalized counseling, comprehensive academic information delivery, and managing student expectations are vital in addressing student needs and reducing dropout risks. For example, tools that monitor academic progress or ensure transparent graduation processes significantly influence retention rates [22] [25] [26] [28].

The integration of BI foundational components elevates the PSRM framework. Through predictive analytics, institutions leverage historical and real-time data to anticipate challenges and implement proactive interventions. Steps such as data preparation, feature engineering, model development, and validation ensure actionable insights for at-risk students. For instance, predictive models identifying students with declining academic performance enable targeted academic support and counseling interventions [25] [26] [29].

This study highlights the transformative potential of combining SRM with BI to address retention challenges. By aligning processes and analytics, the PSRM framework empowers institutions to enhance student persistence and optimize institutional outcomes, providing a comprehensive roadmap for sustainable success in higher education.

CONCLUSION

This research proposes a comprehensive framework integrating Student Relationship Management (SRM) and Business Intelligence (BI) concepts to develop a Predictive Student Relationship Management (PSRM) system for improving undergraduate retention. By combining SRM's focus on fostering meaningful relationships across the student lifecycle with BI's predictive analytics capabilities, the framework offers actionable insights to address retention challenges proactively. The enrollment phase, identified as the pivotal stage, serves as the focal point for data-driven interventions, encompassing critical processes such as student lifecycle management, personalized counseling, academic information delivery, and expectation management. These processes enable institutions to address student needs effectively and reduce dropout risks through proactive strategies.

The inclusion of BI foundational components further enhances the PSRM framework. Predictive analytics enables institutions to anticipate challenges by analyzing historical and real-time data, using techniques such as data preparation, feature engineering, model development, and validation. For instance, models identifying at-risk students based on performance and engagement metrics empower institutions to implement timely academic support and counseling interventions, improving retention rates and academic success.

Future studies should focus on validating the PSRM framework through real-world implementation in diverse higher education contexts. Empirical evaluations can provide insights into its effectiveness, scalability, and adaptability. Additionally, exploring the integration of emerging technologies such as artificial intelligence (AI) and natural language processing (NLP) could further enhance predictive capabilities. Research should also address ethical considerations, including data privacy and security, to ensure the responsible use of student data. Comparative studies across institutions can identify best practices for applying the framework to diverse student populations. By advancing these areas, future research can refine the PSRM framework and expand its application, contributing to the broader goal of equitable and sustainable student retention in higher education.

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