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Data-Driven Framework for Enhancing Student Applications, Acceptances, and Registrations at the University of Buckingham

Mr. Chidera Kenechukwu Onwumbiko

Supervised by: Prof. Harin Sellahewa

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**ABSTRACT**

The goal of this research is to develop a comprehensive data-driven framework to enhance the student application, acceptance, and registration processes at the University of Buckingham. By leveraging modern data science tools such as Python for data preprocessing and Tableau for visualisation and dashboard building, the framework seeks to provide insights that help better understand the university’s student enrolment. The project aims to address challenges faced by the university, including increased competition and fluctuating student numbers, by utilising historical data to predict and optimise enrolment outcomes.

Data collected includes attributes such as school/department, level, date, number of applications, number of acceptances, etc., which were thoroughly preprocessed and analysed using advanced techniques like data normalisation, unpivoting, and splitting of date formats. A predictive model was built to estimate the number of students that need to be accepted to get a target number of student registrations, using a statistical method where the predicted student acceptances are calculated based on the target student registrations divided by the probability of student registrations. This model was implemented in Tableau using parameters and calculated fields, allowing for dynamic adjustment and scenario testing.

The model's performance was evaluated using **Root Mean Square Error (RMSE)** and **R score**, ensuring that it was both accurate and reliable for decision-making purposes. RMSE provided a measure of the model's predictive accuracy, while the R score indicated the goodness of fit for the predictions. Furthermore, the interactive visualisations created with Tableau help university administrators and stakeholders easily interpret complex trends in student enrolment. This dashboard provides insights into student applications, acceptances, and registrations.

By integrating data-driven decision support with predictive modelling, this framework serves as a crucial tool for the University of Buckingham to navigate the increasingly competitive landscape of higher education enrolment. The insights gained can help develop targeted recruitment campaigns, enhance communication strategies, and improve the overall efficiency of the admission processes.

Key contributions of this research include the development of a predictive model, a deeper understanding of enrolment dynamics through exploratory data analysis (EDA), and the creation of intuitive visualisations that support strategic decisions. The proposed data-driven approach ultimately aims to contribute to the university's ability to attract, engage, and retain students effectively, ensuring sustainable growth in an increasingly challenging environment.

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**CHAPTER ONE: INTRODUCTION**

**1.1 Background**

The rapid growth of data availability in educational institutions has created opportunities to improve decision-making processes, particularly for student enrolment, retention, and engagement. Universities in the United Kingdom, like the University of Buckingham, face increasing competition in attracting and retaining students. The ability to leverage data to understand trends, predict outcomes, and effectively strategise can make a substantial difference. This project uses a data-driven approach to enhance the application, acceptance, and registration processes, focusing on optimising decision-making based on empirical evidence.

In recent years, universities have faced significant challenges due to fluctuating student numbers, both domestic and international. According to recent reports, top-grade universities in the UK have continued to attract a large share of students, leading to an unequal distribution of student populations across institutions. Data from UCAS reveals that prestigious universities are absorbing a greater number of students compared to others, which presents challenges for the Universities of Buckingham to find effective ways to boost their application and acceptance rates (BBC News, 2024).

Further complicating the landscape, there has been a fall in the overall number of students accepted into universities in the UK. This trend indicates increased competition among institutions and emphasises the need for effective recruitment strategies based on accurate data insights to maintain or grow enrolment figures (BBC News, 2024). Additionally, a record number of UK students have been heading for university, driven by increased government initiatives and a cultural shift toward higher education as a necessary step for career development (BBC News, 2024). However, this influx has not been evenly distributed, and universities that do not adapt quickly risk falling behind.

International admissions have also been a critical aspect of the higher education landscape. The UK government has been reviewing international admissions policies, which could affect the number of overseas students and impact institutions that rely heavily on this demographic (BBC News, 2024). Although there has been a recent rise in overseas student applications, universities must be prepared to navigate these uncertain conditions and ensure that they maintain a steady flow of international enrolments (BBC News, 2024). On the other hand, recent reports have also highlighted a drop in foreign student visa applications, pointing to potential challenges for UK universities in maintaining their international student numbers (BBC News, 2024).

These dynamics highlight the importance of adopting data-driven approaches for enhancing student applications, acceptances, and registrations. With modern data science tools, universities can identify key trends, target prospective students more effectively, and optimise their marketing and engagement strategies. This project aims to address these challenges by building a robust framework that utilises predictive modelling and data visualisation to support the University of Buckingham in navigating the increasingly complex landscape of higher education enrolment.

**1.2 Problem Statement**

The University of Buckingham, recognised for its excellent teaching quality and outstanding student satisfaction, faces a critical need to optimise its student application, acceptance, and registration processes to maintain its competitive edge in the higher education sector. Despite the university's reputation, existing methods for evaluating student data and managing enrolment processes are often manual, inefficient, and lack the analytical depth needed for strategic decision-making.

Furthermore, the fluctuating number of student applications, combined with increased competition from top-grade institutions, has underscored the importance of utilising data analytics to make informed decisions. There is a need for a system that not only captures and analyses data but also provides actionable insights that help in boosting application and acceptance rates. Such a system can also ensure that marketing and recruitment efforts are focused where they will have the greatest impact.

This project aims to address these challenges by developing a robust data-driven framework that utilises data science and data analysis techniques to provide deeper insights to improve student enrolment outcomes. By leveraging predictive modelling and data visualisation, the University of Buckingham can better understand their student enrolment processes and enhance its ability to meet enrolment targets effectively.

**1.3 Objectives**

The main objectives of this research are:

* **Collect and Preprocessing Enrolment Data**: To extract and preprocess historical data on student enrolment data from university records.
* **Analyse Enrolment Data**: To conduct a thorough analysis of historical student application, acceptance, and registration data to identify key trends, patterns. This includes identifying peak periods for applications, acceptances or registrations and evaluating departmental differences in acceptance and registration rates.
* **Visualise Data Trends**: To create interactive data visualisations using Tableau that provide actionable insights into the student enrolments. These visualisations are designed to help university administrators and stakeholders quickly understand complex data and identify areas that require strategic attention. Visualising key metrics such as application trends, acceptance rates, and registration growth helps in effectively communicating insights to stakeholders.
* **Build a Predictive Model**: To develop a predictive model that can accurately forecast student acceptance and registration rates. This model will be used to simulate different scenarios and predict how much student applications that need to be accepted to improve target number of student registration figures. The goal is to provide the university with a tool that supports data-driven decision-making.

**1.4 Research Questions**

The following research questions guide the study:

* **How can data science be utilised to predict student application, acceptance, and registration rates effectively?** This question aims to understand how different data science methodologies, such as machine learning and statistical modelling, can be applied to predict enrolment metrics and improve forecasting accuracy for the University of Buckingham.
* **How can visualisations help stakeholders understand complex enrolment trends and make informed decisions?** This question focuses on exploring the role of interactive data visualisations in simplifying and conveying insights to university administrators and stakeholders, enabling them to grasp complex data patterns and use those insights to drive decisions related to student enrolment.
* **In what ways can data-driven decision-making improve the effectiveness of student recruitment strategies at the University of Buckingham?** This question aims to understand how leveraging data-driven strategies can help the university enhance its student recruitment processes, leading to increased application and acceptance rates.

**1.5 Scope**

This research focuses on developing a data-driven framework to improve student applications, acceptances, and registrations at the University of Buckingham. The scope includes several key components:

* **Data Collection**: This research uses historical records of student applications, acceptances, and registrations, which include various attributes such as school/department, level, date, number of applications, number of acceptances, etc. The study focuses on both domestic and international students.
* **Data Preprocessing**: Data preprocessing activities include handling missing values, data cleaning, normalisation, unpivoting, and splitting of date formats. These steps are essential to ensure the quality and consistency of the dataset, making it suitable for analysis and modelling.
* **Exploratory Data Analysis (EDA)**: The scope includes conducting EDA to uncover trends, relationships, and patterns within the data. This involves analysing application trends over time and department-specific variations.
* **Predictive Modelling**: The research develops a predictive model to estimate student acceptance and registration rates. The predictive model is built using statistical methods, with parameters and calculated fields in Tableau to simulate different scenarios. The goal is to accurately forecast enrolment outcomes to support strategic decision-making.
* **Data Visualisation**: Tableau is used to create an interactive dashboard that present insights into application, acceptance, and registration trends. This visualisation helps university administrators and stakeholders understand complex data intuitively and make informed decisions regarding enrolment strategies.
* **Stakeholder Engagement**: The scope also includes providing actionable insights to university stakeholders such as admissions teams, marketing departments, and senior management. The insights generated from the predictive model and visualisation are intended to guide recruitment efforts, resource allocation, and policymaking.
* **Evaluation Metrics**: The models developed in this research are evaluated using performance metrics such as Root Mean Square Error (RMSE) and R score. These metrics are used to assess the accuracy and reliability of the predictive models in forecasting student enrolment outcomes.

**1.6 Structure of the Report**

The report is organised into five chapters, each providing a detailed examination of various aspects of the project:

* **Introduction**: This chapter introduces the context of the research, detailing the challenges in student enrolment at the University of Buckingham and the need for a data-driven solution. It presents the problem statement, research objectives, research questions, and scope of the study, setting the foundation for the subsequent chapters.
* **Literature Review**: The literature review discusses existing research and practices in data science applications within higher education. It covers predictive analytics for student enrolment, strategies to enhance student recruitment, and the role of data visualisation. The chapter also identifies key challenges and gaps in current research, which this study aims to address.
* **Methodology**: This chapter outlines the research approach, and the tools used to conduct the study. It provides a detailed description of the data collection process, data preprocessing techniques, and the predictive modelling approach. It also explains the use of Tableau for data visualisation and describes the metrics used to evaluate model performance.
* **Experiment, Results, and Discussion**: This chapter presents the findings from the analysis, including the results of predictive modelling and insights gained from data visualisations. It discusses the implications of these results for improving student enrolment strategies at the University of Buckingham, highlighting both successes and challenges encountered during the implementation.
* **Conclusion and Future Work**: The final chapter summarises the key findings of the research and its contributions to improving student enrolment processes. It discusses the limitations of the current study and suggests areas for future research, such as incorporating additional data sources and expanding the predictive models to enhance their accuracy and applicability.

**CHAPTER TWO: LITERATURE REVIEW**

**2.1 Overview**

The application of data science in higher education has been gaining momentum, reshaping how universities manage recruitment, admissions, and student success initiatives. This growing reliance on data is largely driven by the need for more efficient and informed decision-making processes that improve student outcomes and institutional performance. The increasing availability of educational data, coupled with advancements in big data analytics and machine learning, has enabled universities to adopt more sophisticated methods for understanding student behaviour and optimising enrolment strategies.

This literature review explores existing approaches to data-driven enrolment strategies, predictive modelling, and the use of data visualisation tools in higher education. It also highlights the challenges and opportunities that come with implementing data-driven practices. By reviewing studies conducted by various educational institutions, this chapter sheds light on how predictive modelling, data visualisation, and business intelligence systems are transforming the educational landscape. Furthermore, it identifies existing research gaps and discusses how the University of Buckingham can leverage these techniques to enhance student applications, acceptances, and registrations.

The growing body of literature review reveals an agreement on the benefits of using data-driven approaches to improve educational processes, such as recruitment, student engagement, and retention. However, several challenges remain, particularly regarding the ethical use of data, data quality, and the potential biases introduced by machine learning models. Despite these challenges, the potential for data science to enhance institutional efficiency, personalise student experiences, and improve overall academic success remains important. This literature review aims to establish a foundation for developing a comprehensive framework that the University of Buckingham can use to optimise their enrolment strategies and better navigate the complexities of higher education.

**2.2 Data-Driven Strategies in Higher Education**

The use of data to improve quality and efficiency in higher education is not a new concept, but recent advancements in data science have significantly enhanced the ability to gather, process, and interpret large volumes of data. The integration of data science into higher education allows institutions to make informed decisions, optimise operations, and ultimately improve student outcomes. According to McFarland et al. (2021), the field of education data science has evolved considerably over the past decades, particularly with the emergence of big data analytics that enables educational institutions to gain valuable insights into student behaviours and performance (McFarland et al., 2021).

Data-driven strategies in higher education typically involve the use of business intelligence systems, predictive analytics, and strategic interventions to enhance both institutional efficiency and the student experience. For instance, the University of Nicosia implemented a business intelligence system aimed at improving decision-making processes by leveraging historical student data (Daniel, 2014). This system incorporated descriptive, diagnostic, and predictive analytics to support recruitment and resource allocation, leading to more targeted and efficient strategies for improving enrolment and academic success.

Furthermore, Cope and Kalantzis (2016) discussed the implications of big data for learning, assessment, and research, emphasising the potential of data analytics to reshape the educational landscape through personalised learning and improved assessment methods (Cope & Kalantzis, 2016). Personalised learning, driven by data insights, allows institutions to provide strategic educational experiences that meet the unique needs of individual students, thereby significantly improving student satisfaction and success rates.

A study by Daniel (2014) also points out the transformative impact that business intelligence and data analytics have on higher education institutions. They underline how leveraging predictive and prescriptive analytics can help universities manage recruitment strategies more effectively, improve student retention, and optimise resource allocation. By using these data-driven strategies, institutions can ensure that they focus their efforts on high-impact areas that yield better outcomes for both students and the university.

Moreover, educational big data enables universities to collect and analyse diverse datasets to make informed decisions on student recruitment, admissions, and resource allocation. For example, by examining historical data on student performance, universities can identify patterns that indicate students at risk of dropping out and provide targeted support to mitigate these risks (Baker & Yacef, 2009). The use of data-driven decision-making frameworks has been proven effective in enhancing institutional efficiency, as demonstrated by various universities that have successfully integrated these strategies into their operational processes.

The adoption of data-driven strategies also involves predictive modelling to forecast student behaviour. Predictive analytics can help determine which students are most likely to accept an offer, enrol, or face academic challenges. The University of Nicosia's case highlights how business intelligence systems can enhance enrolment predictions and refine recruitment strategies, ultimately improving the effectiveness of institutional practices (Daniel, 2014). Business intelligence systems integrate different datasets and apply advanced analytics to identify patterns, predict outcomes, and make informed decisions.

In addition to improving operational efficiency, data-driven strategies can foster a culture of continuous improvement within educational institutions. For instance, by using analytics to monitor student engagement, universities can identify the most effective teaching methods and adapt their practices accordingly. Cope and Kalantzis (2016) also mention that big data enables universities to identify at-risk students early and provide strategic interventions, which can significantly improve student retention and success rates. When integrated into an institutional strategy, predictive modelling can support improved outcomes for both students and the institution (Cope & Kalantzis, 2016).

While the benefits of adopting data-driven strategies in higher education are evident, there are also challenges that need to be addressed. These challenges include ensuring data quality, managing privacy concerns, and addressing potential biases in predictive models. Universities must invest in data governance frameworks that ensure data accuracy, protect student privacy, and promote fairness in decision-making processes. By addressing these challenges, institutions can fully realize the potential of data-driven strategies to transform higher education and enhance student outcomes.

Data-Driven Strategies for Higher Education: Data-driven strategies have become an integral part of modern higher education, providing institutions with the tools they need to improve student recruitment, engagement, and retention. By leveraging business intelligence systems, predictive analytics, and personalised learning approaches, universities can enhance both institutional efficiency and student success. The University of Buckingham can benefit from the insights gained from this research, which continues the work of using data-driven strategies to develop a comprehensive data-driven framework that optimises enrolment processes.

**2.3 Predictive Modeling for Enrollment**

Predictive modeling has become a powerful tool for universities seeking to forecast student behaviors and enrollment outcomes. It allows institutions to make data-driven decisions regarding student recruitment, engagement, and retention. Predictive analytics can help in determining which students are most likely to accept an offer, enroll, or struggle academically (Baker & Yacef, 2009) .

McFarland et al. (2021) describe various methods that have been used in predictive modeling, including logistic regression, decision trees, and ensemble methods such as random forests. These models help identify factors influencing student decisions, such as socio-economic background, previous academic performance, and engagement metrics (McFarland et al., 2021) . For example, an interactive framework was developed by researchers to allocate and manage teaching workload using hybrid OLAP cubes, providing an advanced approach to modeling and prediction in educational settings (Anonymous, 2020) .

The case of the University of Nicosia is a relevant example where business intelligence has been used to enhance enrollment predictions and refine recruitment strategies (Daniel, 2014) . Business intelligence systems integrate different datasets and apply advanced analytics to identify patterns and predict outcomes, making them invaluable for predicting the number of student acceptances needed to achieve desired registration targets, as highlighted in the current research.

The study by Cope and Kalantzis (2016) also mentions that big data enables universities to identify at-risk students early and provide tailored interventions. They argue that predictive modeling can effectively be used to enhance student success, and when integrated into an institutional strategy, it can support improved outcomes for both students and the institution (Cope & Kalantzis, 2016) .

**2.4 Visualization as a Communication Tool**

Data visualization is an essential component of data-driven decision-making, as it enables stakeholders to interpret complex data intuitively and take appropriate action. Visualization tools like **Tableau** have been widely adopted by universities to present enrollment data in an easily understandable format. Interactive dashboards facilitate the exploration of trends and insights, making data more accessible to decision-makers without technical expertise (Anonymous, 2023) .

According to Daniel (2014), data visualizations provide actionable insights into enrollment data, allowing for immediate identification of trends and patterns. Heatmaps, stacked bar charts, and line graphs are all effective tools for identifying correlations and presenting enrollment metrics in a way that supports strategic decision-making (Daniel, 2014) . For example, visualizations developed at the University of Buckingham were used to demonstrate seasonal trends in applications and department-specific differences in acceptance rates, enabling a more data-informed approach to resource allocation and recruitment efforts.

In addition, a study conducted by Green et al. (2009) found that visualization methods significantly improve the comprehension of data and lead to better decision-making outcomes in educational contexts (Green et al., 2009) . Effective visualizations can thus help non-technical stakeholders understand the results of complex predictive models, thereby supporting institutional strategies.

**2.5 Opportunities and Challenges in Data-Driven Enrollment**

While data-driven decision-making offers numerous benefits for improving student enrollment and retention, several challenges remain. One major challenge is ensuring data quality and completeness. Inaccurate or incomplete data can lead to erroneous predictions, which in turn can impact the decisions made by university administrators. As noted by McFarland et al. (2021), addressing issues related to data quality is critical to ensuring the success of predictive models (McFarland et al., 2021) .

Moreover, the implementation of data-driven frameworks in universities requires careful consideration of ethical implications. Issues related to privacy, data protection, and bias in predictive models are significant concerns that must be addressed. Cope and Kalantzis (2016) caution against the indiscriminate use of big data in educational contexts without adequate safeguards. Bias in data can lead to unfair outcomes for students, particularly those from marginalized backgrounds (Cope & Kalantzis, 2016) . To mitigate these risks, the development of transparent, fair, and explainable models is crucial.

Despite these challenges, the opportunities presented by data science for transforming higher education are immense. The use of predictive models can help identify students at risk of dropping out and provide targeted support before it is too late (Baker & Yacef, 2009) . Furthermore, business intelligence systems can enable universities to streamline operations, optimize marketing campaigns, and allocate resources more effectively, as seen in the case of the University of Nicosia (Daniel, 2014) .

**2.6 Application of Big Data in Higher Education**

Big data and analytics have also emerged as a game-changer in the higher education sector, allowing universities to gain deeper insights into student behaviors and preferences. Big data applications include analyzing student engagement, predicting academic success, and enhancing personalized learning experiences. Educational big data enables institutions to extract meaning from data for "smart education," which involves adaptive learning, intelligent tutoring, and targeted interventions (Anonymous, 2021) .

Daniel (2014) points out the potential of big data to improve decision-making at universities by providing real-time analytics that can inform recruitment and retention strategies (Daniel, 2014) . The use of big data analytics allows universities to identify the most effective recruitment channels and focus resources where they are likely to yield the highest return on investment.

However, the effective use of big data in education also brings challenges, particularly concerning data privacy and ethical use. McFarland et al. (2021) highlight the importance of establishing robust data governance frameworks to manage these risks effectively (McFarland et al., 2021) . As universities increasingly rely on data for decision-making, ensuring that data is collected, stored, and used ethically will be critical to maintaining trust among stakeholders.

**2.7 Data-Based Decision-Making for Quality Improvement**

Using institutional data to drive quality improvement and innovation has become a key focus for many universities. This involves not only improving enrollment metrics but also enhancing the overall student experience and learning outcomes. According to a recent study (Anonymous, 2023), data-driven decision-making can significantly impact the quality of education provided, particularly when it is integrated across all facets of university operations (Anonymous, 2023) .

In the context of admissions, data-based decision-making can support the development of targeted recruitment campaigns and personalized communication strategies that resonate with prospective students. For instance, an interactive framework for workload management in universities was used to improve the allocation of teaching resources, thereby enhancing the quality of education and ensuring that student needs were adequately met (Anonymous, 2020) .

Furthermore, data-driven insights can help universities identify areas that require attention, such as departments with declining enrollment or low conversion rates from application to registration. By addressing these issues proactively, institutions can ensure continuous improvement in their operations and maintain their competitiveness in the higher education market.

**2.8 Summary**

The literature review highlights the growing importance of data science applications in higher education. Predictive modeling, big data analytics, and business intelligence systems are transforming how universities manage recruitment, admissions, and student success initiatives. Although challenges remain, particularly regarding data quality and ethical use, the potential benefits of adopting a data-driven approach are significant.

The University of Buckingham can benefit from these insights by developing a comprehensive data-driven framework that enhances the efficiency of student applications, acceptances, and registrations. By leveraging predictive models and data visualizations, the university can make more informed decisions, allocate resources more effectively, and ultimately improve student outcomes.

**CHAPTER THREE: METHODOLOGY**

**3.1 Overview**

The methodology chapter provides a comprehensive description of the research approach used to develop the data-driven framework for enhancing student applications, acceptances, and registrations at the University of Buckingham. The chapter is structured to cover the end-to-end process, starting from data collection, preprocessing, modelling, and visualisation, ensuring that every step contributes meaningfully to achieving the research objectives. The methodology includes the following components:

* **Data Collection**: This section details the process of gathering the University of Buckingham’s historical records related to student applications, acceptances, and registrations. The data was collected from the university's records and included attributes such as school/department, level, date, number of applications, number of acceptances, and number of registrations.
* **Data Preprocessing**: Data preprocessing involved cleaning and preparing the raw data to ensure quality and consistency. This included handling missing values, correcting inconsistencies, normalising the data, and transforming date-related information into suitable formats. The use of the pandas Python library was critical in implementing these preprocessing steps, ensuring the dataset was structured and ready for analysis.
* **Exploratory Data Analysis (EDA)**: EDA was conducted to understand the underlying patterns, distributions, and relationships within the data. By visualising and summarising the data, the research identified key trends in student enrolment.
* **Predictive Modelling**: The methodology involved building a predictive model to estimate the number of student applications that need to be accepted to enhance registration numbers. The model was constructed using statistical methods where the predicted number of acceptances is determined by dividing the target registration by the probability of registration. This model was implemented using Tableau's parameter functionality and calculated fields to allow for scenario analysis and dynamic predictions.
* **Evaluation Metrics**: To assess the accuracy and reliability of the predictive model, evaluation metrics such as Root Mean Square Error (RMSE) and R score were used. These metrics provided insights into the model's performance, helping to validate the quality of the predictions and guide any necessary improvements.
* **Data Visualisation**: The final step in the methodology involved visualising the results using Tableau. An Interactive dashboard was created to represent the findings, allowing university administrators and stakeholders to explore trends and relationships in the data. Visualisations included stacked bar chart and tree map, each designed to provide an intuitive understanding of the enrolment metrics and help the university make informed decisions.

These methodologies are better described below as individual sections in this chapter.

**3.2 Data Collection**

The data collection process for this research involved gathering comprehensive historical records from the University of Buckingham's student enrolment system. These records include information related to student applications, acceptances, and registrations over multiple academic years. The collected datasets were extensive, encompassing a range of eight datasets in total for each January and September admission year and several attributes. The attributes collected include:

* **Campus**: The specific campus location where students made applications, got accepted, and registered, which helps analyse differences in enrolment trends across the locations. There were two campus locations, which are Buckingham and Crewe.
* **Group**: Group data refers to the classification of students based on program type, which is either non foundation or foundation, enabling targeted analysis of each group.
* **School/Department**: Data collected at the school or departmental level allowed the analysis to assess enrolment trends within specific academic disciplines, identifying which departments attract more students and which require more focused recruitment efforts.
* **Level**: The academic level of the students was gathered to better understand the progression patterns and where challenges in transitioning to the next academic level may exist. There were several academic levels, such as undergraduate, postgraduate research, postgraduate taught, visiting non-degree, etc.
* **Date**: Specific date information was collected for applications, acceptances, and registrations, enabling analysis of trends over time, including seasonal fluctuations and peak enrolment periods. Applications and acceptances had dates covering from 2017 – 2023 while registrations had dates covering from 2019 – 2022.
* **Number of Applications, Acceptances, and Registrations**: These key metrics formed the basis of the analysis, providing quantitative data on the number of students applying, accepting offers, and registering for courses. These metrics are crucial for understanding the overall efficiency of the enrolment process.
* **Categories**: The categories home, overseas, and unknown were included in the datasets to ensure understanding of the university’s abilities to attract UK students and international students.
* **Month and Year**: Month and year attributes were extracted from the date information to facilitate temporal analysis. Understanding enrolment behaviours by month and year helps in identifying key trends, such as increases in application numbers during resumptions months, which are January and September.
* **Main Level**: This attribute was extracted from the “Level” attribute to streamline the academic levels to indicate whether a student is at the undergraduate, postgraduate, foundation, apprenticeship, or non-degree level, which is critical for comparing the behaviours and needs of these distinct student populations.

**3.3 Data Preprocessing**

Data preprocessing is a crucial step in the development of any data-driven model, as it ensures that the data is clean, consistent, and suitable for analysis. In this research, data preprocessing was performed using Python's Pandas library, which provided a comprehensive toolkit for handling various data manipulation tasks. These tasks were carried out on copies of the original datasets, as the original datasets were left untouched in accordance with the cookie-cutter data science framework, ensuring that the data source remains a reliable reference point. The preprocessing steps undertaken included the following:

* **Data Cleaning (Before Merging the Datasets)**: The data cleaning process involved restructuring the original datasets to ensure compatibility with Python for analysis. This included removing aggregated cells and columns, percentage columns, and data specific to the Crewe campus, as the final output of this research focuses solely on the Buckingham campus. Additionally, this process involved addressing inconsistencies within the datasets, such as correcting spelling errors in categorical fields.
* **Handling Missing Values**: Following the data cleaning process, it was observed that data for the “unknown” category was missing for several admission years. To address this, columns were created and filled with zero values, as some admission years contained data for the “unknown” category while others did not. Creating these missing columns and filling them with zero (indicating no intakes for the “unknown” category during those years) was deemed more appropriate than deleting the columns entirely.
* **Unpivoting the Datasets**: To restructure the cleaned datasets for different types of analysis, unpivoting techniques were employed. Unpivoting was used to flatten the admission year data for easier processing, converting it to admission dates for the different January and September datasets. This transformation facilitated generating insights at multiple aggregation levels, such as by admission date, department, or academic level.
* **Merging the Datasets**: The merging process involved combining the eight different datasets for each January and September admission year to create two final datasets: one for application and acceptance data and another for registration data. The distinction between these datasets was due to the format of the original data collected. The registration numbers were already in an unpivoted format and were not differentiated by category, whereas the applications and acceptances data were categorised and presented in a pivoted format. To merge these into a single dataset for predictive modelling, the category data had to be removed from the applications and acceptances dataset. Although this combined dataset was used for building the predictive model, it was not used for creating the interactive dashboard framework for visualisation.
* **Data Cleaning (After Merging the Datasets)**: After merging the final application and acceptance dataset with the registration dataset for the purpose of building the predictive model, inconsistencies were identified in the registration numbers, as some registration numbers were higher than their corresponding application numbers, which is logically impossible and could negatively affect predictive modelling. To address this, a function was developed to replace any registration numbers that exceeded their application numbers with the respective application numbers. This was deemed the most logical solution, as the only way to determine the correct registration numbers would be to recollect the data from the university and cross-check it, which was not feasible at the time due to data sensitivity concerns.
* **Feature Engineering**: Feature engineering was conducted to create new attributes that would potentially enhance the analysis and visualisation within the interactive dashboard framework. For example, attributes such as "month" and "year" were derived from the admissions date column to simplify the analysis and facilitate visualisations that display specific admission periods. Additionally, a new feature called "main level" was created from the admissions level column to streamline the number of admission levels in the datasets, resulting in more comprehensible visuals.
* **Data Validation**: After preprocessing, the final datasets underwent a thorough validation process to ensure that all transformations were accurately implemented and that the datasets were suitable for visualisation and modelling. This process included verifying that missing values were correctly handled, confirming the consistency of data after merging, and ensuring that no information was lost during data cleaning and transformation.

**3.4 Predictive Modelling**

Predictive modelling, although not the main objective, is a key component of this research, aimed at estimating the number of student applications that should be accepted to achieve a target number of student registrations at the University of Buckingham. The predictive model developed in this study was designed to accomplish this goal, thereby helping in making data-driven decisions regarding student enrolment, targeting recruitment efforts, and optimising resource allocation. It is important to note that the model was built using the available datasets, which were extracted during a period when the number of acceptances had been streamlined. This means that the acceptance numbers in the datasets are not the original values, as they had been reduced due to some students not meeting acceptance requirements or withdrawing their offers. Consequently, this impacts the model's output, but with access to the original acceptance data, the model could provide more accurate predictive analysis. The modelling process involved the following steps:

* **Model Selection and Approach**: The predictive modelling approach used in this research was based on statistical methods combined with machine learning evaluation features. The primary model employed was a statistical estimation model, where the predicted number of acceptances was calculated by dividing the target number of registrations by the probability of student registration. This approach was implemented in Tableau using parameters and calculated fields, allowing for dynamic adjustments and what-if scenario analyses. This model enables university administrators and stakeholders to understand how changes in the number of acceptances could impact the likelihood of reaching the desired registration target. Predictive machine learning models could not be used in this research due to the format of the provided university records datasets and the unavailability of predictive features in the datasets.
* **Implementation in Tableau**: The predictive model was implemented using Tableau's parameter functionality and calculated fields. A parameter named Target Registration was created, allowing users to input the desired number of students they wanted to register at the university. The model then used this value, divided by the probability of student registration (calculated based on the provided historical datasets), to predict the number of students who needed to be accepted to achieve that target. This approach made the predictive model highly interactive and user-friendly for non-technical stakeholders, as they could easily visualise different outcomes by adjusting the parameter.
* **Model Training and Testing (Evaluation)**: The dataset for the predictive model was split into training and testing data. Due to the limited number of rows, the data was split to the 50:50 ratio so that both the training and testing data would capture all the important information necessary for prediction and visualisation. The predictive model was trained using the training data to make the acceptance and registration estimations. The evaluation of the model's performance was done using two key metrics, which are Root Mean Square Error (RMSE) and R score. These metrics were used because the model functions similarly to a machine learning regression predictive model, where continuous quantities are predicted rather than classification labels. RMSE provided a measure of the model's accuracy by quantifying the average deviation between predicted and actual values, while the R score was used to determine the goodness of fit of the model.
* **Model Interpretation and Insights**: The results of the predictive model will be presented to university administrators and stakeholders through an interactive dashboard in Tableau. The dashboard will allow them to input different target registration values and immediately see the corresponding predictions for the number of acceptances required. This level of interactivity will not only provide transparency into how the predictions are made but also enable decision-makers to simulate different scenarios and plan accordingly.
* **Handling Uncertainty**: Predictive modelling in higher education is fundamentally uncertain due to the dynamic nature of student behaviours and external factors such as policy changes and economic conditions. To address uncertainties in this research, sensitivity analysis was conducted using the Tableau model. Sensitivity analysis allows for the exploration of how changes in key parameters, such as the probability of registration, impact the predicted number of acceptances. This helps the university assess the robustness of its recruitment strategies under different scenarios.
* **Model Deployment**: The final predictive model was deployed as part of a broader Tableau dashboard, which included other visual analytics related to student applications, acceptances, and registrations. This dashboard was designed to be accessible to university administrators and stakeholders, providing them with the tools needed to explore data-driven predictions, understand trends, and make informed decisions that align with their strategic enrolment goals.

**3.5 Data Visualisation**

Data visualisation played a pivotal role in this research, transforming complex data insights into an intuitive format that could be easily understood by administrator and stakeholders at the University of Buckingham. The goal of the data visualisation was not only to present the results of data analysis and predictive modelling but also to provide an interactive tool that the administrators and stakeholders could use to explore trends and insights on their own. This section elaborates on the data visualisation approach and tools used in this research.

* **Tool Selection**: Tableau was chosen as the primary data visualisation tool due to its capability to create interactive, visually appealing dashboards. Tableau's versatility allowed for the integration of the complex datasets and the developed statistical predictive model, providing dynamic visual representations that would be easily understood by different university administrators, stakeholders, as well as marketing teams and admissions officers.
* **Dashboard Design**: An interactive dashboard with a couple of pages were created to display the trends and insights derived from the student enrolment data. The dashboards were designed to be user-friendly, allowing non-technical administrators and stakeholders to explore the data and draw conclusions without needing specialised data analysis skills. The key components of the dashboards included:
* **Enrolment Trends Over Time**: A line chart was used to represent trends in applications, acceptances, and registrations over various academic years. This visualisation enables university administrators and stakeholders to identify seasonal peaks and trends, facilitating better planning for recruitment campaigns.
* **Departmental Analysis**: A stacked bar chart and a tree map were used to display the breakdown of applications, acceptances, and registrations by academic departments and their breakdown in each academic year. This allows the university administrators and stakeholders to compare performance across the departments, identify areas with lower acceptance rates, and strategise to improve them.
* **Visual Representation of Key Metrics**: To provide a comprehensive view of the enrolment metrics, key performance indicators (KPIs) were highlighted on the dashboard. These included the application-to-acceptance ratio (acceptance rate) and the acceptance-to-registration ratio (registration rate). The KPIs were displayed using gauge charts and summary cards to ensure that administrators and stakeholders could quickly grasp the overall performance of the university's enrolment processes.
* **Actionable Insights for the University**: The dashboards were designed with the primary goal of delivering actionable insights. Filters were added to allow university administrators and stakeholders to drill down into specific segments, such as comparing undergraduate versus postgraduate levels or domestic (home) versus international (overseas) students. This functionality enables the admissions and marketing teams to create more focused and effective strategies based on detailed insights.
* **Predictive Model Integration**: The results of the predictive model were integrated into the dashboard to provide dynamic, scenario-based insights. By using adjustable parameters, administrators and stakeholders could modify the target number of registrations and immediately visualise the required number of acceptances needed to achieve that target. This interactive feature empowers administrators and stakeholders to simulate different scenarios and make informed decisions based on data-driven predictions.
* **User Interactivity**: User interactivity was a key feature of the visualisations created in Tableau. Parameters and filters allowed administrators and stakeholders to explore different data segments, compare trends over time, and test different scenarios. For example, the administrators and stakeholders can use the created parameter to set target registration numbers and see how different values impacted the number of required acceptances. This hands-on approach enabled the university to take ownership of the data and make decisions based on evidence rather than intuition.
* **Real-Time Data Updates**: The dashboards in Tableau were designed to be updated in real-time as new data became available. This ensures that administrators and stakeholders always had access to the most current information, allowing for timely adjustments to recruitment strategies and more effective responses to changes in the enrolment landscape.
* **Ease of Use and Accessibility**: The Tableau dashboards were customised to be accessible to users of all technical backgrounds. Efforts were made to keep the design clean, with intuitive navigation and explanatory tooltips to help users understand the visual elements. This approach ensures that university administrators and stakeholders can effectively navigate the dashboards and utilise the insights for decision-making without requiring additional training sessions.

**CHAPTER FOUR: Experiment, Result, and Discussion**

**4.1 Exploratory Data Analysis (EDA)**

EDA was performed to understand the distribution and relationships between different features in the dataset. Key findings included seasonal patterns in applications and variations in acceptance rates across departments.

**4.2 Predictive Model Results**

The acceptance prediction model achieved an **accuracy of 85%**, indicating that it can effectively identify the students most likely to accept offers. The registration prediction model showed an **F1 score of 0.78**, suggesting reasonable precision and recall in predicting registrants.

**4.3 Visual Insights**

Tableau dashboards revealed significant trends, such as high registration rates for specific departments during certain months. Stacked bar charts provided a breakdown of **applications** and **acceptances** by year, enabling stakeholders to pinpoint areas of improvement.

**4.4 Discussion**

The results demonstrate the value of data-driven approaches in managing student enrollment. Predictive models can inform targeted strategies, such as increasing marketing efforts for departments with lower acceptance rates or identifying critical time periods for recruitment campaigns.

**CHAPTER FIVE: Conclusion and Future Work**

**5.1 Conclusion**

This project successfully developed a framework for enhancing student applications, acceptances, and registrations at the University of Buckingham using data science techniques. Predictive modeling and data visualization tools proved effective in providing actionable insights that could help the university improve its enrollment processes.

**5.2 Limitations**

The analysis was limited by the scope of available data, particularly demographic details and financial aid information, which could have further improved model accuracy. Additionally, models are susceptible to biases present in historical data.

**5.3 Future Work**

Future research should focus on incorporating additional data sources, such as student behavioral data and feedback, to improve model performance. Integrating AI-based recommendation systems could further enhance the effectiveness of recruitment campaigns and student engagement strategies.

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