ORIGINAL RESEARCH ARTICLE

Modelling business intelligence technologies framework for analyzing academic performance from learning management systems (LMS)

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ABSTRACT

Background: Learning analytics (LA) has been utilized to measure, collect, analyze, and report data regarding learners and their contexts, with the aim of understanding and optimizing the learning process. However, most universities having difficulties in identifying students' academic performance and weaknesses in each subject throughout every semester. **Methods:** Therefore, to address this issue effectively, the integration of result in learning management systems (LMS) with business intelligence (BI) has been proposed. In this case study, power BI tools are used in Universiti Sultan Zainal Abidin (UniSZA) LMS platform known as knowledge and eLearning integrated platform (KeLIP) to analyze student performance. The three-layer business intelligence framework is applied, data source layer, data analytics layer and presentation layer. **Results:** The successful implementation of the integrated LA system with business intelligence tools yielded valuable insights into students' academic performance, facilitating informed decision-making within the academic environment. **Conclusions:** In conclusion, this system will assist lecturers in guiding learners' academic progress and provide them with da-ta-driven insights into their students' performance each semester, enabling learners to enhance their academic achievements as well as their involvement in co-curricular activities. Furthermore, the integration of LA will contribute to optimizing the learning system, teaching methods, and educational management in this new era of education.

Keywords: learning analytics (LA); learning management systems (LMS); business intelligence (BI)

1. Introduction

Learning analytics (LA) has evolved as a strong tool in the area of education, allowing educators to monitor, gather, analyze, and report data about their students and their learning environments. Data-driven insights provide great opportunity to analyze and optimize the learning process. Throughout each semester, professors at Universiti Sultan Zainal Abidin (UniSZA) have obstacles in effectively assessing students' academic performance and finding areas of weakness in various topics. This limits the capacity to give students with tailored assistance and interventions to improve their learning results.

Integration of LA with business intelligence (BI) has been offered as a possible way to overcome these difficulties. Educators can gain valuable insights into students' academic performance, identify patterns and trends, and make data-driven decisions to improve the

learning experience by combining the analytical capabilities of LA with the data processing and visualization capabilities of BI tools.

The objective of this study is to investigate and develop a LA system that leverages data assessment from the knowledge and eLearning integrated platform (KeLIP) using power BI tools. KeLIP serves as the primary source of data, providing comprehensive information about learners and their academic contexts. By integrating BI techniques, the study aims to harmonize and analyze the data from KeLIP to generate actionable recommendations for educators.

Thus, this paper focuses on the modeling and implementation of the LA system within the KeLIP environment. By empowering lecturers with data-driven insights into students' performance, the system aims to guide and support academic progress effectively. Additionally, the integration of LA with KeLIP and BI techniques has broader implications for educational management.

Subsequently, by bridging the gap between data analysis and educational practice, this study aims to contribute to the advancement of LA in the context of UniSZA. The combination of KeLIP and BI approaches opens up the possibility of harnessing the power of data analytics for evidence-based decision-making in education. Finally, the goal of this study is to improve academic achievement, increase student participation, and propel educational greatness in the digital age.

2. Literature review

2.1. Business intelligence

Advancements in data visualization techniques have been a prominent area of re-search within the BI domain. Interactive dashboards and visual analytics tools have gained substantial attention, allowing users to explore and understand complex datasets more effectively. Business intelligence plays a pivotal role in an inevitable decision support system that enables the enterprise to perform analysis on data and throughout the process of business[1]. Moreover, the integration of artificial intelligence (AI) and machine learning algorithms has shown promising results in BI applications. For instance, the work of Plazas et al.[2] proposes a novel conceptual data model based on UML profiles and model-driven architecture (MDA) for modeling and implementing IoT-based BI applications. The aim is to provide highly readable data models of IoT, which are also compatible with traditional BI data models. Furthermore, it could help in the implementation process of the IoT subsystem through automatic code generation.

William et al.[3] provides insights into developing a decision model to support successful BI implementation. The field of business intelligence (BI) has witnessed significant growth and development in recent years, with researchers exploring various emerging topics and methodologies. In addition, a study result by Ahmad et al.[4] contributes to the success of costly BI system projects and will motivate the industry experts to potentially assign investments for the BI projects in the developing countries to sustain in the competitive markets.

BI is also used for university talent to prepare to industrial requirements and needs. A work by Aziz et al.[5] using secondary data, mainly from the Malaysia digital economy blueprint, and Malaysia national policy on industry 4.0, provide an overall landscape of information, communication & technology (ICT) talents in Malaysia. They propose a process-based framework to bridge the gap between ICT demand and supply by using business intelligence technologies.

2.2. Learning analytics (LA)

In the digital age, the widespread adoption of technology in education has generated vast amounts of data related to student learning. LA emerges as a powerful toolset that can unlock the potential of this data,

transforming it into actionable insights to support evidence-based decision-making and improve educational outcomes. Combining educational theory, statistical analysis, and machine learning algorithms, LA enables educators and institutions to gain valuable insights into student behaviors, preferences, and performance. The case study by Moscoso-Zea et al.[6] demonstrates a hybrid information infrastructure for BI and analytics based on an Educational Data warehouse (EDW) and an enterprise architecture (EA) repository that allows the digitization of knowledge and empowers the visualization and the analysis of dissimilar organizational components as people, processes, and technology. In other works, Cruz et al.[7] examine the benefits of the BI data analysis to the educational sector including academic advising, tutoring, scholarships, social service and professional practices, graduates, graduates, academic achievement, dropouts, income, among many others. With this, a broad line of investigation of business intelligence in the educational context with the application of emerging technologies for data analysis is envisioned.

Nonetheless, Yang et al.[8], conducted a systematic review to examine the application of LA in massive open online courses (MOOCs) to improve learning engagement. In order to improve the student's learning outcomes and engagement in programming courses, this study applied LA to the proposed massive online open courses (MOOCs) enabled collaborative programming course. Through the proposed learning activity, instructors receive a monthly report that explains which students are at risk and in need of timely intervention. This study conducted an experiment to evaluate the effectiveness of the proposed learning activity. Students in the experimental group received learning interventions from an instructor according to the result of LA, and students in the control group received interventions according to the instructor's observation. The data for this study were collected over 10 weeks at a university in Taiwan.

3. Materials and method

Agile development, with its iterative and incremental approach, has emerged as the best strategy for this research. This technique combines incremental and iterative processes, with the product being released in continuous cycles and then tested and improved after each iteration.

Agile-based products are built by breaking the whole production process into stages or break tasks into smaller iterations, as shown in **Figure 1**, allowing for faster change execution and deployment. Agile-based solutions, in contrast to the waterfall paradigm, do not require defined deployment downtime times. The six phases of agile development are requirements, design, development, testing, deployment, and review in this context. Agile allows development teams to prevent product faults by focusing on particular stages without being bogged down by other or earlier activities, resulting in greater development-process efficiency and flexibility.

Figure 1. Agile model.

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Furthermore, as shown in **Figure 2**, the suggested framework for this study is divided into three data source layers, the data analytics layer, and the presentation layer.

To begin transferring data from excel to MySQL, first convert the data from KeLIP, which is in excel format. This exported data is read and connected to the MySQL database using a data integration tool or computer languages such as Python or R. To ensure a successful import, tables in MySQL that correspond to the structure of the data being imported must be built. SQL commands or a data integration tool may be used to insert data into these MySQL tables.

Figure 2. Framework.

After the data is put into MySQL, it is transformed and loaded into the data warehouse. This entails conducting data cleansing and transformation procedures on the obtained data. To extract the altered data from MySQL, an extract, transform, load (ETL) tool or programming language such as SQL is used. The converted data is then placed into a separate data warehouse that is designed exclusively for reporting and analysis. It's worth mentioning that the data warehouse may utilize a different database technology than MySQL, such as SQL server or oracle.

The creation of an OLAP cube is a critical step in the data warehousing process. The OLAP cube is created within the data warehouse and functions as a multidimensional representation of the data, allowing for rapid analytical queries. Dimensions (such as time, product, and location) and metrics (such as sales and revenue) are established within the OLAP cube during this step. To generate the OLAP cube based on the required structure, specialized tools such as SQL server analysis services or oracle OLAP are utilized.

To leverage the analytical capabilities of the OLAP cube, a report engine tool is connected to it. This report engine tool that has been used is Microsoft power BI. By connecting to the OLAP cube, users gain access to its multidimensional data for designing and building reports, dashboards, and visualizations. The report engine tool provides a range of features that allow users to interact with and analyze the data effectively. This includes filtering, slicing, drilling down/up, and aggregating data at different levels.

By moving data from excel to MySQL, a data warehouse, an OLAP cube, and eventually using a report engine product like Microsoft power BI, the professor may speed up their data analysis and reporting processes. Universities may make use of the multidimensional analysis provided by OLAP cubes by extracting, processing, and putting the data into the report engine tool to create meaningful reports and visualizations.

This thorough approach gives decision-makers useful data that they may use to pinpoint pupils' academic progress and areas for improvement throughout each semester.

4. Result and discussion

This section describes the modelling business intelligence technologies framework for analyzing academic performance from learning management systems (LMS) results, following the specifications outlined in this study. The objective is to provide an interface that enhances user-friendliness and facilitates the utilization of the system.

4.1. Main page

Administrators are greeted with a dashboard overview on the main page, which includes information about LA, academic choices, the lecturer, view source, admin profile, contact, and log-out buttons. This summary gives a concise and thorough explanation of the current main page in **Figure 3**.
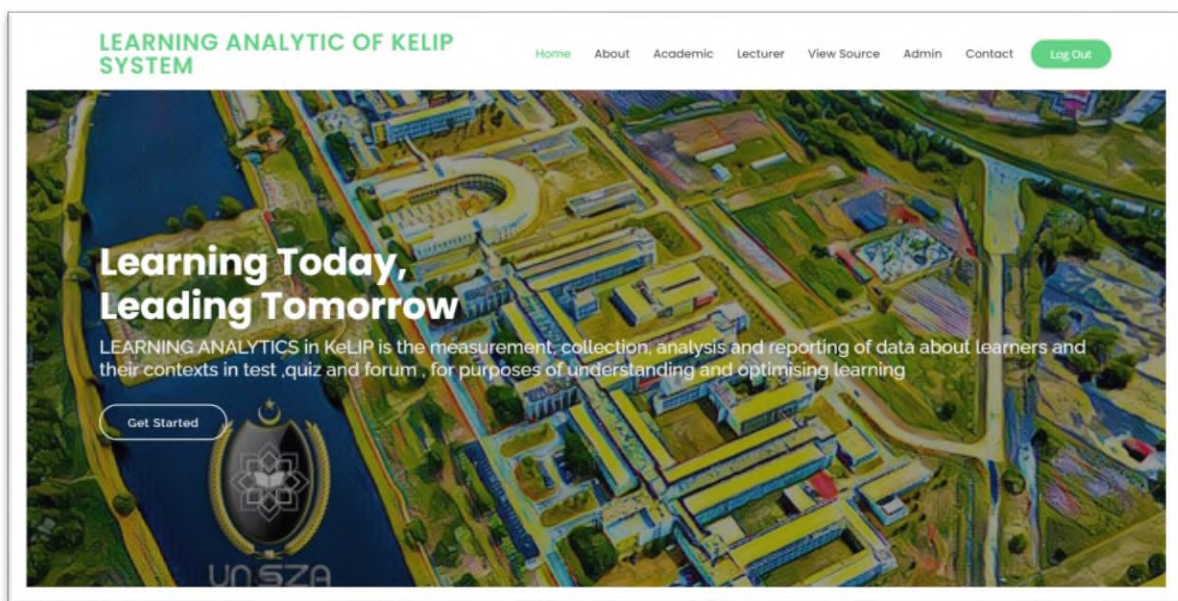

Figure 3. Main page.

4.2. View source

In the "view source" section shown in **Figure 4**, there are two important components: "insert data" and "view data". The "view data" feature is specifically integrated with Microsoft power BI, a robust business intelligence tool. It allows administrators to access and visualize the data that has been published through the data source connected to MySQL.

By leveraging the "view data" functionality, administrators can gain valuable insights and extract meaningful information from the dataset from KeLIP that was stored in the MySQL database. This integration with power BI empowers them to create interactive reports, dashboards, and visualizations that effectively communicate the data-driven findings to the stakeholders of the academic journal.
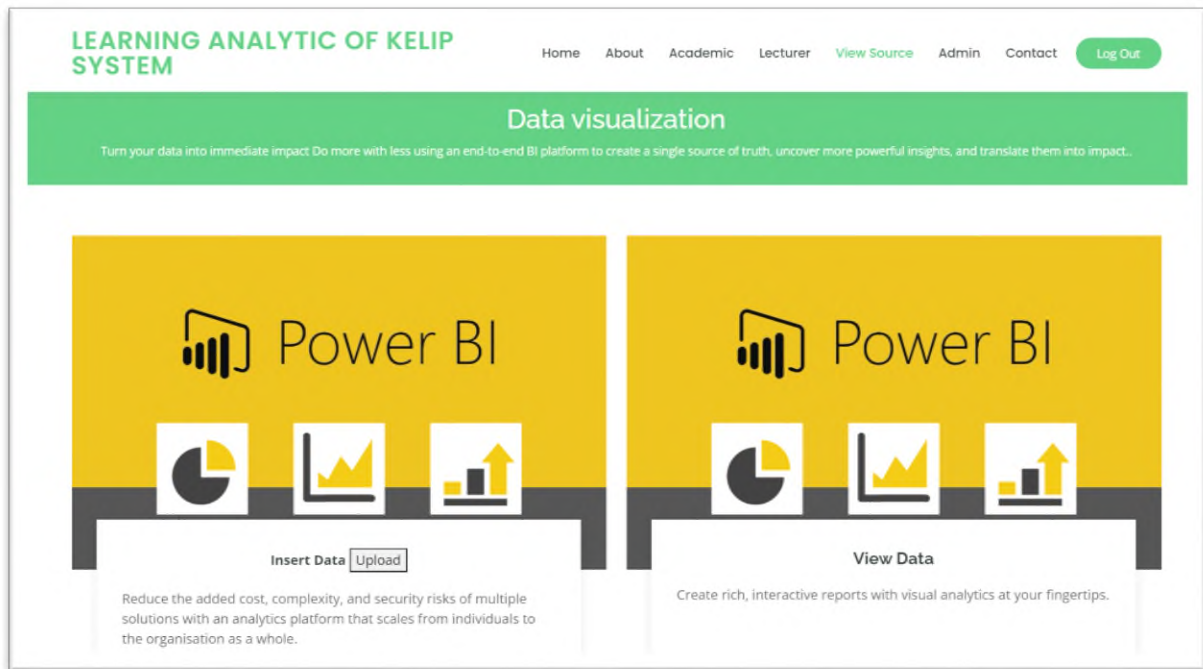
Figure 4. View source.

4.3. Power BI report

The power BI report, as depicted in **Figure 5**, offers a range of possibilities and actions for users. Users can apply filters to focus on specific subsets of data from the KeLIP dataset. These filters can be based on different dimensions, periods, or other relevant criteria.

The report provides visually appealing and informative representations of data through various chart types, graphs, tables, and maps. These visualizations facilitate a better understanding of trends, patterns, and relationships within the data. By leveraging these features, users can effectively communicate complex information and make data-driven decisions.

Also, **Figure 5** illustrates the number of exam evaluations, quiz scores, and forum marks associated with each subject taken by students. Furthermore, the report incorporates the students' names, email addresses, and matriculation numbers. As a result, both lecturers and students have the ability to conveniently access and filter the assessments based on specific students, as well as sort the tests, forums, and quizzes by subject.

As a result, with the help of this report, lecturers will be able to effectively guide students in their academic progress and gain valuable data-driven insights into their performance throughout each semester. This will empower students to improve their academic achievements and actively engage in co-curricular activities, ultimately enhancing their overall educational experience.
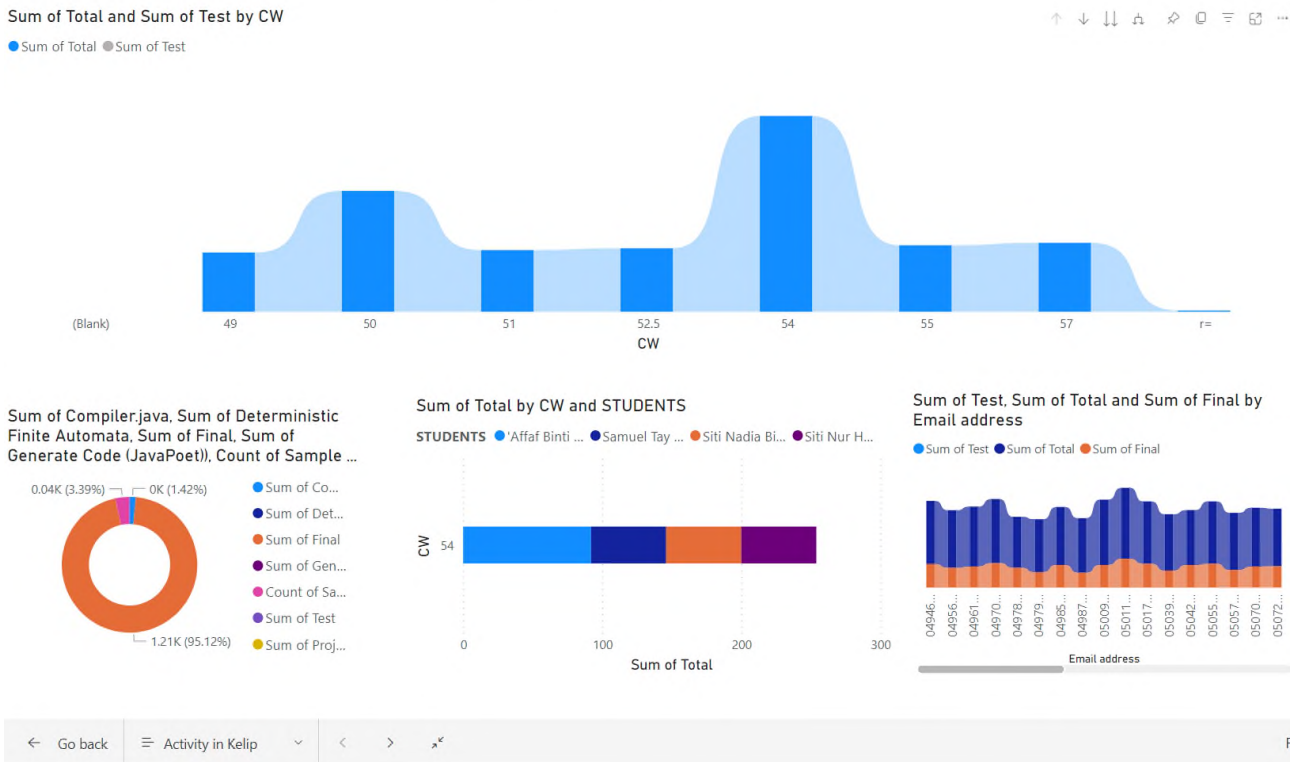
Figure 5. Dashboard page.

5. Conclusions

In summary, the integration of LA and BI in the knowledge and eLearning integrated platform (KeLIP) at UniSZA offers a solution to the challenges faced by universities in understanding and optimizing the learning process. By utilizing power BI tools and a three-layer BI framework, this study demonstrates how data analysis can provide valuable insights into student performance and academic progress. The findings highlight that integrating LA and BI in KeLIP enables lecturers to identify students' academic strengths and weaknesses in each subject throughout the semester. This empowers lecturers to provide personalized guidance and support, leading to enhanced academic achievements and engagement in co-curricular activities. Moreover, this integration contributes to optimizing the learning system, teaching methods, and educational management. By leveraging data analytics, educational institutions can gain a deeper understanding of the learning process, implement evidence-based strategies, and foster a data-driven educational environment that promotes continuous improvement and personalized learning experiences. This study has practical implications for educational institutions seeking to improve student success and educational management. By embracing LA and BI, universities can develop data-driven strategies, identify at-risk students, and implement targeted interventions.

Future research could explore the long-term impact, scalability, and sustainability of integrating LA and BI in educational settings. Additionally, investigating the effectiveness of specific interventions based on data-driven insights would contribute to further advancements in this field. Overall, the integration of LA and BI in KeLIP provides a valuable framework for enhancing the learning experience and achieving improved outcomes for students in the digital era of education.

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Author contributions

Funding

Software

Platform: Windows or Unix or Linux, Database: MySQL, Microsoft Excel, Business Intelligence Tools: Microsoft Power BI, Software Platform: C++ or Visual Studio Code, Web Server: Xampp Web Server.

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Conflict of interest

The authors declare no conflict of interest.

Abbreviation

BI, Business Intelligence; KeLIP, Knowledge and eLearning Integrated Platform; LA, Learning Analytics; LMS, Learning Management Systems; UniSZA, Universiti Sultan Zainal Abidin.

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