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Research Article

Implementation of Business Intelligence Technologies of Course Learning Outcomes based on Multidimensional Model Approaches

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ABSTRACT

Business Intelligence (BI) technologies offer intuitive insights and advanced analytical capabilities by transforming raw data from integrated sources into actionable knowledge. In the context of higher education, where institutions face heightened competition, dwindling public funding, and increased accountability, BI serves as a pivotal tool for data-driven decision-making. This paper addresses the problem of optimizing Course Learning Outcomes (CLOs) by implementing BI technologies. Our objectives are to integrate CLO data into a multidimensional model, apply BI tools for CLO analysis, and evaluate how BI can enhance CLO performance in higher education institutions (HEIs). We propose the Intelligence Course Learning Outcomes Platform (ICLOP) as a solution, utilizing BI technologies to generate efficient student data and performance metrics. The case study involving students from Universiti Sultan Zainal Abidin (UniSZA), Malaysia, demonstrates that BI can significantly improve enrolment management, resource allocation, and student success. The findings conclude that BI tools provide an effective means to enhance CLOs, offering a robust framework for improving educational outcomes and institutional efficiency, highlighting the transformative potential of BI in the academic sector.

Keywords: Business Intelligence, Multidimensional Model, Course Learning Outcomes, ICLOP, Higher Education Institutions

1) INTRODUCTION:

Business Intelligence (BI) offers an intuitive perception of raw data accessed from an integrated data source (Data warehouse) hub with a wide range of analytical capabilities. A distinctive collection of BI tools transforms accessed data into interesting information and then into knowledge, these knowledge are usually displayed to business managers in an attractive interface represented by graphs, charts, pies, tables, geospatial maps, and other statistical diagrams. BI tools aside from data visualization, serve as a crucial intermediary between raw data and informed decision-making. It includes integrated advanced analytics, reporting, and data integration capabilities, forming the backbone of intelligent decision support systems.

The higher education landscape is undergoing a significant transformation. Heightened competition for students, dwindling public funding, and a heightened emphasis on accountability drive institutions toward a data-driven decision-making model. Business intelligence (BI) emerges as a powerful tool in this context, offering a comprehensive set of technologies and processes for transforming raw institutional data into actionable insights. By leveraging BI, higher education institutions (HEIs) can optimize internal operations, allocate resources more effectively, and ultimately enhance student success. The concept of integration BI in Education refers as Educational Intelligence (EI). It has been proposed by Aziz et al. [1] and elaborated in more detail in Meng Chen [2] thesis, titled

"Applying BI in higher education sector: conceptual models and users acceptance" from the University of Bedfordshire, United Kingdom.

A growing body of research highlights the transformative potential of BI in HEIs. Studies have demonstrated its effectiveness in areas such as:

- **Enrollment management:** BI can be used to analyze student demographics, recruitment trends, and retention patterns, enabling institutions to develop targeted outreach strategies and improve overall enrollment [3]
- **Resource allocation:** By analyzing faculty workload, student demand for courses, and program performance metrics, BI empowers institutions to allocate resources more strategically, ensuring faculty expertise aligns with student needs.
- **Student success:** BI allows institutions to track student performance metrics, identify at-risk students early, and develop targeted interventions to improve graduation rates.

Conversely, Course Learning Outcomes (CLOs) play a vital role in shaping students' learning journey. They serve as guiding lights, pointing students toward the knowledge, skills, and competencies they should acquire by the end of a course. Crafting CLOs is a collaborative effort involving educators, curriculum designers, and stakeholders. Together, they distill the essence of the course into clear, actionable statements that encapsulate both the subject matter and broader educational objectives. CLOs provide a roadmap for students, offering clarity and direction in their academic endeavors. With clearly defined outcomes, students can track their progress, identify areas for improvement, and take charge of their learning.

Therefore, the paper highlighted how to analyse CLOs by implementing BI technologies. In this project, students from Faculty of Informatics & Computing, Universiti Zainal Abidin (UniSZA), Malaysia, are used for the case study. UniSZA is one of the public universities in Malaysia, and it has more than 20,000 students. The objectives of the paper are:

- To integrate CLO data into a multidimensional model design
- To implement BI technologies for CLO data
- To evaluate how BI may help HEIs to increase their CLO performances by providing an efficient way to generate student data and performance.

We propose an Intelligence Course Learning Outcomes Platform (ICLOP) platform to integrate BI technologies to achieve the objectives.

2) PREVIOUS WORKS:

A growing body of research highlights the positive impact of Business Intelligence (BI) in Higher Education Institutions (HEIs). Studies demonstrate its effectiveness in areas like enrollment management, resource allocation, and student success. BI empowers HEIs to analyze student trends, optimize resource allocation based on faculty workload and program performance, and identify at-risk students for early intervention. Additionally, BI allows for informed strategic planning by analyzing trends and assessing the effectiveness of current initiatives [4].

However, research also identifies challenges associated with BI implementation in HEIs. These challenges include complex organizational structures with departmental autonomy, leading to data silos and resistance to change. Additionally, challenges associated with implementing Big Data in higher education include the need for specialized skills and resources and institutional support [5]. Also, BI in higher education faces challenges due to budget constraints and the need for a big data platform architecture that offers cost, expandability, and scalability [6].

Furthermore, data quality and integration issues arise due to inconsistent data formats, siloed storage systems, and a lack of centralized data governance frameworks. Data quality is a critical issue in data warehouse construction and utilization, leading to high costs, loss in the supply chain, and degraded customer relationship management. Data quality problems in data warehouse projects include missing values, duplicates, and integrity constraints, leading to wrong conclusions [7]. Security and privacy concerns regarding sensitive student data also require robust security frameworks.

Recent research delves deeper into overcoming these challenges. Successful business intelligence system implementation in higher education institutions requires considering key factors to increase the chances of success and reduce failure rates. Success factors of BI implementation in higher education institutions include proper planning, addressing risks, and overcoming challenges [8].

Studies by Clark et al. [9] pointed out five critical success factors for implementing learning analytics in higher education: strategy and policy, information technological readiness, performance and impact evaluation, people's skills and expertise, and data quality.

Several studies also highlight the need for centralized data governance and quality management processes. Effective change management strategies and user training programs are crucial for gaining buy-in from stakeholders and ensuring user adoption of BI tools.

Another study by Abduldaem and Gravell [10] concludes that successfully adopting BI performance dashboards in higher education can improve performance and decision-making processes, but understanding the factors and metrics that determine success is required. As the research area is complex and multidimensional, the work proposes that the triangulation method has been applied to support a rich set of data, a mixture of a qualitative approach to gather insights into potential factors and a quantitative approach to confirm these factors.

In conclusion, BI offers significant potential for HEIs, but navigating the implementation process requires careful consideration of the identified challenges. By adopting best practices and fostering a data-driven culture, HEIs can leverage BI to optimize operations, improve resource allocation, and ultimately enhance student success.

3) METHODOLOGY:

(a) ICLOP Frameworks

The system implemented standard three layer of BI frameworks. Figure 1 illustrated ICLOP framework.

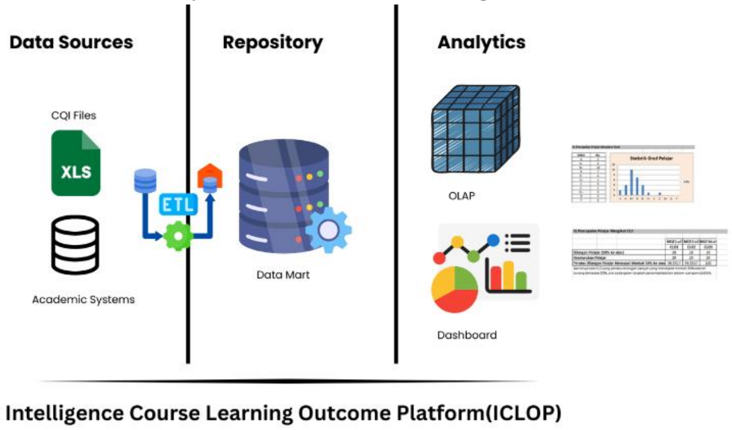

Figure 1 ICLOP Framework

Data sources were extracted from CQI files. The information will be stored in the data staging area for preprocessing, transformation and enrichment. The source files contain CQI information, as shown in figure 2. The process of extraction using Extract, Transform and Load (ETL) tools.

Nc	Matr	CLO1	CLO2	CLO3	TOTAL	CW	FINAL	TOTAL	Grade	Point	Midterm Exam (C4, Short Essay)	Project (A4, Project Presentation)	Assigment (P3, Report)	Assigment (P3, Report)	Final Exam (C4, Short Essay)	
		30.00	60.00	10.00	100.(	60.00	40.00	100.0(	A-	0·	20.0(	10.00	15.00	15.00	40.00	
1	071890	26	37.6	9	73	49.4	23.2	73	B+	3.33	14.4	9	13	13	23.2	S
2	072001	21	31.2	7	60	41.2	18	60	B-	2.67	13.2	7	11	10	18	S
3	072030	21	38.8	8	68	39.8	28	68	B	3	10.8	8	11	10	28	S
4	072104	21	28	7	56	34.4	21.6	56	C+	2.33	6.4	7	11	10	21.6	S
5	072146	26	44.4	9	80	51.4	28	80	A	4	16.4	9	13	13	28	S
6	072167	23	48.8	9	81	48.8	32	81	A	4	16.8	9	12	11	32	S
7	072174	25	48.4	8	82	43.4	38	82	A	4	10.4	8	11	14	38	S
8	072199	27	40	9	76	47.2	28.8	76	A-	3.67	11.2	9	13	14	28.8	S
9	072362	26	47.2	9	83	53.8	28.4	83	A	4	18.8	9	13	13	28.4	S
10	072380	26	36.8	9	72	46.6	25.2	72	B+	3.33	11.6	9	13	13	25.2	S
11	072387	21	38.4	7	67	39.6	26.8	67	B	3	11.6	7	11	10	26.8	S
12	072483	28	48.8	9	86	51.8	34	86	A	4	14.8	9	14	14	34	S
13	072675	25	38.8	8	72	46.6	25.2	72	B+	3.33	13.6	8	14	11	25.2	S
14	072687	25	42	8	75	49.8	25.2	75	A-	3.67	16.8	8	14	11	25.2	S
15	072801	19	48.4	8	76	42.2	33.2	76	A-	3.67	15.2	8	10	9	33.2	S
16	072857	28	40	9	77	49.4	27.6	77	A-	3.67	12.4	9	14	14	27.6	S
17	072954	28	43.6	9	81	52.2	28.4	81	A	4	15.2	9	14	14	28.4	S
18	073033	23	32.4	9	65	45.2	19.2	65	B	3	13.2	9	12	11	19.2	S
19	073180	25	35.6	8	69	41.4	27.2	69	B	3	8.4	8	11	14	27.2	S
20	073206	23	43.2	9	76	46.8	28.4	76	A-	3.67	14.8	9	12	11	28.4	S

Figure 2 CQI files

CQI data will be integrated with existing information from academic databases. The information such as lecturer and subject information, student demographics, program information and others also populated to the staging area using

ETL tools. This study proposes a framework that aims to identify and explore the CSFs for implementing LA within the higher education sector by examining the viewpoints of higher education professionals.

(b) Multidimensional Model

The middle layer (repository) is called Data Warehousing (DW). DW is a critical component of BI systems, enabling organizations to store, retrieve, and analyze large amounts of historical data. Two primary models used in data warehousing are the multidimensional model and the relational model. Each model has distinct characteristics, advantages, and use cases, which are essential for understanding their applications in data warehousing. The multidimensional model, often associated with Online Analytical Processing (OLAP) systems, organizes data into a multidimensional structure known as a data cube. This model facilitates complex queries and data analysis, such as trend analysis, forecasting, data mining, and fast query response.

In DW, fact and dimension tables are fundamental components used to organize and contextualize data for efficient analysis. A fact table contains the core quantitative data (measures) such as sales amounts or quantities sold and foreign keys that link to dimension tables. Dimension tables store descriptive attributes like product names, categories, or dates, which provide context to the measures in the fact table. Together, these tables form a star or snowflake schema, enabling complex queries and analyses by allowing users to aggregate, filter, and explore data from various perspectives. Figure 3 shows design of ICLOP multidimensional model.

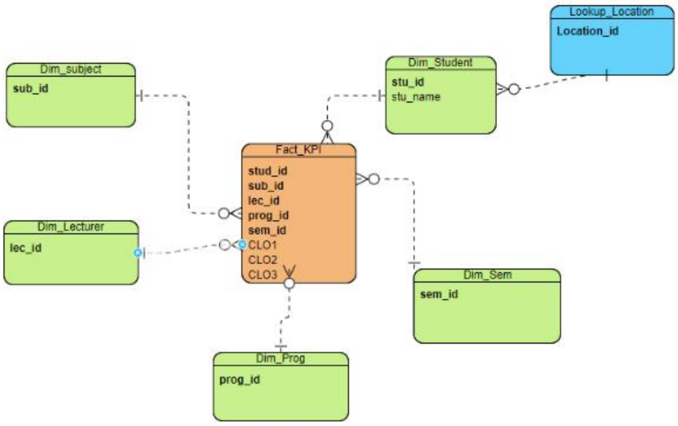

Figure 3 ICLOP multidimensional model

ICLOP multidimensional model contain one important fact tables known as Fact_KPI. In this table 3 CLO (1,2,3) is combine together for detail analysis. The dimension tables including student, subject, lecturer, program and semester are connected to fact table refer as star schema design. Thus, will helps creating fast performance queries with detail analysis (drill down, drill up) using BI tools. In addition, dimensions students link with location as look up tables creating snowflake design.

In general, the multidimensional model provides fast respond queries compared to relational model. Fact in the middle answer queries analysis such as CLO performance based on student, program, semester and demographic information. The design can be populated in BI tools feature known as Online Analytical Processing (OLAP), support multidimensional queries and drill-down, drill-up analysis.

(c) Extract, Load, Process

ETL is one of the most vital operations that consume most of the time in DW development. The requirement for data conversion consumes about 70-80% of the time used to build, thus needing special consideration while constructing a DW. However, this process is achieved with the aid of sophisticated ETL tools specifically designed for such purpose. Moreover, there are various ETL tools of different forms and purposes, commercial and open source.

Our work uses open-source ETL tools known as Talend Open Studio (TOS). TOS offers a variety of tools designed to streamline the organization of data across multiple file formats, making it an invaluable resource for direct mail marketers. This platform proves especially beneficial when managing diverse datasets, such as spreadsheets, requiring normalization and conversion into a standardized format suitable for centralized database management. Among its features, TOS facilitates the automatic identification of data types and potential errors, enhancing efficiency and accuracy in data preparation processes. Figure 4 shows an example of TOS mapping from source to target databases.

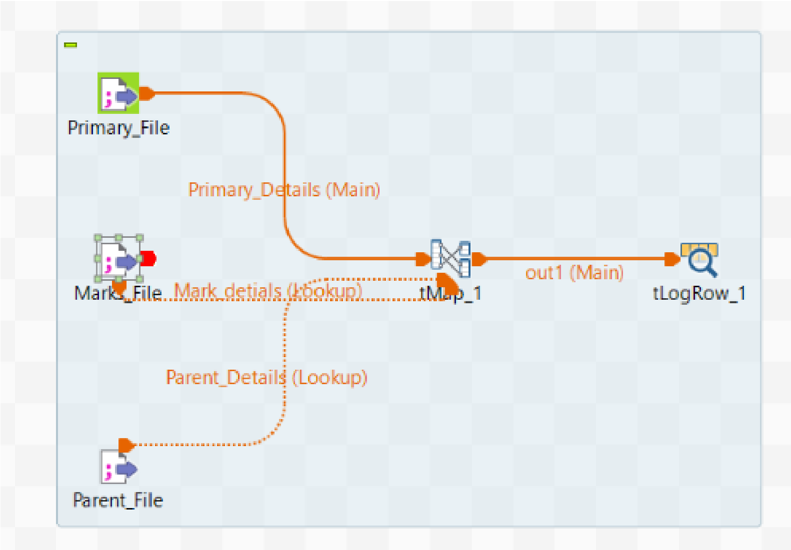

Figure 4 Example of ETL Process

(d) ICLOP Platform

The development of ICLOP aims to provide an integrated platform for supporting the CLO process. It includes providing a single portal platform that the front end uses to supply and analyze data, and the back end runs the ETL and analysis process (ICLOP engine). Figure 5 shows the Context Diagram (CD) for ICLOP. Management will have to insert their details to log into the system. Then, they can view the lecturers' details and reports of each course uploaded or created by the lecturer.

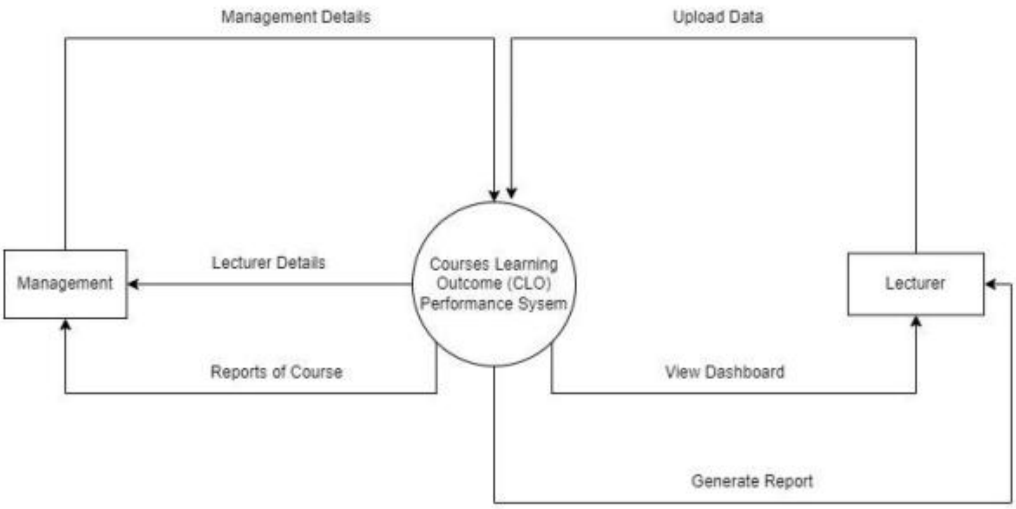

Figure 5 Context Diagram

Figure 6 show the Data Flow Diagram (DFD) structure. It involves five processes. Lecturers may select how or what data to view by going to Manage Dashboard. The lecturer will upload the students' CQI details (source files). The ETL process will automatically populate data and integrate it with available data.

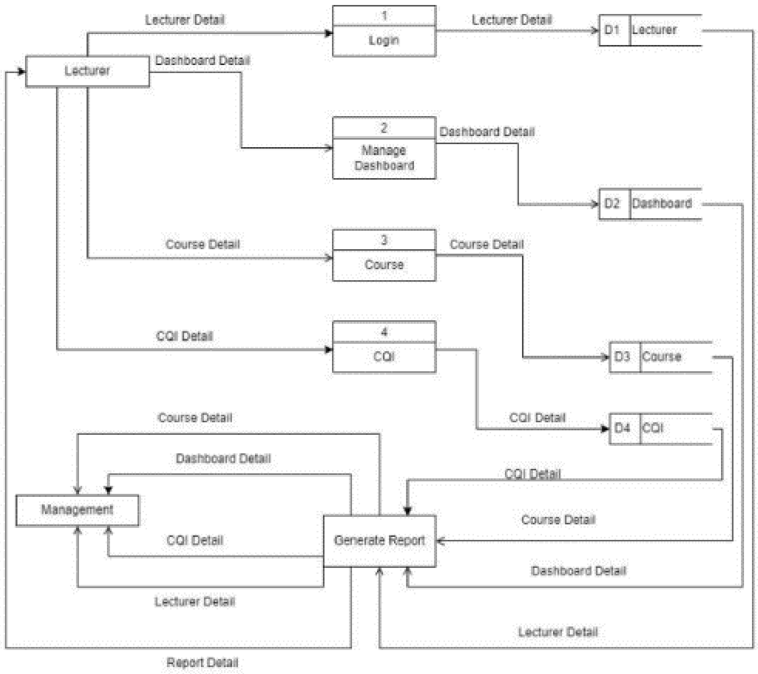

Figure 6 Data Flow Diagram (DFD)

4) RESULT:

ICLOP applies an interactive interface and is user-friendly. Figure 7 shows the platform's landing pages. Users can start registering or login to the systems.

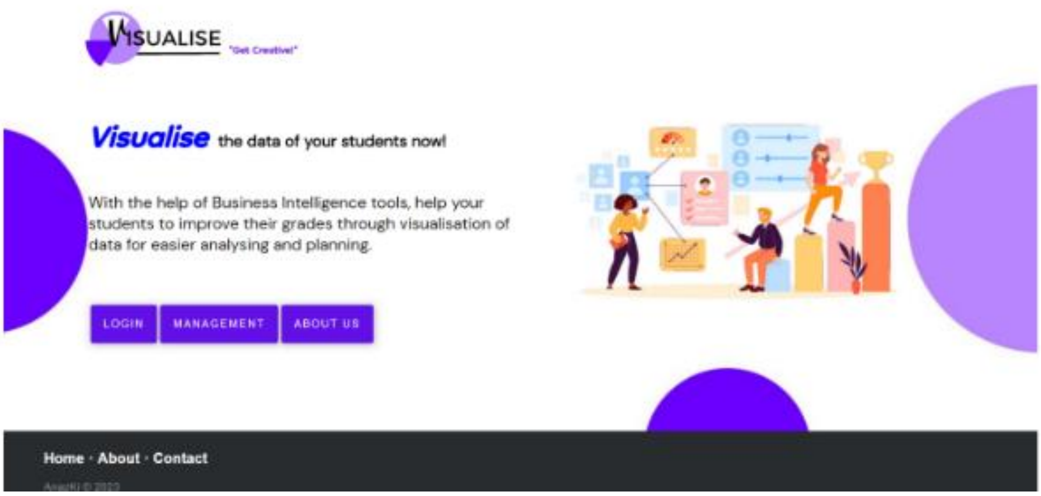

Figure 7 ICLOP landing page

Next, to upload CQI information, a simple GUI interface is prepared as shown in figure 8. After choosing a source file, the import button will be clicked and the ICLOP back-end engine populated data in the database as shown in figure 9.

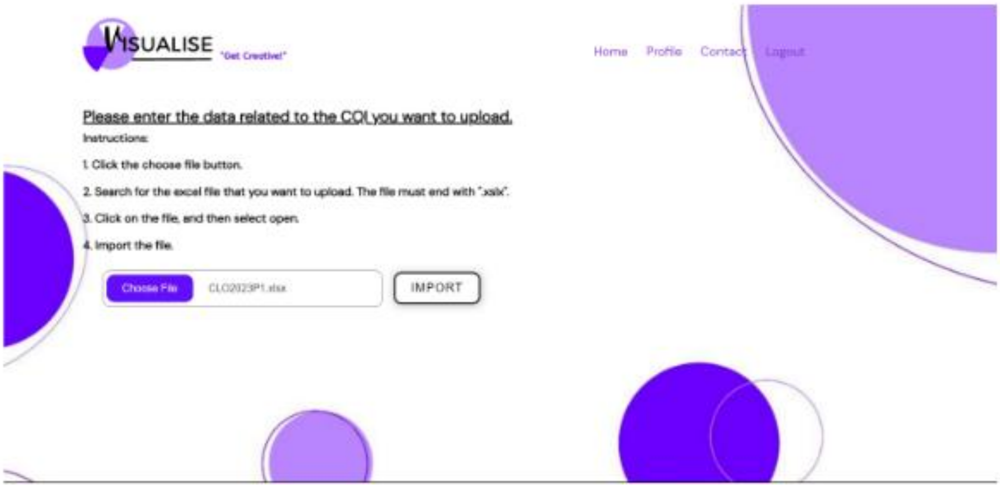

Figure 8 Uploading CQI

	program_id	subject_id	semester	year	student_id	clo1	clo2	clo3	total_1	cw	final	total_2	grade
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B01	14	53	7	75	47	27	75	A-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B02	15	54	7	76	47	29	76	A-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B03	15	50	7	72	50	22	72	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B04	15	37	9	62	49	12	62	B-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B05	12	44	7	64	42	21	64	B-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B06	11	50	9	70	48	22	70	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B07	14	47	9	70	48	22	70	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B08	11	57	9	78	48	29	78	A-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B09	11	52	9	73	48	24	73	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B10	18	48	7	73	50	23	73	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B11	14	44	7	65	47	18	65	B
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B12	14	46	7	68	44	23	68	B
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B13	15	43	9	67	49	18	67	B
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B14	14	39	7	60	46	14	60	B-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B15	11	31	7	49	41	8	49	C-
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B16	9	42	7	58	44	14	58	C+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B17	16	47	7	70	46	24	70	B+
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B18	15	43	7	66	47	18	66	B
Edit Copy Delete	ISMSKPP	CSD33503	6	2023	B19	14	48	7	70	47	22	70	B+

Console

Figure 9 Data in Database

Ultimately, the BI engine will generate the analysis based on the proposed multidimensional model design as shown in Fig. 10. Users can choose to view their data according to dimensions and facts available. For example, analysis of CQI for five semesters based on the program. As for management, they can analyse not only student result but also lecturers' performance which help give proper feedback to lecturers. It will help improve the teaching and learning process for both parties.

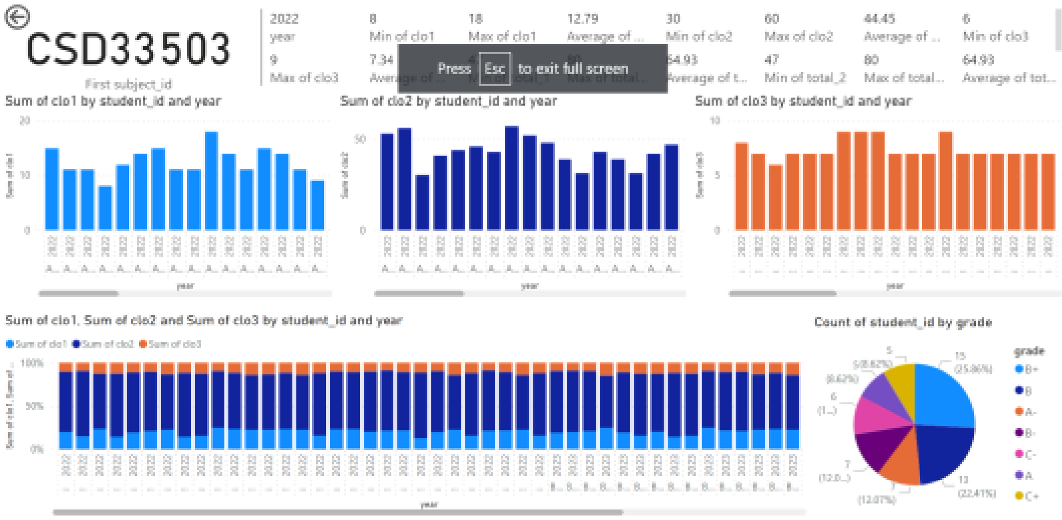

Figure 10 ICLOP Dashboard

5) CONCLUSION AND FUTURE WORKS:

BI has demonstrated its efficacy as a transformative tool in various sectors, including higher education. This paper underscores the potential of BI to revolutionize the management and enhancement of CLO HEIs. By integrating BI tools into the analysis of CLOs, institutions can gain valuable insights into student performance and curriculum effectiveness. This approach aligns with the broader trend of data-driven decision-making in education, aiming to optimize resource allocation, improve student success rates, and enhance overall institutional performance.

The case study involving students from the Faculty of Informatics & Computing at Universiti Zainal Abidin (UniSZA), Malaysia, exemplifies the practical application of BI technologies in educational settings. The development of the Intelligence Course Learning Outcomes Platform (ICLOP) serves as a prototype for integrating BI into CLO analysis. This platform enables data visualization through various analytical tools, providing educators and administrators with actionable insights to refine educational strategies and interventions.

While this study has laid a solid foundation for the integration of BI in analyzing CLOs, several avenues for future research and development remain:

i. **Scalability and Generalizability:**
Future research should focus on the scalability of ICLOP across different faculties and institutions. By conducting comparative studies across diverse educational contexts, researchers can validate the generalizability of the platform and its methodologies.

ii. **Advanced Analytics and Predictive Modeling:**
Incorporating advanced analytics, such as machine learning and predictive modeling, can further enhance the platform's ability to identify at-risk students and forecast academic outcomes. This will enable more proactive and tailored interventions.

iii. **User Acceptance and Training:**
Investigating the factors that influence user acceptance among educators and administrators is crucial for successful implementation. Developing comprehensive training programs and support systems can facilitate the adoption of BI tools.

iv. **Integration with Existing Educational Technologies:**
Exploring ways to seamlessly integrate ICLOP with existing educational technologies, such as Learning Management Systems (LMS) and Student Information Systems (SIS), will streamline data flows and enhance the usability of the platform.

6) ACKNOWLEDGEMENT:

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