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Academic Business Intelligence: Can a Small and Medium-sized University Afford to Build and Deploy it within Limited Resources?

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Abstract

Background: For many years, researches on Business Intelligence (BI) development have been popular in primary industry (trading, telecommunication, and manufacturing). Nevertheless, the academic sector has not been the primary beneficiary. This lack of practices also means there has been limited knowledge relating to the development of BI in the academic sector
Objective: This study presents the development of an Academic Business Intelligence (ABI). Taking an actual ABI development project in a small and medium-sized university in Indonesia context, it specifically sought to understand as to why the university needed an ABI and how it could be developed within the limited resources (funding, IT infrastructure and expertise).
Methods: Following the business intelligence development roadmap, this study was able to develop an ABI as an attempt to provide a smart way for generating valuable information from scattered data interactively. It also successfully deployed the newly developed ABI into the existing IT legacy and then run a series of pilot testing involving the intended users.
Results: The results showed the acceptance rate was high (87.25%) and suggested that the system found to be usable for conducting students' performance assessment and decision making faster. In short, this study contributes to the growing body of BI development literature by providing empirical evidence on how to successfully develop a BI within the unique context of the academic sector.
Conclusion: Considering the findings, this study also draws practical recommendations and highlights a few limitations from which future study could address, especially when developing BI or similar ABI in particular.

I. INTRODUCTION

In the current ever-changing business environment, organizations have faced high demand to utilize their information assets to stay informed and survive in the competitive market. Nonetheless, as the organizations also grow and more data are generated, the process of getting the right information becomes increasingly uneasy and complex. Especially for organizations in major industries (e.g., manufacturing, telecommunication, and finance) which rely on the use of aggregated information for improving and optimizing decision-making process, it is important to develop a Business Intelligence (BI) system to make the required information immediately available and interactive. While there is no single generalized definition found in the literature, this paper refers BI as "*an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance*" [1].

Drawing from the definition above, BI is unlikely just a set of data-centric application which includes several database management systems, extraction tool software, and visualization interfaces. Rather, it can be seen to consist of methods, process, technologies, and tools to enable the collection and transformation of voluminous and scattered data into interactive information, actionable insights or useful knowledge which allow organizations to make a smarter business decision. While BI has gained its popularity since the 1990's, during the revolution of personal computer and visual methods, the trend towards BI development now is still continuing to progress [2]. Especially with the recent digital transformation such as the coming of Big Data technologies, cloud computing, IoT and machine learning, BI has later evolved to become a popular innovation of information services in the modern business landscape. All the mentioned above combined with the advancement of data analysis tools and

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more affordable internet connection have provided organizations in almost all sectors with the opportunity to develop and use BI for going beyond smart and entering intelligence era.

For many years, BI has been the interest of large organizations or companies. According to the recent report published by BI-survey [3]—the world's largest annual survey of BI software users—telecommunication, IT and retail are among top sectors that have used BI for many years. Surprisingly, of interesting findings from the survey are the increasing awareness and the need to use BI by the public sector and non-profit organizations continue to rise in the past few years. Nevertheless, those organizations especially the education sector still lag behind industrial organisations and larger enterprises in taking the initiative to develop and make use BI. A possible explanation for this might be that the education sector is usually under intense cost pressure and the limited budget for buying software other than academic-related applications including BI [4].

This lack of practices and experiences also means there has been limited knowledge existed in the literature relating to the development of the BI system in the academic sector. This, in particular, suggests that more and more studies which provide empirical evidence on the development of BI in the academic sector are needed. Therefore, the objective of this paper is to describe the details of an actual BI development project in an educational sector which is here and after known as Academic Business Intelligence (ABI). Taking the specific development process in The University of XYZ (pseudonym), this paper specifically aims at conducting the first comprehensive empirical study due to the lack of knowledge in this area. Furthermore, by using the actual case of an ABI development project, the empirical findings presented in this paper might also offer practitioners with insights and approaches they can use to develop an ABI or address the constraints and problems encountered during the process (e.g., limited fund, time and expertise).

The University was chosen as the case study because it is considered as a small and medium-sized university that fits with the objective of this research. Briefly, the university is a public-owned institution. It was established in 2001 and considered as a medium-sized university (enrollment range: 6,000-7,000 students annually). The university has been developed and employed an Academic Information System (AIS) since the last decade ago to serve the typical activities in a higher education ranging from admission, enrolment, alumni, graduate and other academic operations. Instead of the AIS, the university has also used a range of information systems for collecting and processing data such as payroll, asset management, finance, and human resources. While the university has employed various information systems, however, the database of each system and the systems were deployed independently.

One frequent and critical area in this university was that the board management needed to access and analyzed all the data generated by the AIS especially for assessing and generating a report about student academic performance. This was important as the top level management usually needed to make the decision promptly in response to results from student performance assessment. Examples included highlighting the subjects which most students failed, examine contributing factors and notified parents about students' performance. In addition, the university was also required to provide actual and precise information on the overall academic performance generated from various data sources as part of self-evaluation and external quality audit by the national accreditation board.

Nevertheless, the management very often had difficulties to aggregate and gain valuable information without the assistance from IT experts due to such scattered data sources. In addition, some of the data are transactional in nature which would grow the volume exponentially and likely added complexity, especially when dealing with analyzing a huge amount of data for supporting decision making and creating report immediately. Even if the management were able to gain timely information; however, the process might take longer than expected and the aggregated data might not be the updated one. This was because the current AIS and existing management information systems did not offer repository services or feature which stored useful data for decision making. Furthermore, developing for such a fully integrated system need a certain level of funding which was not current prioritize as a public medium-sized university. All the problems above, therefore, have highlighted the need for the university to develop an ABI which required less budget and time as well as expertise.

The rest of this paper is organized as follows. Section 2 reviews the literature on BI and ABI, in particular, to argue there is currently little research reporting the development of ABI. Section 3 summarizes the approach used in this research for guiding the development of ABI. Taking an actual case of an ABI development project in University XYZ, Section 4 then presents the outcomes of the development process using framework introduced in Section 3. Finally, Section 5 discusses the related conclusions, major contributions, and limitations as well as possible future research.

II. Literature Review

In this section, the literature reporting the development of BI is reviewed and analyzed. This includes examining how the existing BI systems have evolved over time based on the understanding of previous research. This section also synthesizes the literature on the development BI system used in various organizations to identify the area which is lack of attention. The results indicate while researches on the development of BI resulting solution in many areas such as trading, telecommunication, and manufacturing have been popular, however, the academic sector has not been the primary beneficiary as presented in the followings.

A. Development of BI Systems

One of the central discussions among researchers over the last decades in the BI literature is how to develop BI system. From a historical viewpoint, the term of BI was firstly coined by Richard Millar Devens in 1865 to describe how a banker sought to understand and use the information he had gathered from external sources to win the competition. Whereas, the development of BI system as it is understood today as a smart analytical tool, can be traced back in 1958 when an IBM scientists, Hans Peter Luhnan, described "*an automatic system…developed to disseminate information to the various sections of any industrial, scientific, or government organization*" and later referred as a *Business Intelligence System* [5]. This notable foresight on how a BI system could be designed had offered an overarching foundation for other scholars to develop similar systems. However, during this early time, little progress had been made in the subsequent years and much of BI development research was carried out by researchers with specialized expertise in database management. One notable example was Edgar Codd [6], who proposed a relational model for data storage as a revolutionary approach for managing fragmented data into disjoint and usable information.

Further review from the literature showed during the late of the 1980s or early 1990s especially with the advent of the relational model combined with the rapid innovation on storage systems for managing a large amount of data at that time, research on BI development had started gaining its popularity. During this decade, BI system was mainly developed to enable organizations systematically collect and analyze unstructured data from various external sources (e.g., markets, customers, suppliers and competitors) and later convert the data into information needed for decision-making activities [7] [8]. Therefore, early BI-development was mostly seen as a process of developing data-centralized with the capability of doing the analytical task and providing information interactively which were very much influenced by preceding Decision Support System (DSS) research area. In addition, much of the efforts undertaken by researchers and scholars at this time were about studying ways to develop BI systems through technological methods.

The next decade, the 2000s, the development of BI was extended to be more advanced which aims of turning and making sense information into useful knowledge to be used for various actions. It can be also noticed from this decade, BI was developed to be more simple, practical, easy to use, can be operated or used by all people within organization and even understood by those who are considered as technologically-adverse [9] [10] [11]. Therefore, despite technical aspects, another major research stream was around user-related aspects of BI-development including usability, interface design, ethical, security, personalization, and privacy features for better quality decisions [12] [13]. Notably, in this decade, the early understanding of BI-development from technology-viewpoint was extended to address those emerging issues of user aspects in the BI system. In addition, the research area of BI-development at this time was characterized as a multidimensional and holistic process to consist of people, process, analytical methods, and existing technologies rather than just data analytics under computer application.

Now coming to decade 2010 onwards, the recent information technology advancements such as cloud infrastructure, Internet of Thing (IoT), big data, mobile computing, and real-time services, have fuelled the continuous evolution of BI [14] [15] [16]. In the BI-development world, these changes have improved fundamentally the way hardware, software, analytical tool, and visualization, as well as, reporting can make up and transform BI system become even more sophisticated. For instance, the central idea of IoT which places sensors everywhere to capture real-time events and connected to the internet could make legacy BI more -ion based, smart, real-time and automated. Also, the cloud infrastructures combine with mobile computing will enable data analytics feature grown more approachable and at the same time increased in speed, security, scalability, and flexibility. Furthermore, the coming of Big data will possibly discover a new way to develop BI with adequate performance to gather and make use vast amount of data from outside organizations and has the promise to extend the ability to perfect data for decision making. This evident from the literature highlights BI-development in the future will be likely affected by the next major step in information technology advancement.

All the above review while showed the development of BI has had a historical connection to the advancement of IT; it is also evident that BI-development is increasingly depended on industry sectors. Review from the literature indicated that early BI-development was aimed mostly as a managerial tool at the company-wide level known as enterprise BI, but has later evolved to become available to support front-line workers keep day-to-day operations at maximum efficiency and monitor real-time performance (operational BI). In an example, UPS, a leading logistics and transportation company, developed an operational BI called ORION to help company collect daily vehicles performance and monitor its online map to reconfigure a driver's pickups and drop-offs in real time [17]. Using this operational BI, the company was able to save more than 8.4 million gallons of fuel by cutting 85 million miles off of daily routes. Other examples of operational BI-development include in environmental reporting [18], marketing [19] and Small business [20].

As more data is being collected and used to support different activities, the demand for using BI has been considered to be one of the most important needs for many organizations. This, in particular, has resulted in a wide-spread of BI-development initiatives in different industrial sectors as a way to address the need for gathering, analysing and utilizing business data. In other words, it can be noted that BI-development is likely seen to be shaped or influenced by different types of industry with varying needs. From the recent report, published by BI-survey [3], the top-3 industries area that has been long influencing BI-development can be attributed to being telecommunication, IT, and retail. While Marjamäki [2] found that industries which can be seen having most influence for BI-development were finance or banking, healthcare, supply chain or logistics.

Although the findings seem to be different, apparently, both surveys agree that in the last few years public sector is considered to be the industry-area influencing the BI-development. This notable finding can be explained by the fact that BI use in the public sector and related government agencies is spreading and gaining more interest. In addition, it is also important to note based on the surveys that BI-use is also on the rise in non-profit organizations especially educational institutions which triggered the need to develop BI. The next section, therefore, synthesises the existing studies relating to the development of BI in the education sector to highlight what is currently known as well the gap from which this research aims to address.

B. Development of BI Systems in Academic Sector

As introduced earlier, this study is aimed at describing the development of a BI system in the academic sector that is known as Academic Business Intelligence (ABI). There have been several studies calling for the importance of the development of systems or analytics tools for use in academia [21] [22]. This is due to the fact that recently education sector is also dealing with the massive growth of data which requires an advanced analytical process of voluminous data to support all activities of both operation and management of an academic institution [23].

At the main operation of education activity, there is a large volume of studies found in the literature investigating the design of ABI that aims to support students in learning activities. For instance, a number of authors [4] [24] [27] have described the development of ABI as an innovative way of teaching and pedagogies for especially learning related courses. In their studies, the authors showed how the existing learning or teaching approaches and theories such as Bloom's taxonomy, professional vision, and personalised learning can be adapted to design and develop ABIs. The authors especially indicated that the implementation of ABIs had improved students' involvement during teaching and made learning activities more engaging. Furthermore, Chen-Chiang [28] highlighted the need to continue to design various ABI tools to tackle the increased demand on the innovative teaching and learning and to prepare students with adequate skills for practice.

In another study, a growing body of literature has investigated the design and the development of an ABI in higher education as an opportunity to achieve operational excellence and efficiency. For example, some authors [29] [30] [31] found that the development of ABI has provided universities an efficient way to remove barriers in collecting, storing and analysing a wide range of both internal and external data sources for strategic aims and decision-making process faster. In the same vein, researchers [32] [33] also suggested that the development of ABI found to be crucial particularly for higher education seeking to respond to the growing need for 'big data' analytics and to get real-time insights of their performance promptly.

Review from the literature also found the development of ABI used for supporting higher education but not directly related to teaching and learning activities. For example, various studies exist in the literature reporting the design and development of ABI for particularly managing admission process [30], libraries [34] [35], behaviour patterns of students [36] and resources management [37]. As the BI research in academic sector is becoming increasingly popular, several recent studies have attempted to investigate the factors contributing to the readiness and successfulness of higher education in adopting ABI into their operations [38] as well as the impacts of implementing such system on its performance [39] [40] [41]. Further, to ensure the achievement of the potential benefits (e.g. managing large amount of data, monitoring real-time performance and enabling decision-making faster) researchers have offered various models, architectures and frameworks which could be used to guide the development of ABI in the academic environment [42] [43] [44].

Considering all of the evidence discussed above, it seems that BI study into the academic sector has gained its popularity. However, the recent reviews studies [21] [22] [23] suggested that more research is needed to help universities address the demand to enhancing the teaching and learning activities more effective and interactive. In addition, due to the heterogeneous nature of the academic sector which different characteristics, the findings of previous works were based on specific context, limiting generalisability and may not be applicable to other cases. This in particular highlights more studies are still needed and an opportunity for future study from which this research can make an important contribution by describing the ABI design development processes in a higher education context.

III. METHODS

As introduced earlier, the objective of this research was primarily to design and develop an ABI system. More specifically it aimed to address three main deliverable objectives which are to: identify and analyze ABI systems requirements in the context of opportunities for monitoring students progress and improving decision making in a higher education; develop and deploy a working prototype into an existing IT infrastructure to show a proof-of-concept of an ABI and finally identify shortcomings through series evaluation. Given the above objectives, this study, therefore adapted Business Intelligence Roadmap suggested by Moss and Atre [45], as cited in previous work [46], as an overarching development framework to achieve the expected outcomes. Fig. 1 below illustrated the framework and how it was applied in this study.

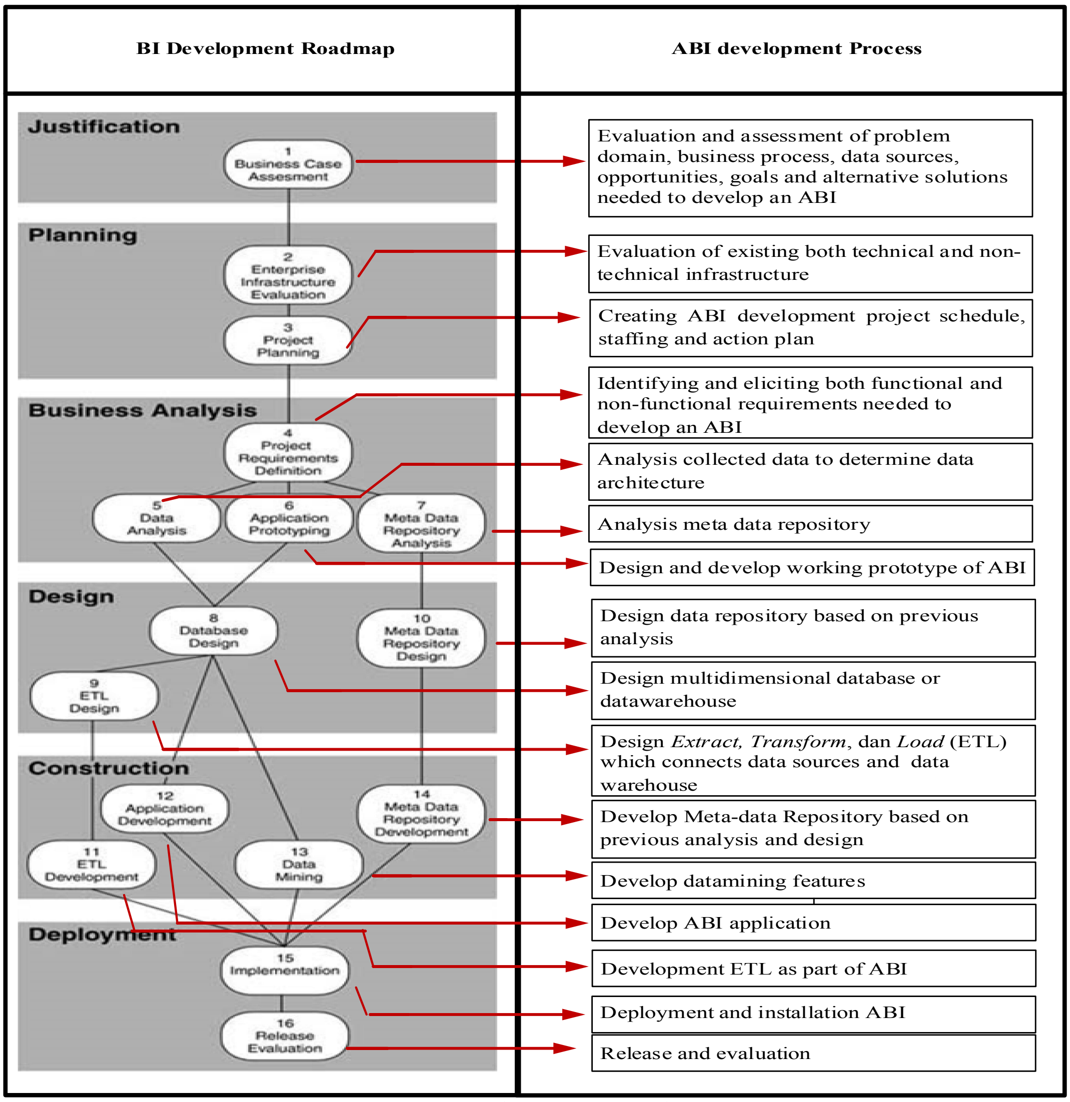

Fig. 1 ABI Development Framework [46]

IV. RESULTS

This section follows on from the previous section, which employed the framework as a guidance to develop proposed ABI outlined in Section 3 above (see Fig. 1). All the development stages were adopted, nonetheless, in reporting the results, some activities in a row that had same deliverable objectives were discussed in one section for effectiveness. For instance, a series of activities of database design, ETL design and development during design and construction stages had similar aim to produce data repository. For this reason, the Design and Construction phases are reported into once section. The sub-sections below reported the design and development of ABI in the University SYZ lasted nearly ten months in totals (January to October 2017).

A. Justification Phase

This stage mainly aimed to undertake a business case assessment with the focus of justifying the rationale for the University XZY to develop an ABI. The assessment was carried out in the first month of the project that involved cost-justification of the current business environment, identifying pain points to be addressed as well as the potential benefits and opportunities needed to achieve based on feedback from the top management as the intended users of ABI. Furthermore, the IT environment was assessed to list the shortcomings of the existing systems which caused issues or problems especially when accessing, aggregating different sources of data for reporting and analysis. By using common business analysis models such as SWOT, Porter's five forces and PEST framework, the overall in-depth assessment revealed a number of shortfalls from which it was plausible for the university to initiate the development of ABI as summarized in Table 1 below.

TABLE 1
KEY ISSUES IN THE CURRENT BUSINESS PROCESS OF THE UNIVERSITY XYZ

No.	Aspects	Current shortfalls need to be addressed by ABI
1.	Operational	The existing systems generated a huge amount of disparate data and extra time was required to produce integrated reports Operational hours for the AIS staffs followed usual business hours which sometimes resulting in a delay in providing the most updated progress report
2.	Management	Top level management face high demand related to having a measurable university's performance as the basis for strategic planning and decision making As a public institution, there is a need also to implement a quality prioritized investment where at a certain level the university may not be able to provide the funding required for the development of a fully integrated ABI
3.	Technical	There was no legacy system for the repository which stored useful data for decision making Some software and hardware components required for developing ABI has not existed, while the existing ones may need to be updated for ABI for function effectively

B. Planning Phase

Planning was the next phase conducted to develop the ABI for use by the University XYZ. Two main steps were carried out in this phase. The first step mainly involved enterprise infrastructure evaluation to identify what components were already in place. It also aimed to see the possibility of the existing legacy systems that have been developed previously could be used as part of the ABI such as hardware, network components, operating systems, libraries, DBMS, and meta-data repositories. In addition to those technical aspects, the evaluation also attempted to determine non-technical infrastructure components, such as guidelines, procedures, logical data model, workflow, various standards for ensuring consistency in data-naming, data structure and data set from which were also useful as the foundation for developing ABI. The evaluation identified some key recommendations that should be taken into account before started the development of the ABI in the University environment. Table 2 summarised some examples of recommendations resulting from the enterprise infrastructure evaluation. The second step was project planning. It mainly involved listing the necessary works to be done along with resources (e.g. time, staff and materials) required to achieve the proposed milestones. In addition, the project planning also included measurable outcomes that would be used later for monitoring actual progress against the planned goals. Having completed this phase, a project schedule was created that would provide a roadmap for the developer team to arrange, execute, monitor and optimising the workloads during the technical development of ABI. Similar to the justification phase, this phase was accomplished within a month.

TABLE 2
RESULTS FROM THE EXISTING INFRASTRUCTURE EVALUATION

No	Aspects	Current shortfalls need to be addressed by ABI
1.	Hardware	The existing hardware could be still used as the main infrastructure, however, due to the high volume of the data transaction and for the reliability purpose, it was recommended for further upgrade to more higher specification no longer than two years after ABI implementation.
2.	Software	There was no any Extract, Transform, Load (ETL) tools installed in the server and needed to identify appropriate ETL tool as well as the suitable operating systems. For this purpose, it was decided to choose Pentaho Data Integration (PDI) as the ETL tool due to its popularity and open source license.
3.	DBMS	A centralized database for managing data academic was identified but no legacy system put in place for the repository which could store and joint aggregated useful data for the basis of decision making process. As recommendation the next step should develop an ETL. Some software and hardware components required for developing ABI has not existed, while the existing ones might need to be updated for the ABI to function effectively. Several applications were identified that would be installed in the server upon which the ABI would run.
4.	Non-technical aspects	The university already has implemented a naming-standard which set rules for choosing the name for file, component, unit and libraries and could be still used for ABI.

A. Business Analysis, Design, and Construction Phase

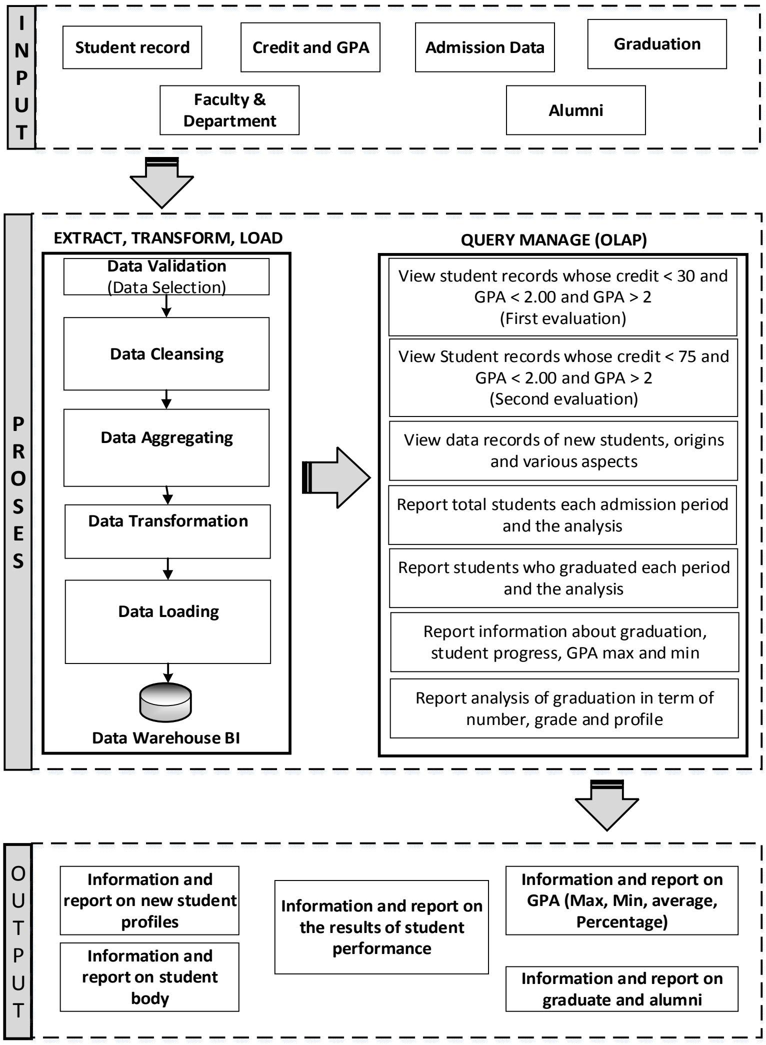

Fig. 2 Analysis on input-process-output for which the ABI would cater

After having an initial work plan, in the last two months, the ABI development process moved to the next phase that was Business Analysis. As illustrated in the framework above (see Fig. 1), there were four steps to be completed in this phase. The first step was Requirements Definition which mainly aimed to discover, analyze, and document the requirements especially from the users' perspective that needed to be catered by the proposed ABI. For this purpose, a survey was distributed to the top level management, as the primary users to collect initial information about their expectation towards ABI. To gain more insights and confirm their opinions provided in the survey, they were then invited in a series of interview sessions. The interviews also aimed to identify the emerging requirements as well as resolve any different or conflicting needs regarding the aggregated information they wanted to obtain from ABI. In addition to the interviews, a content analysis of the related documents, manuals, and relevant reports was also performed. All the collected information was then organized into three aspects: data, application and metadata for further analysis to provide input for the ABI functional specifications as discussed in the next steps.

Following the definition of business requirements, the project moved to the second step that was data analysis. As discussed above, the main goal of this step was to define the requirements about the data need to be collected and processed as well as the information needs to be generated by the ABI (see Fig. 2). It can be seen from the figure, the analysis of the business process suggested three layers of data flow from the input, process and the transformation into useful information useful for supporting sound decision-making process. At the input layer, the data needed to be input included student records, admission, alumni, and grade from all faculties. The second layer, process, would manage the transformation the raw data gathered from various sources into more useful data required for the next analysis. Finally, the third layer provided data repository and query services that would be used for aggregating analysis, visualizing and reporting as well as decision-making process.

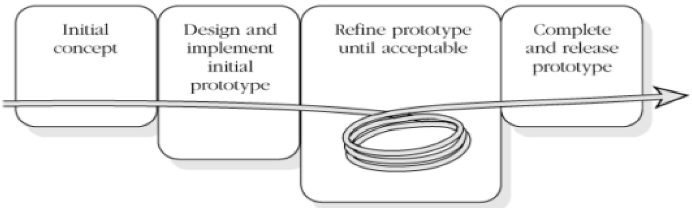

Fig. 3 Evolutionary Prototyping (EP) framework for ABI prototype development [47]

Moving from data analysis step, the third step was developing a working prototype based on the requirements and functional specifications defined in the first step. The Evolutionary Prototyping (EP), suggested by [47] was adopted as a development framework which was marked by three cycles of activities including development, user verification, and refinement. Each cycle of EP yielded an improved prototype based on emerging requirements and user feedbacks. This iterative work was undertaken until there were no more errors found and users satisfied and then an ABI application dashboard was produced as illustrated in Fig. 3 above.

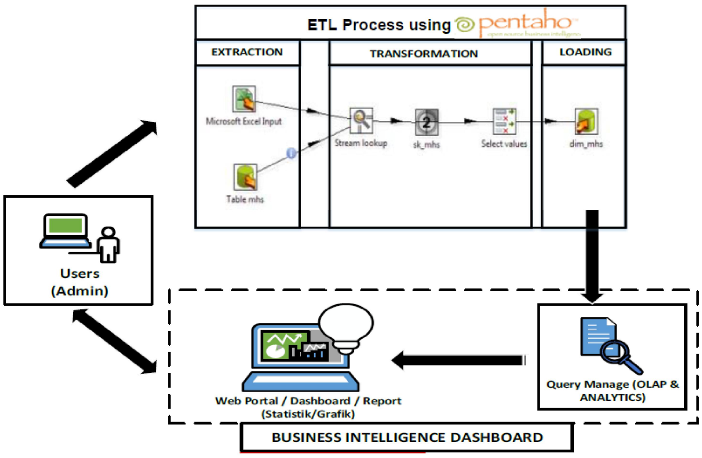

Fig. 4 ABI's Architecture [46]

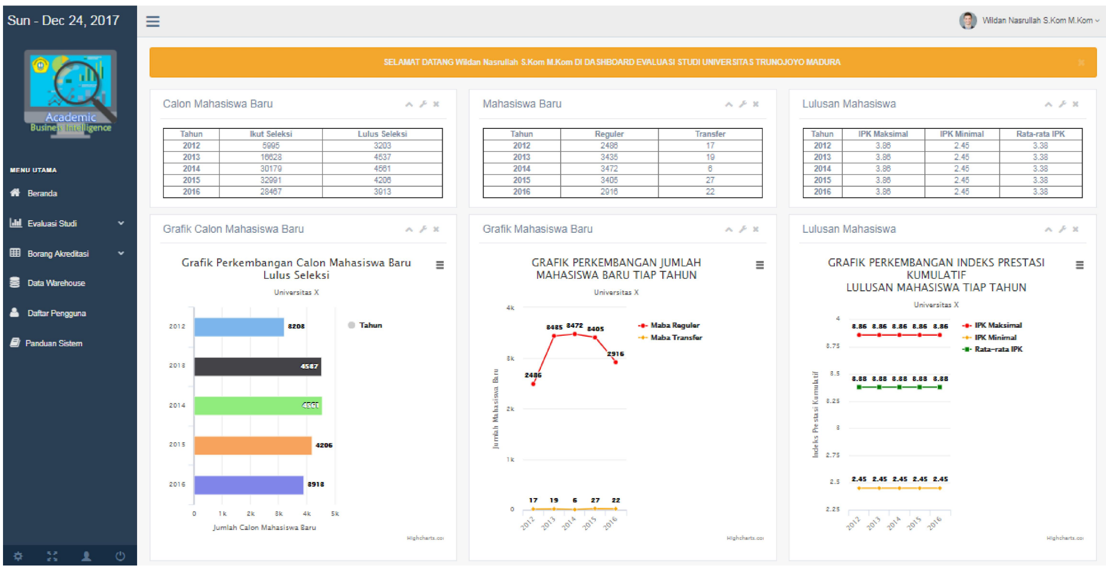

Fig. 5 Sample of ABI's feature for interactive students' performance assessment

Despite the BI application yielded through the prototyping approach, another crucial component that needed to be well developed at the same time was metadata repository as data warehouse of the application. For this reason, during the seven-month of prototyping, the development team also worked on building a data warehouse which the main function was to integrate and store useful data generated from the extract and load process of data from different sources. Fig. 5 illustrated the architecture of the data repository and how it connected users with the ABI's application services. As can be seen in the Fig 4, this ABI's architecture was built mainly by using PDI as the ETL tool that was set periodically to pull data from different database sources into the data warehouse or when new data or record available. Once the data was stored, by using the ETL services provided by the ABI application the users were then able to load the required or aggregated data and then analyzed, visualize, and generated reports promptly and at any time. The development team needed four months to produce the first prototype and then took several cycles of refinements to enhance the prototype before it went to the deployment phase. Finally, after two months of iterative process, the development team was able to produce a working prototype and ready for testing.

B. Deployment Phase

Once the prototype enhancement was done and there was no more feedback, the development process moved to deployment phase carried in the last three-month of the project. This phase was regarded as the final stage in which the ABI application was verified and fully tested before it went to actual used in the university environment. To run the deployment smoothly, in the first month, a series of training sessions on how to use the ABI was conducted. Prior to the training, it was important for the development team to carefully recruit the participants to represent the different user groups of ABI in the University. Therefore, rather than having all the staffs, the development team mainly involved key persons in the management level who would actually use the ABI or dealt with the decision-making process as summarized in Table 3 below.

TABLE 3
USER GROUP PARTICIPANTS AND THEIR ROLES IN THE UNIVERSITY

User group	Number of reps.	Roles in the University and their interests toward ABI
Rectorate	2	The highest governing body and used the ABI for monitoring University's performance
Senate	2	The foremost advisory body to the University and used ABI to support decision- making
Administrative	4	Used ABI to manage and provide the information required by the top level management
IT Dept.	2	Responsible for ensuring the IT services including ABI can be accessed to all level of users

Following the training sessions, all the 10 participants were asked to try the ABI individually or within a group to familiarize with the system for about one month. Once the trial time was finished and participants were confident to use the ABI, a culminate usability testing was conducted in the remaining month to check the ease of use of the system. To start the evaluation, several scenarios were developed ranges from simple task such as login functionality, slice and dicing of two dimensional data until more complex tasks of aggregating multiple data sets from different sources. One example of complex task was how to simultaneously generate visualization within one single dashboard view of aggregated data enrolment and academic performance where the data sources were technically stored in different databases as seen in Figure 5. All of the participants were required to complete the tasks in each scenario and then assessed upon the completion in term of the average of time spent, success, and, error-rates as summarized in Table 4 below.

TABLE 4
RESULTS OF USABILITY TESTING

Complexity	EXAMPLE OF SCENARIOS	Avg. Time Spent		Avg. Error Rates		Avg. Completion Rates	
		Baseline	Result	Baseline	Result	Baseline	Result
Low	Test the Login Functionality	1.00 second	0.85 second	0%	0%	100%	100%
Medium	Slicing and dicing to generate figures of all students performances and all categories (e.g. subjects, faculties and departments)	1.50 second	1.34 second	0%	3%	90%	97%
High	Generating visualization within one single dashboard view of aggregated data enrolment and academic performance	3.00 second	2.5 second	0%	6%	90%	94%

Finally, to measure the acceptance, the participants were invited to answer survey questions based on the Computer Usability Satisfaction Questionnaire (CUSQ) suggested by Lewis [48]. The survey included 19 questions pertaining to usability aspects of the ABI's dashboard such as operability; learn-ability, easy to understand, and attractive. Using Likert's scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”) the participants' answers were then measured to see the level of user satisfaction and acceptance towards the ABI. As can be seen in Table 3, results from the user acceptance testing showed that overall the acceptance and satisfaction rates were 87.25% which means the ABI found to be excellent according to users. As no more defects found, at this stage, the ABI development project was approved and finished.

TABLE 5
FINAL SYSTEM USABILITY AND ACCEPTANCE QUESTIONNAIRE RESULTS

Aspect	CUSQ questions based on Lewis [48]	Results (mean)
OPERABILITY	Q1. Overall, I am satisfied with how easy it is to use this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.80
	Q2. It was simple to use this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.70
	Q3. I could effectively complete the tasks and scenarios using this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.40
	Q4. I was able to complete the tasks and scenarios quickly using this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.90
	Q5. I was able to efficiently complete the tasks and scenarios using this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.80
	Q6. I felt comfortable using this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.00
	Rate of Acceptance	**92%**
LEARNABILITY	Q7. It was easy to learn to use this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.70
	Q8. I believe I could become productive quickly using this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.30
	Q9. The system gave error messages that clearly told me how to fix problems. Strongly agree 1 2 3 4 5 Strongly disagree	4.70
	Q10. Whenever I made a mistake, I could recover easily and quickly. Strongly agree 1 2 3 4 5 Strongly disagree	4.70
	Q11. The information provided with this system was clear. Strongly agree 1 2 3 4 5 Strongly disagree	4.30
	Q12. It was easy to find the information I needed. Strongly agree 1 2 3 4 5 Strongly disagree	4.50
	Rate of Acceptance	**90%**
EASINESS	Q13. The information provided for the system was easy to understand. Strongly agree 1 2 3 4 5 Strongly disagree	4.00
	Q14. The information was effective in helping me complete the tasks. Strongly agree 1 2 3 4 5 Strongly disagree	4.30
	Q15. The organization of information on the system screens was clear Strongly agree 1 2 3 4 5 Strongly disagree	4.30
	. **Rate of Acceptance**	**84%**
ATTRACTIVE	Q16. The interface of this system was pleasant. Strongly agree 1 2 3 4 5 Strongly disagree	4.00
	Q17. I liked using the interface of this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.60
	Q18. This system has all the functions and capabilities I expect it to have. Strongly agree 1 2 3 4 5 Strongly disagree	4.50
	Q19. Overall, I am satisfied with this system. Strongly agree 1 2 3 4 5 Strongly disagree	4.10
	Rate of Acceptance	**82%**

V. DISCUSSION

As introduced earlier, the purpose of this study was aimed at filling the gap in the current growing literature on Business Intelligence in the education sector by reporting the experiences of developing an Academic Business Intelligence (ABI). Taking into account the problem encountered by the University XYZ in assessing student performances faster and making decision accurately, this study proposed and designed a data warehouse as a repository which was able to collect data from different sources and then extract, load and transform into useful information automatically. Furthermore, following the BI development roadmap, it also successfully built an ABI application dashboard in attempt to offer users with practical, interactive and smart way to access and analyse the aggregated information stored in the data warehouse for assessing academic performance quickly, enabling decision making process faster and generating various reports without the assistance from IT experts.

Drawing from findings discussed above, this study makes several noteworthy contributions. Firstly, it fills the gap on the limited but growing body of BI development in public sector by providing insights along with the empirical evidence on how to successfully develop a BI within the unique context of academic sector. More specifically, this study address the call for more works on developing BI in academic sector as highlighted by Agustiono and Nasrullah [46] by presenting in-depth a case study of ABI development project. Secondly, the findings of this study enhance our understanding provided by the previous works [23] [27] [29] [49] [50] regarding the challenges, complexity and best practices to successfully ABI development. Thirdly, the findings of this study show the applicability of Moss and Atre [45] Business Intelligence Roadmap as suggested by Agustiono and Nasrullah [46] to guide the development of ABI. All these findings in particular offer another contribution in practices from which any with similar interest and needs to develop ABI or BI, in general, can take the experiences and lesson learned to make the development process successful.

VI. CONCLUSIONS

As discussed above, this study successfully design and deployed the newly developed ABI application dashboard within the university's environment. To ensure the ABI demonstrate proof-of-concept and free from errors, a series of comprehensive testing and verification involving users was run before the actual use. As can be seen from evaluation (see Table 3), overall response from user acceptance testing showed the usability rate proved to be at a higher rate (87.25%) and suggested that the system found to be useful, easy, practical, and applicable especially to cater to the university's need in conducting students' performance assessment and decision making faster. In short, it can be, therefore, concluded that the ABI meet the requirements and user's expectations.

While acknowledging the contributions, it is also important to note that the study is not free from limitation from which future research could address in order to make an advance contribution. First of all, given the unique nature of academic, more study in this area is still needed. This is because this study based on a single case study, and more study within different academic context could offer new insights. Second, as the BI technology is evolving in response to the current IT advancement, it is important for the future study to explore the possibility of any ETL tools, architecture, and framework as ingredients for developing BI and ABI more specifically and see the appropriateness. Finally, given the most ABI literature focused on higher education, it is also important to examine the development of ABI in the context of secondary or primary school.

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