Business Intelligence for Data-Driven Decision-Making in Vocational Education

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Received: 26 May 2022; Revised 20 June 2022; Accepted 29 July 2022

ABSTRACT: *In this paper, the researchers were interested in data-driven decision-making support systems in vocational education. The conceptual framework of Business Intelligence (BI), when combined with academic processes, can be significantly improved. This paper aims to explain BI solutions to support the academic activities of vocational education. With BI, we can leverage a suite of analytical tools that support decision-making for different types of users (students, faculty, administrators, and decision-makers). Data-driven decision-making (DDDM) processes with BI solutions for proposed vocational education management include Data, Information and Knowledge. The decision-making process is taken through the ELT process (Extract, Transform, Load) and then stored in a data warehouse (DW) for the decision outcome. The decision outcome is then applied and returned to the classroom, building or district.*

Keywords: business intelligence, Data-Driven decision making, vocational education

1. Introduction

Nowadays, many educational institutions collect and produce information about educational institutions, such as student information, faculty, academic process, courses, research and innovation, and collaborate with other organizations or establishments to analyze and use it as a decision-making tool. The use of Business Intelligence (BI), a business process, is used in education to analyze all data by developing a data warehouse and a data-driven decision-making system. Sources retrieved from different sources are integrated into the integration system (Yulianto & Kasahara, 2018).

Vocational education in Thailand, where vocational education management is the management of professional education to produce and develop a workforce of three levels: skill level (professional diploma level), technical level (higher vocational certificate level) and technology level (bachelor's degree in technology or operational line), which is the management of long-term education and vocational training and the management of short-term studies. The objective is to ensure that learners and graduates are competent in accordance with the needs of the establishment, community and self-employed.

Thai vocational education is not widespread in any system that can provide instant data analysis in the organization. Although there are several online application services in the main educational management. At present, executives simply request conventional data reports in a paper or document file.
Therefore, the development of a multipurpose data warehouse system to analyze and visualize data is essential for data-driven decision-making. This archive provides solutions beyond independent online applications, such as

teaching courses, admissions, student enrollment, programme selection, and portal systems in vocational education that combine data from multiple sources into one source (Yulianto & Kasahara, 2018).

2. Literature Review

2.1 Business Intelligence

Depending on who determines it, business intelligence does not yet have a clear definition (Krasic et al., 2021). Some consider BI as data reporting and visualization; some define BI as performance management. Database vendors highlight data extraction, transformation and integration. Analytics vendors emphasise statistical analysis and data mining (Azvine et al., 2006).

Business Intelligence (BI) is an enterprise management system that describes applications and technologies used to collect and change data, and analyze information about a business to improve decision-making processes (Moss & Atre, 2003). The BI lifecycle is a step towards developing effective Business Intelligence (BI) decision support applications, such as Academic Dashboards, with six steps in the BI lifecycle, starting from the beginning to implementation. These include justification, planning, business analysis, design, construction, and deployment, each of which has been developed to be more detailed according to the needs of the BI environment (Moss & Atre, 2003; Destiandi & Hermawan, 2018).

Business Intelligence (BI) is an online and real-time application that large and modern organizations require to increase their competitive advantage in a globally competitive environment. Higher Education (HE) institutions can be organizations with excellent resources, so it is necessary to use an application that can be a tool to achieve the business goals of the group (Trisnawarman & Imam, 2020). Higher education can successfully implement and apply business intelligence because this wise decision-making mechanism can improve student achievement. (Mutanga, 2014).

The researcher synthesized BI elements from the review, which shows that BI characteristics have two design groups. Most researchers determined BI consisted of four components: data source, data integration, data storage, and report and visualization, as shown in Table 1.

Table 1. The synthesis of BI

Topic	Concepts	Example of activities/materials/ equipment	Reviews
Business Intelligence	Business intelligence (BI): Business processes that apply to organizations in data analysis to achieve results that will help senior management make effective business decisions.	• Data Source • Data Integration (ETL) • Data Storage (DW, DM) • Report & Visualization	(Krasic et al., 2021) (Talaoui & Kohtamäki, 2020) (Azvine et al., 2006) (Eggert & Alberts, 2020) (Muntean et al., 2021) (Sierra et al., n.d.) (Moscoso-Zea et al., 2019) (Boulila et al., 2018)
		• Data Source • Selected Data • Preprocessed Data (ELT) • Transformed Data • Data Mining • Knowledge	(Villegas-Ch et al., 2020) (Scholtz et al., 2018)

Table 1 shows a synthesis of BI elements from the review and highlights that the characteristics of BI have two design groups. Most researchers determined that BI consisted of four components: data source, data integration, data storage, and report and visualization. These different perspectives make it clear that BI has many aspects to visualization (Azvine et al., 2006). BI is the collection of raw data from multiple sources. Next, data is extracted, transformed, and loaded into data storage for analysis and reporting through various tools as shown in Figure 1.

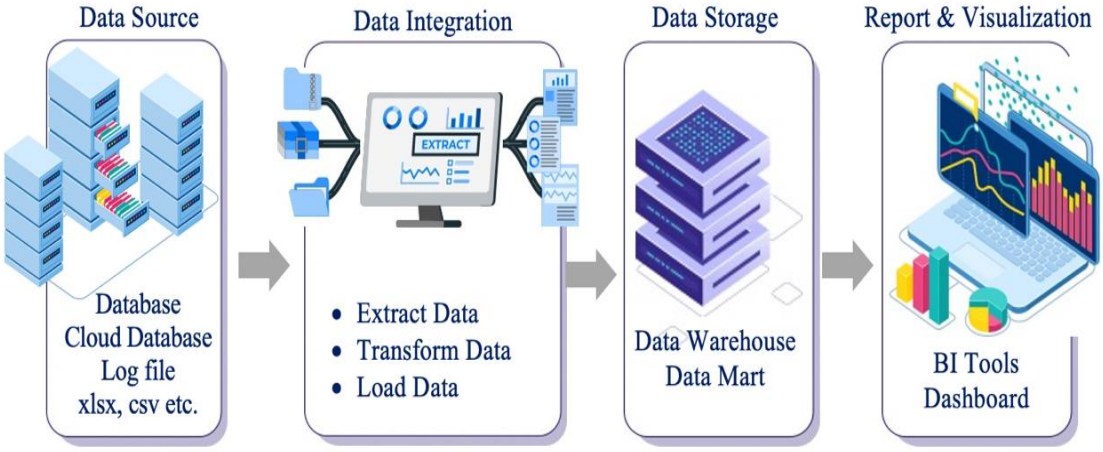

Figure 1. Business Intelligence Framework
Source: Self-Modeling Author

Figure 1 describes the framework of the BI solution used in the present paper. The main components of the BI solution are: (1) data sources containing data for the academic process. This data comes from databases, cloud databases, log files, xlsx, csv etc., (2) data integration, several ETL operations are needed to load the data into the data warehouse, (3) data warehouse containing the information needed for the BI solution and, (4) the results of using BI tools are presented in reports and visualizations.

2.2 Data Driven Decision Making

Data-driven decision-making (DDDM) is a term that refers to the systematic collection, evaluation, review and collection of results to support decision-making and strategies in university education. DDDM is a common technique that may be used to strengthen commercial processes as well as operational frameworks and regulations in any business. At the same time, DDDM is an ideal method to collect and understand concrete information to identify realistic solutions to complex problems and challenge stubborn behaviour that does not meet the requirements of key decision-makers (Awan et al., 2021; Ashaari et al., 2021).

The goal of data-driven decision-making (DDDM) is the same as encouraging stakeholders to make data-driven decisions. Taking this goal into account, it is important to understand the historical and political context of information usage practices in schools, although a wide range of data can affect educators' decisions and actions on a daily basis. Numerical data that relies heavily upon students' test scores has received particular attention in policy and practice. For example, U.S. school funding and reputation are based on test results data (Dodman et al., 2021).

The researcher synthesized DDDM elements from the review, which shows that DDDM characteristics have two groups, and most researchers determined that DDDM consisted of six components: data, information, knowledge, decision, implement, and impact, as shown in Table 2.

Table 2. The synthesis of DDDM

Topic	Concepts	Example of activities/ materials/equipment	Reviews
Data Driven Decision Making	Decision-making models for senior executives who are suitable for technological change Decisions require a wide range of information.	• Data - Organize - College • Information - Summarize - Analyze • Knowledge - Prioritize - Synthesize • Decision • Implementation	(Mandinach, Rivas, et al., 2006) (Kavitha & Chinnasamy, 2021) (Hwang & Chu, 2009) (Gill et al., 2014) (Akanmu & Jamaludin, 2015) (Dodman et al., 2021)

Topic	Concepts	Example of activities/ materials/equipment	Reviews
		• Impact	
	Data-driven decisions at the school level	• Technological Infrastructure and Hardware • Data Usage Culture • Data Usage Purpose • Data Literacy	(Doğan & Demirbolat, 2021)

Table 2 shows a synthesis of DDDM elements from the review, which shows that DDDM characteristics have two groups. Most researchers determined DDDM consisted of six components: data, information, knowledge, decision, implement, and impact.

The conceptual framework for data-driven decision-making is shown in Figure 2. This framework was developed based on the assumptions of educators on how to be driven by information without limiting particular areas in the educational system. There are questions or problems that need to be collected, analyzed, and verified to make informed decisions. As mentioned above, it is important to note that the model presented here represents decision-making within the school district, focusing on classroom, building, and district levels (Mandinach, Honey, et al., 2006).

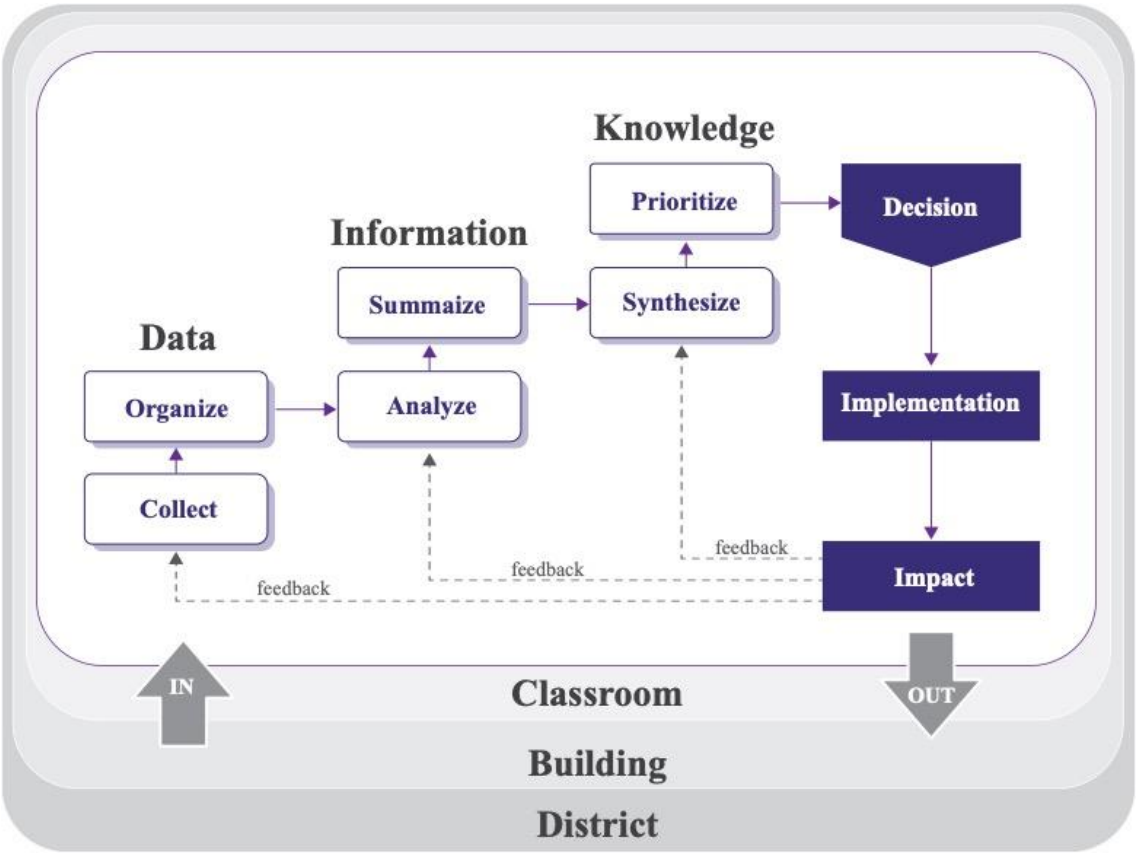

Figure 2. Framework for Data-Driven Decision Making
Source: Self-Modeling Author

In Figure 2, according to Ackoff (1989), data, information and knowledge contribute to a continuation in which raw data is converted into data and ultimately into knowledge that can be used to make decisions.

Data does not have meaning in itself, which can be in any form, whether or not it becomes data depends on the understanding of the data setter.

Information is data used to understand and organize the environment by revealing an understanding of the relationship between information and context. However, that alone has no impact on future operations.
Knowledge is a collection of beneficial information before implementation the sequence of the establishment of knowledge-based concerning information and tested teacher ability. The investigation of teacher ability is to consider students' performance evaluation to their skills in the classroom.

2.3 Vocational Education

Vocational education in Thailand is the management of professional education to produce and develop a workforce of three levels: skill level (Vocational certificate), technical level (Diploma) and technology level (Bachelor's degree in Technology), which is the management of long-term education and vocational training, and the management of short-term studies. The objective is to ensure that learners and graduates are competent in accordance with the needs of the establishment, community and self-employed.

Thai vocational education is not widespread in any system that can provide instant data analysis in the organization. Although there are several online application services in the main educational management. At present, executives simply request conventional data reports in a paper or document file.

The researcher synthesized VE elements from the review, which shows that VE characteristics have two groups, and most researchers determined VE as shown in Table 3.

Table 3. The synthesis of Vocational Education

Topic	Concepts	Example of activities/ materials/equipment	Reviews
Vocational Education	Higher vocational education	• Administration and management • Service and resource obtaining • Teaching and HR fostering • Academic research and development	(Chang & Hsu, 2010)
	Vocational qualification level	• Vocational certificate • Diploma • Bachelor's degree in Technology	(OVEC, 2019)
	The digital transformation framework for Vocational Education Colleges	• Supervision and Management • Curriculum and Learning management • Students and Graduates • Teachers and educational personnel • Infrastructure • Research • Community service • Excellence of college	(Rujira et al., 2020) (Vocational Education Standard, 2017) (OEC, 2018) (APACC, 2016)

3. Result

From document, synthesis and research related to business intelligence, data driven decision making, and vocational education, the network clusters are shown in Figure 3.

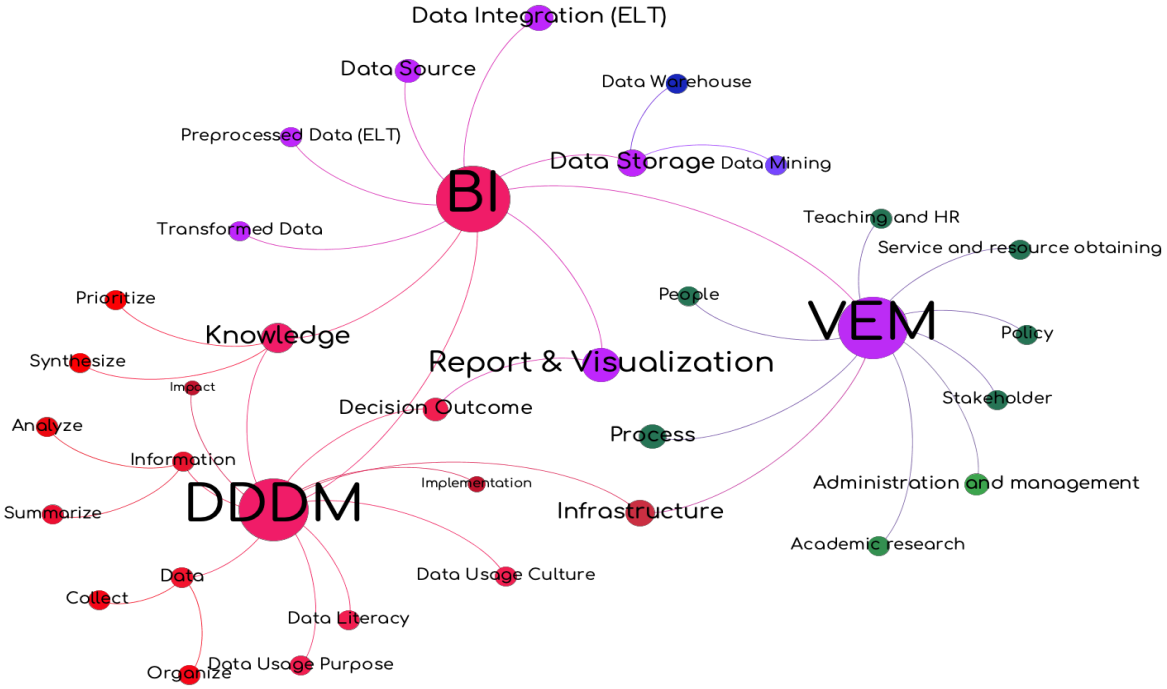

Figure 3. Network showing modularity

Figure 3 shows that the organizational network consists of three main clusters: Business Intelligence (BI), Data-Driven Decision Making (DDDM), and Vocational Education Management (VEM).

From the study, synthesis and research related to business intelligence, data-driven decision making and vocational education can be applied to develop a conceptual framework and examine the factors affecting decision-making in vocational education, as shown in Figure 4.

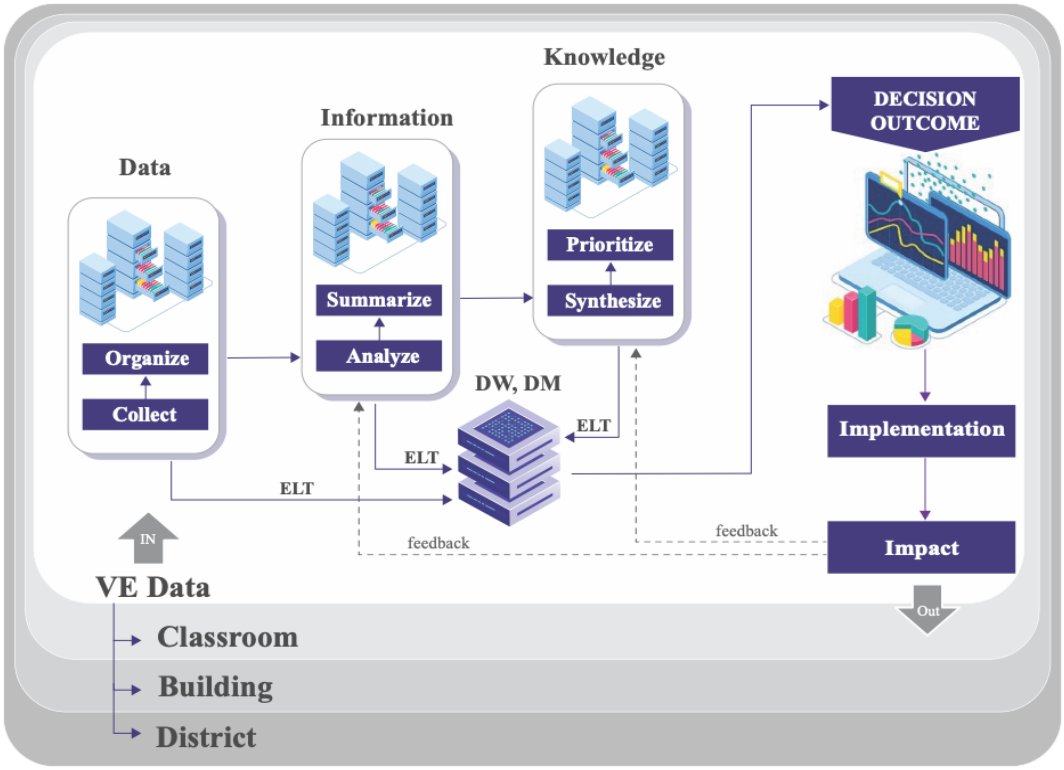

Figure 4. Conceptual Framework of DDDM process with BI *Source: Self-Modeling Author*

Figure 4 describes the framework of the DDDM process with BI solutions for proposed vocational education management that include: Data, Information, and Knowledge. The decision-making process is taken through the ELT process (Extract, Transform, Load) and then stored in a data warehouse (DW) for the decision outcome. The decision outcome is then taken and returned to the Classroom, Building, and District. This model applies to vocational education management.

Data is what we perceive and store, without being processed. This may be true or false information. Take the simplest example, such as photographs, sounds, etc.

Information is the use of raw data then organized to use in decision making.

Knowledge is the bringing together of information, to select and build new knowledge and decision making.

The Decision Outcome is the result of data, information and knowledge being brought into the data warehouse process.

Data does not have meaning in itself, which can be in any form. Whether or not it becomes data depends on the understanding of the data setter.

4. Conclusion

In this paper, the authors propose a data-driven decision-making approach combined with BI processes for vocational management. In the proposed model, the driven data is related to vocational education. All data will be collected and organized in order to obtain information that can be used in decision making. A large amount of information is then synthesized and prioritized as new knowledge. The data, information, and knowledge gained will go into the BI process to achieve better results and used in decision-making in vocational management.

The development of a BI system includes the fact that the system truly supports and helps users at various stages of the decision-making process based on the observed research. The model is based on the management procedures used by the institution, such as the financial management, the equality in education, and the professional excellence management, which include behavioral assessment, research, curriculum and learning, dropout, and resource management. Applications have the power to affect college that are looking for innovation and results to those who need it to make decisions. It is obvious that the BI development process depends on source data ingested into the data warehouse, which may be accomplished by the reporting process while taking into consideration insights gathered from the past to the present from stakeholders across all sectors.

However, this concept is only a guide for presenting a decision-making model. There may be changes in the data format. Methods for obtaining outcomes may be based on the context of educational institutions in each region.

Acknowledgements

The researchers would like to thank the Thonburi Commercial College, Institute of Vocational Education Bangkok, Office of Vocational Educational Commission, Ministry of Education Thailand and King Mongkut's University of Technology North Bangkok, Thailand, which supported this research.

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