DATA VIRTUALIZATION DESIGN MODEL FOR NEAR REAL TIME DECISION MAKING IN BUSINESS INTELLIGENCE ENVIRONMENT

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Ayad Hameed Mousa Albadri
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Abstrak

Tujuan utama Kepintaran Perniagaan (BI) ialah untuk memberi tumpuan kepada menyokong pembuatan keputusan strategik, operasi, dan taktikal sesebuah organisasi dengan menyediakan salinan data yang menyeluruh, tepat, dan jelas kepada pembuat keputusan. Sebuah Gudang Data (DW) dianggap sebagai input dalam aktiviti-aktiviti sistem pembuatan keputusan, dan dibentuk melalui proses Ekstrak (Extract), (Ubah) Transform, dan Beban (Load) (ETL). ETL beroperasi dalam tempoh yang tertentu dan memerlukan data untuk memproses dan menghantar data. Walaubagaimanapun, menyediakan maklumat menghampiri masa nyata bagi membantu pengintergrasian data dalam menyokong pembuatan keputusan adalah satu isu yang telah diketahui. Ketidakbolehcapaian maklumat menghampiri masa nyata boleh diatasi menggunakan pemayaan data (DV) kerana ia menyediakan maklumat yang utuh, abstrak, menghampiri masa nyata, dan terlindung bagi memenuhi permintaan pengguna. Tidak ketinggalan, ketika ini, terdapat kajian yang terhad berkaitan model BI bagi membangun dan mengurus data dalam persekitaran maya yang mampu memenuhi keperluan organisasi. Oleh itu, matlamat utama kajian ini adalah bagi mengusulkan sebuah model DV untuk pembuatan keputusan menghampiri masa nyata dalam persekitaran BI. Kaedah penyelidikan sains reka bentuk diadaptasi bagi mencapai objektif kajian. Sebagai hasil kajian, sebuah model yang dinamakan Model Pembangunan Pemayaan Data (DVDeM) diusulkan, yang mengemukakan fasa-fasa dan komponen-komponen yang mempengaruhi persekitaran BI. Bagi mengesahkan model, semakan pakar dan perbincangan kumpulan fokus telah dijalankan. Sebuah prototaip berdasarkan model yang diusulkan telah dibangunkan, dan dilaksanakan dalam dua kajian kes. Selain itu, satu alat pengukuran telah dibangunkan bagi menilai kebolehgunaan dan keupayaan model dalam menyediakan data menghampiri masa nyata. Sejumlah 60 subjek kajian telah terlibat, dan dapatan menunjukkan 93% daripada subjek kajian bersetuju bahawa prototaip yang menerapkan DVDeM berupaya menyediakan data menghampiri masa nyata dalam menyokong proses pembuatan keputusan. Daripada jakian tersebut, dapatan juga menunjukkan bahawa majoriti responden (melebihi 90%) dalam sektor pendidikan dan perniagaan, telah mengakui kefungsian DVDeM dan kebolehgunaan prototaip, khasnya keupayaan menghantar data pembuatan keputusan menghampiri masa nyata. Dapatan juga menunjukkan sumbangan teoririkal dan praktikal bagi pembangun untuk membangun aplikasi BI yang cekap menggunakan teknik DV. Juga, min bagi setiap item ukuran adalah lebih besar dari 4 yang menunjukkan responden setuju dengan setiap pernyataan bagi setiap item pengukuran. Sementara itu, skor min bagi atribut kebolehgunaan model reka bentuk DVDeM secara keseluruhan adalah “tinggi” atau “agak tinggi”. Oleh itu, keputusan menyediakan petunjuk yang cukup bahawa pembangunan sistem yang menerap DVDeM membuahkan sistem yang dilihat oleh majoriti responden sebagai berkebergunaan tinggi dan berupaya menyokong data pembuatan keputusan yang menghampiri masa nyata.

Keywords: Kepintaran Perniagaan, Sistem Sokongan Keputusan, Pemayaan Data, Gudang Data, Pembuatan Keputusan.

Abstract

The main purpose of Business Intelligence (BI) is to focus on supporting an organization's strategic, operational and tactical decisions by providing comprehensive, accurate and vivid data to the decision makers. A data warehouse (DW), which is considered as the input for decision making system activities is created through a complex process known as Extract, Transform and Load (ETL). ETL operates at pre-defined times and requires time to process and transfer data. However, providing near real time information to facilitate the data integration in supporting decision making process is a known issue. Inaccessibility to near real-time information could be overcome with Data Virtualization (DV) as it provides unified, abstracted, near real time, and encapsulated view of information for querying. Nevertheless, currently, there are lack of studies on the BI model for developing and managing data in virtual manner that can fulfil the organization needs. Therefore, the main aim of this study is to propose a DV model for near-real time decision making in BI environment. Design science research methodology was adopted to accomplish the research objectives. As a result of this study, a model called Data Virtualization Development Model (DVDeM) is proposed that addresses the phases and components which affect the BI environment. To validate the model, expert reviews and focus group discussions were conducted. A prototype based on the proposed model was also developed, and then implemented in two case studies. Also, an instrument was developed to measure the usability of the prototype in providing near real time data. In total, 60 participants were involved and the findings indicated that 93% of the participants agreed that the DVDeM based prototype was able to provide near real-time data for supporting decision-making process. From the studies, the findings also showed that the majority of the participants (more than 90%) in both of education and business sectors, have affirmed the workability of the DVDeM and the usability of the prototype in particular able to deliver near real-time decision-making data. Findings also indicate theoretical and practical contributions for developers to develop efficient BI applications using DV technique. Also, the mean values for each measurement item are greater than 4 indicating that the respondents agreed with the statement for each measurement item. Meanwhile, it was found that the mean scores for overall usability attributes of DVDeM design model fall under "High" or "Fairly High". Therefore, the results show sufficient indications that by adopting DVDeM model in developing a system, the usability of the produced system is perceived by the majority of respondents as high and is able to support near real time decision making data.

Keywords: Business Intelligence, Decision Support Systems, Data Virtualization, Data Warehouse, Decision-Making.

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List of Abbreviations

BI	Business Intelligence
CRM	Customer Relationship Management
CG	Conceptual Graph
DW	Data Warehousing
DV	Data Virtualization
DSS	Decision Support System
IT	Information Technology
IS	Information System
LOB	line-of-Business
SOA	Service Oriented Architecture
UML	Unified Modeling Language
SEU	Subjective Expected Utility
ERP	Enterprise Resource Planning
VDIS	View based Data Integration Theory
WST	Work System Theory
OLTP	Online Transaction Processing
EII	Enterprise Information Integration
GD	Goal-Driven
VDIS	View based Data Integration Theory
WST	Work System Theory
RFID	Radio Frequency Identification
ODS	Operational Data Store
GDT	Goal Decomposition Tree
GUI	Graphical User Interface

KPIs	Key Performance Indicators
OMT	Object-Method Table
RTBI	Real Time Business Intelligence
CA	Comparative Analysis

List of Publication

The following are a few publications related to this that have been published in journals and proceedings:

JOURNALS

1. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2015a). Process Oriented Data Virtualization Design Model for Business Processes Evaluation (PODVDM) Research in Progress. *Jurnal Teknologi*, 72(4).

2. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2014c). Virtual Data Mart for Measuring Organizational Achievement Using Data Virtualization Technique (KPIVDM). *Jurnal Teknologi*, 68(3).

3. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2014b). Generic Framework for Better Choosing Between Data Integration Types (GFCBDIT) During Build Business Intelligence Applications. International Journal of Digital Content Technology and its Applications, 8(5), 27.

4. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2016). Evaluation Framework for Business Process Evaluation Approaches. *Journal of Computer Science & Computational Mathematics*, 6(3), 7.

PROCEEDINGS

1. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2014). Data Warehouse for Business Process Evaluation Approach Opportunities and Challenges Paper presented at *the Knowledge Management International Conference (KMICe)*, Malaysia.

2. **Mousa, A. H**., Haider, N, Kh & Bakar, M. S. A (2013, August). Intelligent Iraqi Health System (IIHS) Using Online Analytical Process (OLAP) Model. Paper presented at *the 4th International Conference on Computing and Informatics, ICOCI*, Sarawak, Malaysia.

3. **Mousa, A. H**., & Shiratuddin, N. (2015). Data Warehouse and Data Virtualization Comparative Study. Paper presented at *the Developments of E-Systems Engineering (DeSE)*, 2015 International Conference on (pp. 369-372). IEEE.

4. **Mousa, A. H**., Shiratuddin, N., & Bakar, M. S. A. (2015b). RGMDV: An approach to requirements gathering and the management of data virtualization projects. Paper presented at *the Innovation and Analytics Conference and Exhibition (IACE 2015*): Proceedings of the 2nd Innovation and Analytics Conference & Exhibition.

CHAPTER ONE
INTRODUCTION

1.1 Overview

This chapter provides some background of the study that deliberates on issues that lead to the motivation aspects of the study, the specification of the problem, identification of research gap, and formulation of research questions and objectives. It also discusses the scope and limitations of the study, contribution of study, and research framework, operational definitions of terms used throughout the study, as well as chapter summary.

1.2 Background of Study

The background of this study can be classified into six main sections: business intelligence, decision support system, data sources, real-time business intelligence, data warehouse, and finally, data virtualization. The following are the list of details:

1.2.1 Business Intelligence

Business Intelligence (BI) is the mechanism to provide insights for most of the operations and performance of organizations, in addition to identifying strategic business opportunities. Over the years, numerous definitions of BI have emerged; however, there is no comprehensive definition that is acceptable by all researchers in this area. BI from a technical point is a set of techniques, tools and methodologies that work together to transform the information and data belonging to the organizations into meaningful and actionable information and making this information available to decision makers in an organization (Cody, Kreulen, Krishna, & Spangler, 2002; Dayal, Castellanos, Simitsis, & Wilkinson, 2009; Kimball, Ross,

The contents of the thesis is for internal user only

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Appendix A

Expert Review Form

Universiti Utara Malaysia

INSTRUMENT FOR EXPERT REVIEW:

DATA VIRTUALIZATION DESIGN MODEL FOR NEAR- REAL TIME DECISION MAKING IN BUSINESS INTELLIGENCE ENVIRONMENT

Dear Prof. / Dr. / Sir / Ma,

I am Ayad Hameed Mousa Albadri who is currently pursuing his PhD study in Multimedia at University Utara Malaysia. I am delighted to inform you that you have been selected to participate in this research on the reason as follows:

- Your qualifications either in higher education or database data integration or human computer interaction or instructional design or computer science areas, and/or technology or data virtualization or business intelligence.
- You have been studying/researching/teaching in data virtualization or data integration or data mining or business intelligence or computer science areas for many years.

My PhD research proposes the **Data Virtualization Design Model for Near- Real Time Decision Making in Business Intelligence Environment.** It aims is to propose an appropriate structure, layout and navigation as part of how to integrate and manage data in virtualize manner and deliver them in data consumers(end users). These proposed model will provide on-demand data and data on fly, live data (real data in real time to real users) in order to support decision makers to make better decisions.

One part of this research is to evaluate the proposed appropriate design strategies in a few dimensions as listed in the review form.

You will see the review questions give you ample opportunity to use your expertise, experiences, interest, and creativity. It would be greatly appreciated if you could complete this evaluation form.

The information supplied will be treated as confidential and will be used for the research purposes, which will be reported anonymously in academic publications.

Please feel free to contact me by e-mail: maryemayad@yahoo.com in regard to any queries.

Instructions:

The model development consist of three main phases the first one is Data virtualization requirement gathering, while the second one represent Data virtualization development, finally, the third one represent Data virtualization presentation. The first figure shows the proposed model in general while the others show each phase in details. Please read and go through them carefully. Once this is done, with the expertise you possess, please provide feedback for the entire question in the provided spaces. Finally, regarding other components in this model (Data virtualization validation and control and Data consumer feedback). Regarding Data virtualization validation and control: - In Data virtualization environments, traceability and change management must be carried out in both requirements and architectural spheres. The former is concerned with managing changes to agreed requirements and its impact to other requirements inside the same or in external documents. The Data consumer Feedback is important to overcome the shortcomings that may occur at all levels of this model.

EXPERT REVIEW DETAILS

Name* :_____

Age : _____

Gender : Male ☐ Female ☐

Highest education level* :_____

Years of Working Experience* :_____

Signature & Stamp* :_____

ITEMS TO REVIEW

Based on the attached figures of **proposed appropriate structure, phases and navigation** (as depicted in the attached), please tick (√) your choice.

	Items	All are relevant	Some are definitely not relevant	Some may not relevant	Total
Q1	**Relevancy of proposed model phases**				
1.1	Model main phases				

1.2	Linking between Phases				
1.3	DV Requirements Gathering				
1.4	DV Model Development				
1.5	DV Model Presentation				
1.6	Content Structure				
1.7	theory				
Q2	**Relevancy of proposed model phases and their components**				
DV Requirements Gathering					
2.1	Organization and Business Requirements				
2.2	Data Sources requirements				
2.3	Infrastructure requirements				
2.4	Linking between components				
DV Development					
2.5	Data Preparation and connection				
2.6	Data manipulation and management				
2.7	GODV approach				
2.8	Linking between components				
DV Presentation					
2.9	View data sources				
2.10	View virtual table				
2.11	View reports				
2.12	View virtual data mart				
2.13	View report based on virtual data marts				
2.14	Publishing virtual table				
2.15	Linking between components				
Q3	**Items**	**Need very details explanation**	**Needs some explanation**	**Is easy to understand**	**Total**
1	**Clarity of terminology**				
3.1	Model main phases				
3.2	Linking between Phases				
3.3	DV Requirements Gathering				
3.4	DV Model Development				
3.5	DV Model Presentation				

3.6	Content Structure				
3.7	Theory				
	Data Virtualization Requirements Gathering				
3.8	Organization and Business Requirements				
3,9	Data Sources Requirements				
3,10	Infrastructure Requirements				
3.11	Requirements Specifications				
3.12	Linking between components				
	Data Virtualization Development				
3.13	Data Preparation & Connection				
3.14	Data Manipulation & Management				
3.15	GODV approach				
3.16	Linking between components				
	Data Virtualization Presentation				
3.17	View data sources				
3.18	View Virtual Tables				
3.19	View Virtual data mart				
3.20	View report based on virtual table				
3.21	View report based on virtual data mart				
3.22	Publishing virtual table				
3.23	View virtual table based on GODV approach				
3.24	View virtual data mart based on GODV				
3.25	Create and view reports based on GODV approach (virtual table)				
3.26	Create and view reports based on GODV approach (virtual data marts)				
3.27	Linking between components				

Interpretations of the scales: 4= Strongly Agree, 3= Agree, 2= Disagree, 1= Strongly Disagree

	Question	4	3	2	1
4.	I found that terminologies used are easy to understand				
5.	I found the connections and flows of all components are logically appropriate				
6.	I found that proposed phases and components will guide designers to develop of data virtualization system in Business Intelligence				

7.	Generally, I found that the proposed appropriate design data virtualization model are readable and understanding				

Please write your further comments below:

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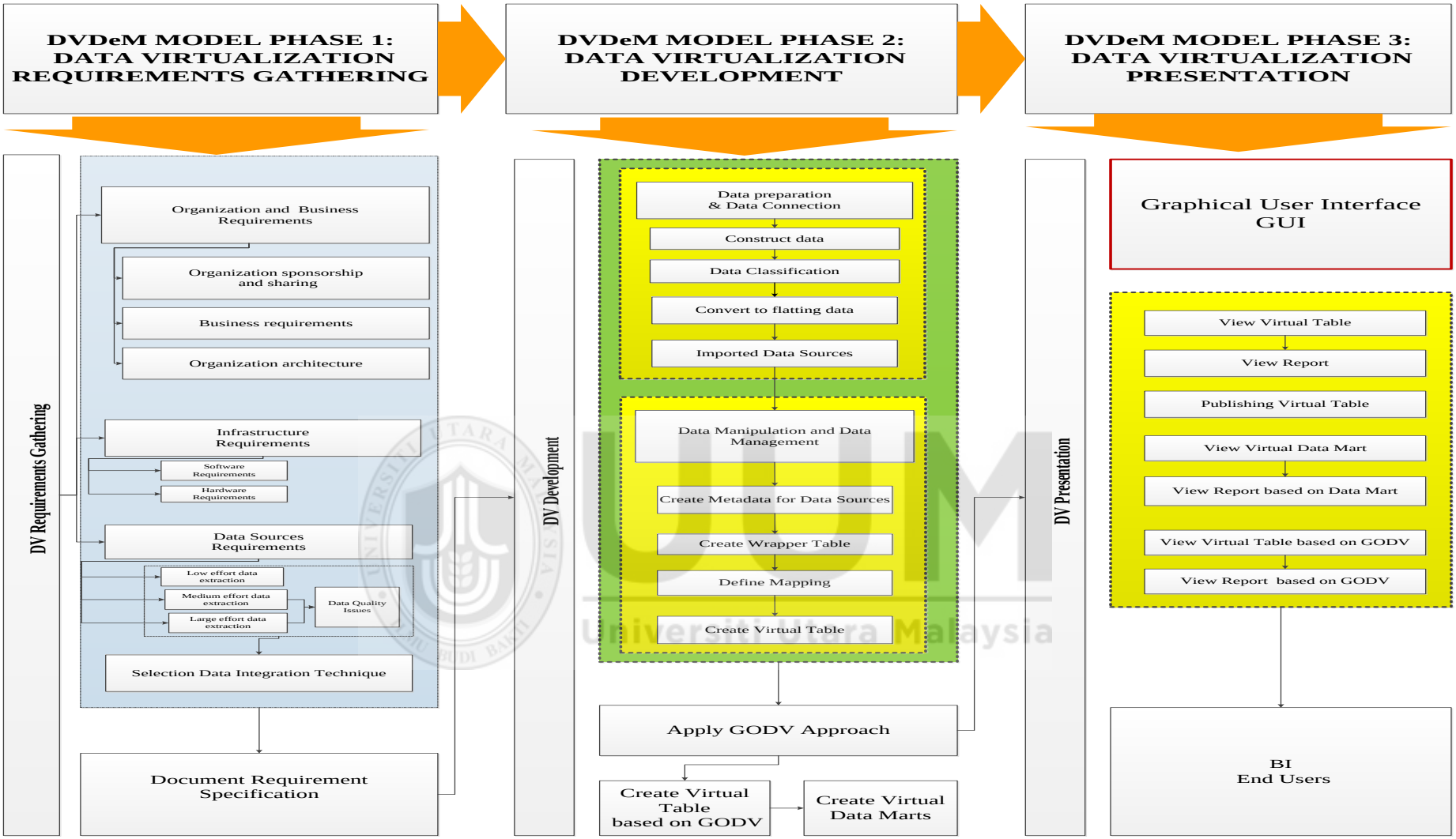
Thanks for your usual cooperation
Ayad Hameed Mousa Albadri



The Proposed Model

Appendix B

Focus Group Discussion Form

INSTRUMENT FOR FOCUS GROUP DISCUSSION:

DATA VIRTUALIZATION DESIGN MODEL FOR NEAR- REAL TIME DECISION MAKING IN BUSINESS INTELLIGENCE ENVIRONMENT

Dear Prof. / Dr. / Sir / Ma,

I am Ayad Hameed Mousa Albadri who is currently pursuing his PhD study in Multimedia at University Utara Malaysia. Firstly, I would like to thank you for your attending and listening to my presentation.

My PhD research proposes the **Data Virtualization Design Model for Near- Real Time Decision Making in Business Intelligence Environment.** It aims is to propose an appropriate structure, layout and navigation as part of how to integrate and manage data in virtualize manner and deliver them in data consumers(end users). These proposed model will provide on-demand data and data on fly, live data (real data in real time to real users) in order to support decision makers to make better decisions.

One part of this research is to evaluate the proposed appropriate design strategies in a few dimensions as listed in the review form.

You will see the review questions give you ample opportunity to use your expertise, experiences, interest, and creativity. It would be greatly appreciated if you could complete this evaluation form.

The information supplied will be treated as confidential and will be used for the research purposes, which will be reported anonymously in academic publications.

Instructions:

The model development consist of three main phases the first one is Data virtualization requirement gathering, while the second one represent Data virtualization development, finally, the third one represent Data virtualization presentation. The first figure shows the proposed model in general while the others show each phase in details. Please read and go through them carefully. Once this is done, with the expertise you possess, please provide feedback for the entire question in the provided spaces. Finally, regarding other components in this model (Data virtualization validation and control and Data consumer feedback). Regarding Data virtualization validation and control: - In Data virtualization environments, traceability and change management must be carried out in both requirements and architectural spheres. The former is concerned with managing changes to agreed requirements and its impact to other requirements inside the same or in external documents. The Data consumer Feedback is important to overcome the shortcomings that may occur at all levels of this model.

PARTICIPANTS DETAILS

Name* :_____

Age : _____

Gender : Male ☐ Female ☐

Highest education level* :_____

Years of Working Experience* :_____

Signature & Stamp* :_____

ITEMS TO REVIEW

Based on the attached figures of **proposed, phases and linking between phases and their components** (as depicted in the attached), please tick (√) your choice.

	Items	**Need very details explanation**	**Needs some explanation**	**Is easy to understand**	**Total**
Q1	How clear are the terminologies in terms of :				
1.1	Model main phases				
2.1	Linking between Phases				
Q2	To what extent the understanding the DV requirements gathering in terms of :				
2.1	Organization and Business Requirements				
2.2	Data Sources Requirements				
2.3	Infrastructure Requirements				
2.4	Requirements Specifications				
2.5	Linking between them				
Q3	**To what extent the understanding the DV Development gathering in terms of :**				
3.1	Data Preparation & Connection.				
3.2	Data Manipulation & Management				
3.3	Linking between them				
Q4	**To what extent the understanding DV Presentation in terms of:**				
4.1	View data sources				
4.2	View virtual table				
4.3	View virtual data marts				
4.4	Publishing virtual table				
4.5	View virtual table based on GODV				

4.6	View virtual data marts based on GODV.				
4.7	Create and view report based on GODV (virtual table).				
4.8	Create and view report based on GODV(virtual data mart).				

	Questions	**Strongly Agree**	**Agree**	**Dis-agree**	**Strongly Disagree**
5	I found the connections and flows of all elements are logically appropriate				
6	Generally, I found that the proposed Model are readable and understanding				
7	I found that proposed model can be used as guideline by BI developers.				

Please write your further comments below:

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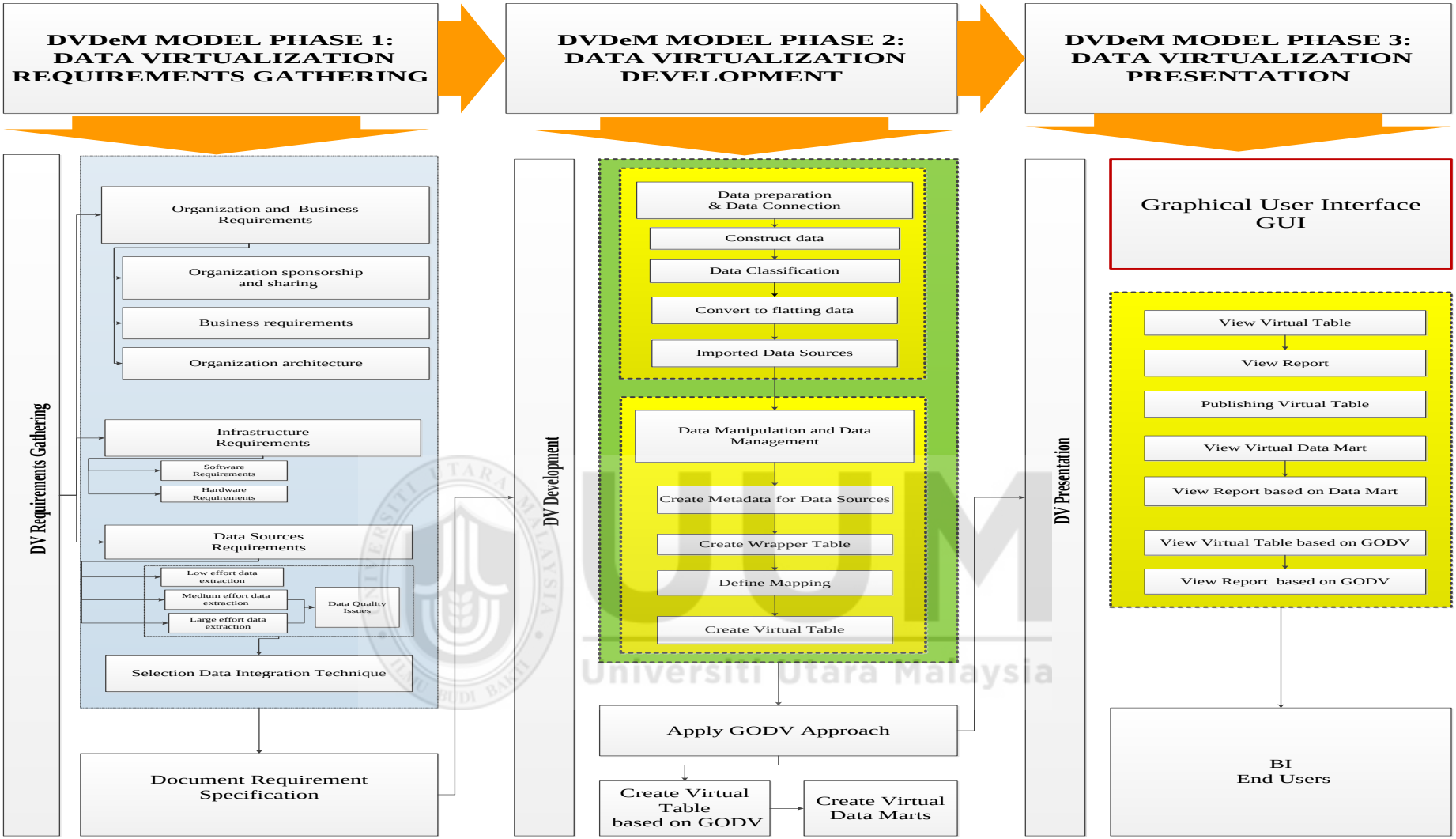
Thanks for your usual cooperation

Ayad Hameed Mousa Albadri



The Proposed Model

Appendix C

Q-U Instrument

Q-U Evaluation Instrument for Measuring Usability of the DVDeM Prototype

PARTICIPANTS DETAILS

Age: _____

Gender : Male ☐ Female ☐

Highest education level* :_____

Years of Working Experience* :_____

Interpretations of the scales: Strongly Agree (5); Agree (4); neutral (3); Disagree (2); and Strongly Disagree (1).

	Q-U INSTRUMENT ITEMS		
1	**Visibility Items**		
	1	*This system can display the information (Virtual Tables, Virtual Data Mart, and BI Reports) in an uncluttered and well-structured manner.*	5 4 3 2 1
	2	*All instructions are visible and self-explanatory.*	5 4 3 2 1
	3	*Navigation options in this application such as (Links, shortcuts, home, back, forward, etc.) are displayed in visible manner.*	5 4 3 2 1

	4	*The system is able to communicate the status at all times (whether resting, processing etc.).*	5 4 3 2 1
	5	*In this system the data is concisely presented.*	5 4 3 2 1
	6	*This system has all the functions and capabilities I expect it to have.*	5 4 3 2 1
	7	*I like using the interface of this system.*	5 4 3 2 1
	8	*The interface for this system is pleasant.*	5 4 3 2 1
	9	*The organization of information in the system screen was clear.*	5 4 3 2 1
2	**Flexibility Items**		
	1	*I felt fully in control when using this system.*	5 4 3 2 1
	2	*This system has customizable feature.*	5 4 3 2 1
	3	*In this system the design for data entry is flexible.*	5 4 3 2 1
	4	*The data can be used, manipulated, and/or processed in easy manner.*	5 4 3 2 1
	5	*This system handles user-specified windows.*	5 4 3 2 1
3	**Learnability Items**		
	1	*In this system the data grouping reasonable for easy learning.*	5 4 3 2 1

	2 *In this system promotes learnability to make it accessible for infrequent usage.*	5 4 3 2 1
	3 *In this system the grouping of menu options is logical.*	5 4 3 2 1
	4 *I believe I could become productive quickly using this system.*	5 4 3 2 1
4	**The Application Behavior Items**	
	1 *This system enhances user efficiency through a consistently rapid response rate.*	5 4 3 2 1
	2 *The system behavior is consistent.*	5 4 3 2 1
	3 *The information was effective in helping me complete the tasks and scenarios.*	5 4 3 2 1
	4 *It was easy to find the information I needed.*	5 4 3 2 1
	5 *Whenever I made a mistake using the system, I could recover easily and quickly.*	5 4 3 2 1
	6 *I was able to complete the tasks and scenarios quickly using this application.*	5 4 3 2 1
5	**Error Control & Help**	
	1 *This system has ability for error prevention and error recovery.*	5 4 3 2 1
	2 *The information (such as online help, onscreen messages and other documentation) provided with this system was clear.*	5 4 3 2 1
	3 *The system gave error messages that clearly told me how to fix problems.*	5 4 3 2 1
	4 *The system provides a help on demand.*	5 4 3 2 1

	5 *Overall, I am satisfied with this system.*	5 4 3 2 1
	6 *Overall, I am satisfied with how easy it is to use this system.*	5 4 3 2 1
6	**Near Real Time Decision Making**	
	1 *In this system, the knowledge sharing is allowed.*	5 4 3 2 1
	2 *This System provides the information visualization functionality (comparison charts, graphs to reveal trends etc.) to assist in decision making.*	5 4 3 2 1
	3 *In this system, the breadth and depth of the data provide sufficient coverage for all data resources.*	5 4 3 2 1
	4 *In this system, data is received on time to take suitable actions and decisions.*	5 4 3 2 1
	5 *In this system, the data is always live data and up to date.*	5 4 3 2 1
	6 *In this system, the data was cleaning, cleansing, and profiling, so there are almost no errors in the data.*	5 4 3 2 1

1. I agree that the system based on DVDeM can help users to create the intended reports in right time. Yes ☐ No ☐
2. I agree that the system based on DVDeM can be used in business intelligence environment. Yes ☐ No ☐

Appendix D

Detail Results Of The Pilot Study

1. Reliability test of Measurement for Visibility Items

Reliability Statistics	
Cronbach's Alpha	N of Items
0.709	9

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
46.42	3.468	1.862	9

Item Statistics			
Items	Mean	Std. Deviation	N
V_Q1	5.12	.454	67
V_Q2	5.07	.252	67
V_Q3	5.18	.390	67
V_Q4	5.20	.403	67
V_Q5	5.10	.354	67
V_Q6	5.27	.446	67
V_Q7	4.98	.537	67
V_Q8	5.17	.740	67
V_Q9	5.33	.475	67

Item-Total Statistics				
Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
V_Q1	41.30	2.417	0.597	0.761
V_Q2	41.35	3.181	0.249	0.755
V_Q3	41.23	3.029	0.210	0.766
V_Q4	41.22	3.529	-0.148	0.758
V_Q5	41.32	2.864	0.399	0.750
V_Q6	41.15	3.248	0.013	0.737
V_Q7	41.43	2.589	0.342	0.759
V_Q8	41.25	2.597	0.135	0.760
V_Q9	41.08	2.790	0.285	0.760

2. Reliability test of Measurement for Flexibility Items

Reliability Statistics	
Cronbach's Alpha	N of Items
.719	5

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
25.55	1.736	1.318	5

Item Statistics			
Items	Mean	Std. Deviation	N
FL10	5.12	.409	67
FL11	5.10	.431	67
FL12	5.18	.458	67
FL13	5.25	.438	67
FL14	4.90	.526	67

Item-Total Statistics				
Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
FL10	20.43	1.310	.276	.740
FL11	20.45	1.221	.346	.748
FL12	20.37	1.328	.187	.733
FL13	20.30	1.303	.240	.746
FL14	20.66	1.077	.350	.737

3. Reliability test of Measurement for Learnability Items

Reliability Statistics	
Cronbach's Alpha	N of Items
0.725	4

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
20.57	1.673	1.294	4

Item Statistics			
Item	Mean	Std. Deviation	N
LR15	5.00	.426	67
LR16	5.19	.584	67
LR17	5.18	.386	67
LR18	5.19	.529	67

Item-Total Statistics				
Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
LR15	15.57	1.007	.567	.750
LR16	15.37	.722	.616	.739
LR17	15.39	1.726	.199	.748

LR18	15.37	.844	.566	.734

1. Reliability test of Measurement for Application Behavior Items

Reliability Statistics	
Cronbach's Alpha	N of Items
.771	6

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
31.03	2.908	1.705	6

Item Statistics			
Item	Mean	Std. Deviation	N
AB19	5.15	.359	67
AB20	5.31	.467	67
AB21	4.97	.651	67
AB22	5.21	.538	67
AB23	5.15	.500	67
AB24	5.24	.553	67

Item-Total Statistics				
Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
AB19	25.88	2.258	.483	.727
AB20	25.72	1.812	.697	.730
AB21	26.06	2.299	.094	.729
AB22	25.82	2.149	.298	.737
AB23	25.88	2.379	.181	.745
AB24	25.79	2.350	.149	.729

2. Reliability test of Measurement for Error Control & Help Items

Reliability Statistics	
Cronbach's Alpha	N of Items
.723	6

Item Statistics			
Item	Mean	Std. Deviation	N
EC25	4.94	.795	67
EC26	5.18	.650	67
EC27	5.45	.610	67
EC28	5.25	.560	67
EC29	5.36	.620	67
EC30	5.27	.592	67

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
31.45	6.190	2.488	6

Item-Total Statistics				
Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
EC25	26.51	4.526	.305	.745
EC26	26.27	4.260	.563	.717
EC27	26.00	5.394	.150	.740

EC28	26.19	4.492	.584	.721
EC29	26.09	4.477	.506	.743
EC30	26.18	4.089	.731	.732

3. Reliability test of Measurement for Near Real Time Decision Making Items

Reliability Statistics	
Cronbach's Alpha	N of Items
.745	6

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
31.52	4.950	2.225	6

Item Statistics			
Item	Mean	Std. Deviation	N
BI31	5.31	.583	67
BI32	5.25	.560	67
BI33	5.37	.599	67
BI34	5.13	.600	67
BI35	5.34	.478	67
BI36	5.10	.581	67

Item-Total Statistics					
Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
BI31	26.21	3.319	.608	.970	.734
BI32	26.27	3.715	.427	.754	.732
BI33	26.15	3.402	.539	.970	.738
BI34	26.39	3.393	.541	.906	.720

BI35	26.18	4.270	.228	.136	.742
BI36	26.42	3.641	.438	.761	.720

Appendix E

The Terminologies Definitions

	Terminologies	Definitions
1	**Extract, Transform, Load (ETL).**	*Three database functions that are combined into one tool to pull data out of one database and place it into another database.*
2	**Extract.**	*The process of reading data from a database.*
3	**Transform.**	*The process of converting the extracted data from its previous form into the form it needs to be in so that it can be placed into another database. Transformation occurs by using rules or lookup tables or by combining the data with other data.*
4	**Load.**	*The process of writing the data into the target database.*
5	**Line-of-business (LOB).**	*General term that describes the products or services offered by a business or manufacturer. A company that manufactures solid state disk drives, for example, might claim their LOB is data storage.*
6	**Operational Data Store (ODS).**	*An operational data store (or "ODS") is a database designed to integrate data from multiple sources for additional operations on the data. Unlike a master data store, the data is not passed back to operational systems. It may be passed for further operations and to the data warehouse for reporting.*
7	**Key Performance Indicator (KPI).**	*A business metric used to evaluate factors that are crucial to the success of an organization. KPIs differ per organization; business KPIs may be net revenue or a customer loyalty metric, while government might consider unemployment rates.*
8	**Comparative Analysis.**	*Comparative analysis refers to several existing models from previous studies being analyzed and*

		compared.
9	**Graphical User Interface (GUI).**	*A visual way of interacting with a computer using items such as windows, icons, and menus, used by most modern operating systems.*
10	**Evaluation Instrument (Q-U).**	*Evaluation Instrument used to measuring prototype usability in BI environment compressed of six attributes named: visibility, flexibility, learnability, application behavior, error control and help, and near real time decision making used for test usability of business intelligence prototype in business intelligence environment.*
11	**Information system (IS).**	*Any organized system for the collection, organization, storage and communication of information. More specifically, it is the study of complementary networks that people and organizations use to collect, filter, process, create and distribute data.*
12	**Artificial Intelligence (AI).**	*The theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.*
13	**Online Transaction Processing (OLTP).**	*A class of software programs capable of supporting transaction-oriented applications on the Internet. Typically, OLTP systems are used for order entry, financial transactions, customer relationship management (CRM) and retail sales.*
14	**Zero-latency enterprise (ZLE).**	*Any strategy that exploits the immediate exchange of information across technical and organizational boundaries to achieve business benefit*
15	**Conceptual Graph (CG).**	*A conceptual graph (CG) is a graph representation for logic based on the semantic networks of artificial intelligence and the*

		existential graphs of Charles Sanders Peirce. The research CGs have explored novel techniques for reasoning, knowledge representation, and natural language semantics.

Appendix F
The Descriptive Statistics for Education Sector

Q-U Instrument Attributes	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Visibility Items									
Item 1	30	1	4	5	125	4.170	0.069	0.379	0.144
Item 2	30	1	4	5	122	4.070	0.046	0.254	0.064
Item 3	30	1	4	5	124	4.130	0.063	0.346	0.120
Item 4	30	1	4	5	126	4.200	0.074	0.407	0.166
Item 5	30	2	3	5	122	4.070	0.067	0.365	0.133
Item 6	30	1	4	5	128	4.270	0.082	0.450	0.202
Item 7	30	1	4	5	124	4.130	0.063	0.346	0.120
Item 8	30	2	3	5	127	4.230	0.104	0.568	0.323
Item 9	30	1	4	5	130	4.330	0.088	0.479	0.230
Flexibility Items									
Item 1	30	2	3	5	124	4.130	0.079	0.434	0.189
Item 2	30	2	3	5	123	4.100	0.088	0.481	0.231
Item 3	30	2	3	5	125	4.170	0.084	0.461	0.213
Item 4	30	1	4	5	127	4.230	0.079	0.430	0.185
Item 5	30	2	3	5	118	3.930	0.082	0.450	0.202
Learnability Items									
Item 1	30	2	3	5	119	3.970	0.076	0.414	0.171
Item 2	30	2	3	5	125	4.170	0.108	0.592	0.351

Item 3	30	1	4	5	125	4.170	0.069	0.379	0.144
Item 4	30	2	3	5	125	4.170	0.097	0.531	0.282
Application Behavior Items									
Item 1	30	1	4	5	124	4.130	0.063	0.346	0.120
Item 2	30	1	4	5	129	4.300	0.085	0.466	0.217
Item 3	30	2	3	5	122	4.070	0.082	0.450	0.202
Item 4	30	2	3	5	125	4.170	0.097	0.531	0.282
Item 5	30	2	3	5	124	4.130	0.093	0.507	0.257
Item 6	30	2	3	5	127	4.230	0.104	0.568	0.323
Error Control & Help Items									
Item 1	30	2	3	5	120	4.000	0.117	0.643	0.414
Item 2	30	2	3	5	125	4.170	0.118	0.648	0.420
Item 3	30	2	3	5	132	4.400	0.113	0.621	0.386
Item 4	30	2	3	5	127	4.230	0.104	0.568	0.323
Item 5	30	2	3	5	130	4.330	0.111	0.606	0.368
Item 6	30	2	3	5	128	4.270	0.106	0.583	0.340
Near Real Time Decision Making Items									
Item 1	30	2	3	5	128	4.270	0.106	0.583	0.340
Item 2	30	2	3	5	127	4.230	0.104	0.568	0.323
Item 3	30	2	3	5	130	4.330	0.111	0.606	0.368
Item 4	30	1	4	5	127	4.230	0.079	0.430	0.185
Item 5	30	1	4	5	130	4.330	0.088	0.479	0.230
Item 6	30	2	3	5	123	4.100	0.111	0.607	0.369

Appendix G
The Descriptive Statistics for Business Sector

Q-U Instrument Attributes	N	Range	Min	Max	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Visibility Items									
Item1	30	2	3	5	123	4.100	0.088	0.481	0.231
Item2	30	1	4	5	122	4.070	0.046	0.254	0.064
Item3	30	2	3	5	122	4.070	0.082	0.450	0.202
Item4	30	1	4	5	126	4.200	0.074	0.407	0.166
Item5	30	2	3	5	122	4.070	0.082	0.450	0.202
Item6	30	1	4	5	127	4.230	0.079	0.430	0.185
Item7	30	2	3	5	119	3.970	0.102	0.556	0.309
Item8	30	2	3	5	124	4.130	0.115	0.629	0.395
Item9	30	2	3	5	128	4.270	0.117	0.640	0.409
Flexibility Items									
Item1	30	2	3	5	127	4.230	0.133	0.728	0.530
Item2	30	2	3	5	131	4.370	0.131	0.718	0.516
Item3	30	2	3	5	122	4.070	0.117	0.640	0.409
Item4	30	2	3	5	129	4.300	0.128	0.702	0.493
Item5	30	2	3	5	126	4.200	0.121	0.664	0.441
Learnability Items									
Item1	30	2	3	5	121	4.030	0.102	0.556	0.309
Item2	30	2	3	5	125	4.170	0.097	0.531	0.282

Item3	30	2	3	5	124	4.130	0.093	0.507	0.257
Item4	30	2	3	5	124	4.130	0.093	0.507	0.257
Application Behavior Items									
Item1	30	1	4	5	125	4.170	0.069	0.379	0.144
Item2	30	2	3	5	127	4.230	0.092	0.504	0.254
Item3	30	2	3	5	124	4.130	0.079	0.434	0.189
Item4	30	2	3	5	126	4.200	0.101	0.551	0.303
Item5	30	2	3	5	125	4.170	0.097	0.531	0.282
Item6	30	2	3	5	125	4.170	0.097	0.531	0.282
Error Control & Help Items									
Item1	30	2	3	5	126	4.200	0.111	0.610	0.372
Item2	30	2	3	5	129	4.300	0.119	0.651	0.424
Item3	30	2	3	5	130	4.330	0.111	0.606	0.368
Item4	30	2	3	5	124	4.13	0.115	0.629	0.395
Item5	30	2	3	5	129	4.30	0.128	0.702	0.493
Item6	30	2	3	5	127	4.23	0.124	0.679	0.461
Near Real Time Decision Making Items									
Item1	30	2	3	5	130	4.33	0.111	0.606	0.368
Item2	30	2	3	5	126	4.20	0.101	0.551	0.303
Item3	30	2	3	5	131	4.37	0.112	0.615	0.378
Item4	30	1	4	5	126	4.20	0.074	0.407	0.166
Item5	30	1	4	5	131	4.37	0.089	0.490	0.240
Item6	30	2	3	5	125	4.17	0.108	0.592	0.351

Appendix H
The DVDeM Prototype Pseudocode

The main procedure to achieve the organization requirements:

1- Connect To the server
2- Connect to sources databases
3- Understand and analysis the all tables and attributes in order to select which attribute are should import.
4- Verify data quality issues.
5- Create wrapper table by joined three tables (business, loan , and loan applicant), however, the wrapper table named as (MST_ relation) and it's consist of ten attributes named: [NoIC],[Nama],[AccNo],[SIS_Id],[SIS_Desc],[Status],[Status_Id],[Sp],[Upd_Date],and[Tkh_Ekstrak].
6- Create virtual Tables.
7- Apply GODV approach.
8- Create virtual tables and virtual data marts based on GODV.

Pseudocode

Start
1. Remove incorrect data like (Null data, out of rang data) if found.
For all table row;
If the row has null value then delete row
End if
2. Select the NoIC, Nama, AccNo, SIS_Desc , SIS_Id , Status, Status_Id, Sp , Upd_Date , and Tkh_Ekstrak by Joining business, loan, and loan applicant. Group them if necessary Order them by if necessary'.
3. Create the wrapper table.
End


```
CREATE VIEW [dbo].[v_PerformanceCategoriesbyBusinessSector]
AS
SELECT              COUNT(*) AS qty, LEFT(BUSNSS, 1) AS bussid, CASE WHEN
LEFT(BUSNSS, 1) = '1' THEN 'Argriculture'
                                                                WHEN
LEFT(BUSNSS, 1) = '2' THEN 'Manufacturing'

                              WHEN LEFT(BUSNSS, 1) = '3' THEN 'Wholesale'

                              WHEN LEFT(BUSNSS, 1) = '4' THEN 'Commerce'

                              WHEN LEFT(BUSNSS, 1) = '5' THEN 'Construction'

                              WHEN LEFT(BUSNSS, 1) = '6' THEN 'Services'

                              WHEN LEFT(BUSNSS, 1) = '7' THEN 'Others'

                              WHEN LEFT(BUSNSS, 1) = '8' THEN 'Transportation'

                              WHEN  LEFT(BUSNSS,  1)  =  '9'  THEN  'Others
Services'                                END AS CATEGORIES
FROM           dbo.BUSNINFO_D
WHERE       (LEFT(BUSNSS, 1) NOT IN ('A', ' '))
```

```
GROUP BY LEFT(BUSNSS, 1)
GO
```

Therefore, the Pseudocode to create virtual tables for this organization is:

Pseudocode Virtual Table1 V1:

```
Craete virtual table V1 as SELECT COUNT(*) AS count, SIS_Desc
FROM  dbo.tbl_MST_Relation
WHERE (SIS_Desc NOT IN ('NULL', 'Blacklist', 'Komputer', 'Pendahuluan',
'Pelajaran'))
GROUP BY SIS_Desc,
////////////////////////////////////////////////////////////////////////
```

Pseudocode Virtual Table1 V2:

```
Create virtual table V2 as SELECT COUNT(*) AS bil, LEFT(BUSNSS, 1) AS
bussid,
CASE WHEN LEFT(BUSNSS, 1) = '1' THEN 'Agriculture'
     WHEN LEFT(BUSNSS, 1) = '2' THEN 'Premises'
     WHEN LEFT(BUSNSS, 1) = '3' THEN 'Manufacturing'
     WHEN LEFT(BUSNSS, 1) = '4' THEN 'Commerce'
     WHEN LEFT(BUSNSS, 1) = '5' THEN 'Contractor'
     WHEN LEFT(BUSNSS, 1) = '6' THEN 'Services'
     WHEN LEFT(BUSNSS, 1) = '7' THEN 'Trading'
     WHEN LEFT(BUSNSS, 1) = '8' THEN 'Transportation'
     WHEN LEFT(BUSNSS, 1) = '9' THEN 'Other Services' END AS bussdesc
   FROM  dbo.BUSNINFO_D
   WHERE (LEFT(BUSNSS, 1) NOT IN ('A', ' '))  GROUP BY LEFT(BUSNSS, 1)
////////////////////////////////////////////////////////////////////////
```

Pseudocode Virtual Table1 V3:

```
Create virtual table V3 as SELECT TOP (100) PERCENT dbo.LEDGER_D.TRAN_AMT * -
0.01 AS AMT_withPoint, LEFT(CAST(dbo.LEDGER_D.PROC_DTE AS CHAR(8)), 4) AS
Tahun, SUBSTRING(CAST(dbo.LEDGER_D.PROC_DTE AS CHAR(8)), 5, 2) AS Bulan,
dbo.LEDGER_D.TRN_CENT_CODE, dbo.LOAN_M.DAERAH AS pusat, dbo.LEDGER_D.[TRAN]
FROM  dbo.LEDGER_D LEFT OUTER JOIN
dbo.LOAN_M ON dbo.LEDGER_D.LOANEE# = dbo.LOAN_M.LOANEE#
WHERE (dbo.LEDGER_D.[TRAN] = N'KA') OR
         (dbo.LEDGER_D.[TRAN] = N'DA') OR
         (dbo.LEDGER_D.[TRAN] = N'KB') OR
         (dbo.LEDGER_D.[TRAN] = N'DB') OR
         (dbo.LEDGER_D.[TRAN] = N'KR') OR
         (dbo.LEDGER_D.[TRAN] = N'DR')
ORDER BY bulan, tahun
```

(Education Sector)

The main procedure in Order to achieve this requirement:

1- Connect To the server
2- Connect to sources databases
3- Understand and analysis the all tables and attributes in order to select which attribute are should import.
4- Verify data quality issues.
5- Create wrapper table by joined three tables ['RAW DATA$'] INNER JOIN lec_Information INNER JOIN lec_Assessment ON lec_Information.Lecturer = lec_Assessment.Lecturer INNER JOIN lec_Resources ON lec_Assessment.Lecturer = lec_Resources.Lecturer INNER JOIN lec_Activities ON lec_Assessment.Lecturer = lec_Activities.Lecturer ON ['RAW DATA$'].Lecturer = lec_Assessment.Lecturer.

```
CREATE VIEW [dbo].[WRAPPER_ ACCOUNTING] AS SELECT
lec_Information.Lecturer,lec_Information.Lecturer_School,lec_Inform
ation.Information, lec_Resources.Resources,
lec_Activities.Activities, lec_Assessment.Assessment
FROM lec_Assessment INNER JOIN
lec_Activities INNER JOIN
lec_Resources INNER JOIN
lec_Information ON lec_Resources.Lecturer
= lec_Information.Lecturer ON lec_Activities.Lecturer =
lec_Information.Lecturer ON lec_Assessment.Lecturer =
lec_Information.Lecturer
GO
```

6- Create virtual Tables.
7- Apply GODV approach.
8- Create virtual tables and virtual data marts based on GODV.

In order to know the lecturer blended or not blended, we should calculate the assignment value, information, activities, and resources. It’s difficult to calculate all in one SQL-statement. Therefore, as mentioned in Chapter 5, there are multi-level databases tables should be joined.

Pseudocode Virtual Table1 V1:

```
CREATE VIEW [dbo].[FINAL] AS SELECT
DISTINCT(TEST_ACCOUNTING1.CourseShort), TEST6.Activities,
TEST6.Assessment, TEST6.Resources, TEST6.Information,
TEST_ACCOUNTING1.Lecturer
FROM TEST6 INNER JOIN
TEST_ACCOUNTING1 ON TEST6.Lecturer =
TEST_ACCOUNTING1.Lecturer
GO
```

Pseudocode Virtual Table1 V2:

```
CREATE VIEW [dbo].[FINAL1] AS SELECT
VIRTUAL_TABLE_LAST_RESULT1.IS_BLENDED, FINAL.CourseShort
FROM FINAL INNER JOIN
VIRTUAL_TABLE_LAST_RESULT1 ON
FINAL.Lecturer = VIRTUAL_TABLE_LAST_RESULT1.Lecturer
GO
```

Pseudocode Virtual Table1 V3:

```
CREATE VIEW [dbo].[virtual table-_ACCOUNTING1] AS SELECT
DISTINCT (TEST_ACCOUNTING.CourseFull),TEST_ACCOUNTING.Lecturer,
TEST_ACCOUNTING.Lecturer_School, TEST6.Information,
TEST6.Resources, TEST6.Assessment, TEST6.Activities
FROM TEST_ACCOUNTING INNER JOIN
TEST6 ON TEST_ACCOUNTING.Lecturer =
TEST6.Lecturer
GO
```