Management and Business Research Quarterly

2017(4) 1–11

Presenting a Model to Evaluate Information Visualization Methods to Apply in Business Intelligence

Mohammad Fathian*, Alireza Moini, Pouria Abedin

University of Science and Technology, Tehran, Iran.

Received 2 August 2017 Accepted 13 September 2017

ABSTRACT

Various features of different visualization methods can influence and facilitate decision-making and management processes. The purpose of this paper is to present a model to evaluate visualization methods for business intelligence in electronics stores. The population of the research is all managers in Tehran electronic stores and the sample size is 378; The data were collected, identified and questioned in the form of questionnaire. The model was tested through structural equations in LISREL software and the impact of all 8 key factors was confirmed.

Keywords: *Business Intelligence, Visualization, Decision-Making, Electronic Store, Visualization Evaluation*

Introduction

Information is an important part of human life nowadays. A large number of data were collected via various sources and stored in different types and formats. There is a problem due to the volume of information that is how to display information in the most effective way for the user. The main problem is how to represent and display information to the user in a noticeable way. In general, data collection is not inconvenient, but knowledge discovery and the information beyond it, is challenging. Visualization techniques make tangible a large volume of data and

 Correspond author E-mail address: fathian@iust.ac.ir

provide a new view of information for users (Khan, M., & Khan, S., 2011).
Visualization is defined as a relation between information and graphical representation. Images were used even before the advent of written language for data transfer. An image can be rich in information and much faster than words and pages to be understood and that is why the images are processed in parallel in human perceptual system and very quickly understood (Grinstein, Keim & Ward, 2015). The purpose of visualization is that the user understand a large amount of information easily (Khan, M., & Khan, S., 2011).

Up to date, many organizations are trying to prepare information in correct way and transfer it to employees and managers in the right time, to help them make proper decisions. Employees at each level of organization need to access important business information and they should have the required ability to analyze and share the information with vendors, partners and customers. Therefore, the need for a business intelligence system is felt in any organization. Since the strategic and important decisions of organization are made by top managers, the need in managerial positions, particularly in senior management posts. In the current era, as time goes ahead, Science and Technology progress dramatically. In the meantime, organizations will be more complex and controlling them will be more difficult due to the advent of needs and deep challenges, a huge amount of data and information may be useful for organizations, but this information will not be applied without analyzing and processing. This concept will be important when we accept that in each organization in addition to the huge and creative source of intelligent staff, intelligent technologies also play an important role in the process of organizations performance. Intelligent systems for large-scale data processing seem necessary. Business Intelligence by the help of decision-makers at every level of organization permits to access the information everywhere and anytime and understand and analyze them better (Rezai Dolatabady, Khorasani, 2015).

Business Intelligence has become the first priority of many organizations. They face difficulties in producing a lot of information in both national and international aspects. One of the aspects of business intelligence systems is in context of decision-making in which using this information provides a decision-making environment for managers. A decision-making environment is defined as a combination of different types of decisions taken and processing information needed for decision-makers. Two significant factors in this environment are kind of decision making and processing the required information. Processing information depends on the organizational issues and kind of decision-making varies according to specific cases. Gregory and Scott Morton**?** have provided a management framework of information for decision-making on the basis of the kinds of decision models (Işık, Jones, & Sidorova, 2013).
Based on available information, and the fact that the information processing and received information is very influential on decision-making, two issues can be expressed:

1. Decision making differs in each area according to the type of data of the field, type of processing and preparing information.

2. The information plays a key role in this part, in a way that false information or false expression and analysis of available information affect slightly business decision making.

As mentioned earlier, visualization as a tool to display immense and intricate information, is a user-friendly way. Considering the massive and complex nature of business intelligence information systems, visualization tools are consistently used as alternatives for the systems, because they cause not only a better visibility for managers but also, they make decision-making process fast and easy to understand.

Information visualization and business intelligence

Visualization techniques make understandable the massive and complex amount of information. Data visualization is a visual user interface that provides an insight of information for the user (Ware, 2012). The primary goal of visualization is the interactive visual representation of information that uses human perception and cognitive ability to solve problems. The purpose of visualization is that the user easily understand and interpret the complicated and large amount of information (Spence, 2001).

Many organizations are trying to prepare the information in its correct way and transfer it to employees and managers in the right time, to help them make proper decision. Employees at the organization need to access important business information and they should have the required ability to analyze and share the information with vendors, partners and customers. Since the strategic and important decisions of organization are made by top managers, the need in managerial posts, particularly in senior management posts. Intelligent technologies also play an important role in the process of organizations performance. Intelligent systems for large-scale information processing are necessary. Business Intelligence by the help of decision-makers at each level of organization permits to access the information everywhere and anytime and understand them better and analyze (Rezai Dolatabady, Khorasani, 2015). In this section, definitions of key words are defined.

The concept of visualization

Visualization is a mental image or a visual representation, object, scene, person or abstraction which is similar to human sensation and perception (Bashiri, Sadeghi, Shafi'i, 2013). Visualization has many definitions; a case that is referred to more, is the use of computer support, interaction and visual representations of data to develop understanding and provide knowledge which means human power of understanding or using knowledge (Card, Mackinlay & Shneiderman, 2009). Visualization is an accurate and effective graphical representation to clarify complex ideas. The graphical depiction can be easily understood and effectively interpreted (Campo & Teyseyre, 2009). The purpose of the visualization is analyzing, discovering and portraying the relationship of information in a way that is understandable (Kowalski & Maybury, 2006). Visualization is a powerful tool to use for various cognitive processes like exploratory, analytical and descriptive (Almond, Bergeron, Butler, Brodlie, Haber, 1993).

Business Intelligence

The term Business Intelligence developed by Gartner Group in the mid-1990s however; the term has become very popular recently and is rooted in MIS reporting systems in the 1970s. Reporting systems of static were used to be two-dimensional and unable to analyze, in the early 1980s, the concept of EIS (Executive Information System) was created. The concept raise computer support systems to senior and executive managers' levels. These systems had the capability of dynamic reporting and multi-dimensional (Ad hoc or on demand) forecasting, analysis of process, detailed examination, access to the position and key success elements.

The main concept of executive information system was changed to Business Intelligence; by 2005 business intelligence systems had artificial intelligence capabilities and high analytical abilities (Friedman, 2005).

Business Intelligence is a cover concept that involves architecture, tools, databases, applications and methodologies (Raisinghani, 2003). This concept is not related to the content and its meaning differs from human to other entities. A part of business intelligence confusion is due to the terms and tools (such as business performance management). The main goal of business intelligence is that it provides interactive accessibility (and sometimes on time) to data and data management and helps business managers to analyze their data. Decision-makers by analyzing current and historical data, positions and performances gain a good perspective and on the basis of this information, make better decisions (Kashner & Zaima, 2003).

Background of the research

In order to identify the factors influencing visualization on decision-making in business intelligence, different models have been used in previous researches. Table 1 shows some models along with the variables used in the proposed research.

Table 1. *The Models Raised in Previous Researches with the Variables*

Line	Reference Number	Variables investigated in the research
1	(Cava, Freitas, Luzzardi, Nedel, Pimenta, Winckler, 2002)	View all meaning and data on the screen, how to layout graphical representation, using graphic symbols for showing specific meanings, the duration of the restoration of graphic elements after the user command, settings for directions (Navigations), changing the user's view, search and represent specific data, data filtering and clustering
2	(Barnes, Craft, Dobrenz, Dornbush, Hunter, Morris, Stone, 2015)	Ability to increase team participation on decision-making, showing the past, present and future data, using a spreadsheet tool, the use of mobile phone and tablet, using graphical representation
3	(Yi, 2008)	Sorting data, weighting the data attributes, bar graph, showing all the information on a page, capability of highlight, capability of annotations with data, filtering data, coding data by color, viewing all information on one page
4	(Ahokas , 2008)	The ability to change scale of the charts, line graph, bar graph, pie chart, gauge, the possibility of moving elements on the page, using the same layout and design on other software, single-page reports, multi-page and isolated reports

5	(Grinstein, Keim & Ward, 2015)	The location and position of graphic elements on the page, graphical forms (associated with specific meanings), the amount of transparency
6	(Shneiderman, & Plaisant, 2006)	Refining, different levels of detail, view past history and information of each case, overview and summary of the whole data
7	(Kellen, 2005)	Color, table, graph, two-dimensional, three-dimensional, top-down view, bottom-up view
8	(Khan, M., & Khan, S. S., 2011)	Personalization of reports, using familiar layout to the user, single-page and multi-page reports

According to Table 1 and discussed cases, all the factors and characteristics of visualization that are effective on decision making are collected from the perspective of different researchers. Considering the importance, share of factors and overlapping meaning of some of the factors, finally a list included 40 factors of the most important factors have been recognized as effective factors. Table 2 shows the list of these factors.

Table 2. *The Effective Factors Extracted From Literature Review*

Line	Factors	Line	Factors	Line	factors	Line	Factors
1	View all information on the screen [16]	11	View present information [17]	21	Top-down view change [16]	31	Display as 3-Dimensional [21]
2	Layout and type graphical representation [16]	12	View future information [17]	22	Bottom-up view change [16]	32	Changeability of the graphical layout [21]
3	Special graphic symbols [16]	13	Reconfigure of settings [17]	23	Change scale of charts [21]	33	Handling elements on the page [2]
4	Time to display after the user command [16]	14	Adjust the level of abstraction [17]	24	Graphical summary [21]	34	Table to display information [21]
5	Show paths [16]	15	Ordering Information [18]	25	Annotation [18]	35	Graph to show information [21]
6	Change user view [16]	16	Weighting the elements and Showing related to it [18]	26	Display on Mobile and Tablet [16]	36	Bar graph [21]
7	Refining and clustering [16]	17	Display information on a page [18]	27	Using only one color [18]	37	Pie Chart [21]
8	Search information and display it [16]	18	Show information on Separate pages [18]	28	Use multi-color [18]	38	Histogram [21]
9	Team participation [17]	19	Change the name of field and display based on it [18]	29	Changeability of the color of the elements [18]	39	Gauge [21]
10	View past information [17]	20	Capabilities of highlighting the information [18]	30	Display as 2 - dimensional [21]	40	Adjusting the brightness [2]

Research method

In this study, first the literature was reviewed, then the effective factors were identified and argued and data needed to assess and measure the variables and approving or rejecting them were collected by questionnaire as a field study, the steps of research are shown in Figure 1.

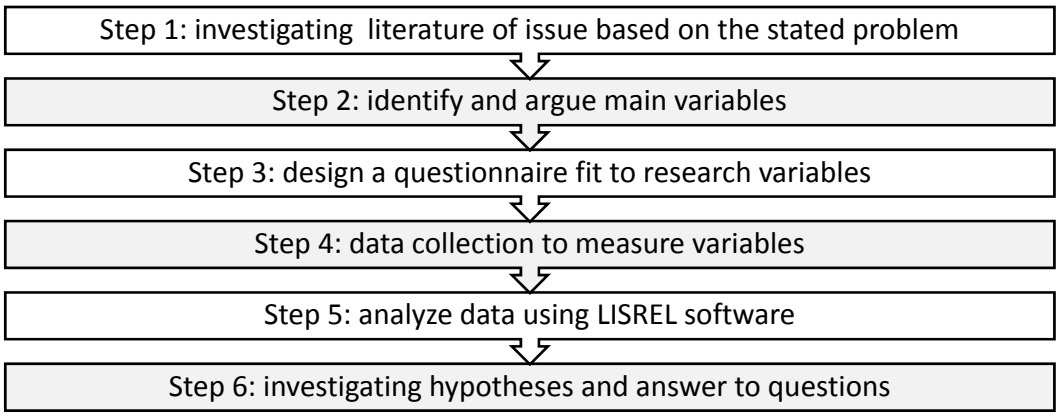

Figure1. Research steps

Research questionnaire

Based on 40 factors presented in Table 2, a questionnaire was designed and interviewed to 10 experts in the field as a pretest. After confirmation of questionnaire by experts, it was used for research data gathering.

Population and sampling

The population of this study is Iranian electronic stores' managers in Tehran. In this study, all participants of the sample had the same chance to be selected, so the simple random sampling method was used. According to Cochran, with the accuracy of 5%, the sample size of 378 people is suggested. Therefore, the sample size in this study is 378. The questionnaire consists of two parts of general and specific questions. The first section collects demographic information of respondents, which includes 6 questions about gender, age, marital status, education, and management experience and job position. The second part of the questionnaire contains 40 questions which are related to variables. The reliability was tested by Cronbach's alpha and its value is equal to 0.714 in which considering more than 0.7 is an appropriate and acceptable amount.

In this study, structural equation modeling and software LISREL are used for data analysis. To evaluate the suitability of data for factor analysis, indicators of KMO and Bartlett's test are used. KMO index is an index for sampling adequacy. The index is in the range of 0 to 1. If the index value is close to one, the data are suitable for factor analysis otherwise (usually less than 0.6) results of factor analysis to the data is undesirable. The Bartlett's test compares the observed correlation matrix to the identity matrix. It checks if there is a certain redundancy between the variables that we can summarize with a few number of factors. If significance of Bartlett test is smaller than 5% (sig <0.05), the factor analysis to identify the structure (factor model) is appropriate, because the assumption of recognizing correlation matrix is rejected (Faal Ghaiyoomi, and Momeni, 2010).

Investigating the total validity of the model

In order to extract key factors in the study, exploratory factor analysis is used. To meet the aim, principal components analysis was used with Varimax rotation. In the exploratory analysis, first indicators of Kaiser- Meyer- Olkin (KMO=0.869; Chi Square= 10453.987) and Bartlett's test P=0.000 are calculated and after ensuring the ability of factor analysis, process of analysis was done.

There are a wide range of criteria and fit indicators that can be used to measure the fit of the model. Unfortunately, none of these are superior in all respects than others. Because a particular fit index to the sample size, the method of estimation, model complexity or a combination of the above conditions acts differently. Hence, different people depending on the model conditions might use various parameters for fitness of model (Freitas, et al., 2002). Therefore, various measures are applied to evaluate the fit of the model in this study that include:

RMSEA index is applied in most of the confirmatory factor analysis and structural equation modeling.

When the value of this statistic is less than 0.05, it shows that the model has a good fitness, if the value is between 0.05 and 0.08, the fitness is acceptable, if it is between 0.08 and 0.1, the fitness is average and if it is greater than 0.1, the fitness is poor.

Normalized Chi Square index is one of the general indicators to consider the free parameters in calculating fitting indices of normalized chi-square index that is calculated from simple division of Chi Square on degree of freedom. The values below 3 of this index are acceptable. GFI index is the most important tests of fitting structural equation modeling. The index does not depend on the sample size. GFI ranges between zero and one. GFI must be equal or greater than 0.9, index NFI that is called the index of Bentler-Bonnet is acceptable for high levels of 2.9 and shows the fitness of model. Index CFI is acceptable for higher than 2.9 and shows the fitness of model. CFI index in terms of meaning is as NFI. The only difference is **that fines for?** the volume of sample. NNFI index though its value is resistant to the volume of sample group, but because its range is not limited to zero and one, its interpretation is more difficult than NFI. Based on the contract, the values less than 0.9 require revising in the model. It can be used in two directions. Compare two or more models with the same data and compare the hypothesized model with a zero model. If its value is more than one, it is considered as one.

Research Findings

According to conducted analysis using LISREL software, out of 40 studied factors, one factor was not confirmed in this study and finally of 39 factors, 8 key factors were identified that after reviewing research literature, these key factors were labeled. These key factors include: using graphical tools showing information, quick access to data, changing data view, display the appropriate graphic symbols, group decision and emphasis on future information, filtering information, view full details of information and color.

In general, applying LISREL software leads to the conclusion that each of the indices itself,

obtained for the model, doesn't indicate that this model is fit enough. In some resources, for chi-square proportion to the degree of freedom, the value below three is acceptable that in the model of this research, the value is calculated as 2.98. GFI criterion represents a measure of the relative amount of variances and covariance that is explained by the model. The criterion varies between zero and one that whatever is closer to number one, goodness of fit with the observed data is more. GFI amount reported for the model is 0.93. Root mean square of residuals is considered if the difference between elements of observed matrix in sample group and matrix elements estimated or predicted assuming the truth of model. To check how a model acts well specially compared with other possible models, in terms of explaining sets of observed data, the values of normalized fitness index (NFI), non-normalized fitness index (NNFI), increasing fitness index (IFI) and comparative fit index (CFI) are used. Values above 0.9 indicate the much desired fitness of designed model compared to other possible models.

Finally, to investigate how the considered model combines the fitness and saving, the very capable index of square root of the variance estimation of error of approximation RMSEA is applied. Index RMSEA is root mean square approximation and for the research model, 0.073 is estimated.

Table 4 indicates that the data of this study, have a desired fit with the factor structure and theoretical underlying of research and indicates the alignment of questions with theoretical structures.

Table 4. *Interpreting Structural Equation Model*

Index name	Estimate main models	Permitted limit
Chi Square on the degree of freedom	2.98	Less than 3
(GFI) goodness of fit	0.93	Higher than 0.9
(RMSEA) root mean square error of estimate	0.073	Less than 0.09
(CFI) modified fitness	0.91	Higher than 0.9
(NFI) normalized fitness	0.95	Higher than 0.9
(NNFI) non-normalized fitness	0.94	Higher than 0.9
(IFI) increased fitness	0.93	Higher than 0.9

Another type of relationship between latent variables in structural equation modeling is from the direct effect. In fact, direct effect is one of the constituents of the structural equation models and shows an oriented relationship between the two variables. This type of effect in fact indicates assumed linear causal effect of one variable on another variable. Within a model, each direct effect specifies and expresses relationships between a dependent variable and independent variable.

Although a dependent variable in other direct effect can be independent variable and vice versa. In this study, based on eight key factors identified for each of these factors, a hypothesis to verify the impact of each key factor on making decision is supposed. The results obtained of this method can be seen in Table 5.

Coefficient of determination (R Square) shows how much the investigated factors could

affect the decision. This coefficient has been reported for this model 0.765. So examining factors will have a significant impact on decision-making.

Table 5. *Path Coefficients, T-Statistics and Hypotheses Results*

Hypotheses	Path coefficient (β)	t static	Coefficient of determination	Sig level	Result of research hypothesis
Impact of monitoring tools	1.10	12.85	0.765	<0.05	Confirmed
Impact of rapid access	14.81	0.34		<0.05	Confirmed
Impact of the changeability of vision	19.38	1.17		<0.05	Confirmed
Impact of display symbols	12.42	1.01		<0.05	Confirmed
Impact of group decision	17.83	0.82		<0.05	Confirmed
Filtering impact	8.75	0.26		<0.05	Confirmed
Full display of information	8.43	1.43		<0.05	Confirmed
Color	12.68	11.0		<0.05	Confirmed

According to the results in the table above, display tools, quick access, the ability to change, display symbol, group decision-making, refining, full display of information and color are effective factors on making decisions to apply in business intelligence of electronic stores, as it is mentioned, all hypothesis are confirmed. Each of these 8 key factors has factors or indicators that in fact, are the same questions of questionnaire. Using software output LISREL, percentage of the impact of each key factor has been determined. Prioritizing the key factors of visualization on decision making is done based on the load factor, with the results in Table 6.

Table 6. Prioritizing Key Factors and the Percent of Impact of Each Factor

Line	Key Factor	Factor (percent of impact)	Percent
1	the use of information display tools (such as graphs and tables)	1. Bar chart (16.316) 2. Histogram (13.447) 3. Pie chart (13.228) 4. Graph to show information (12.826) 5. Gauge (11.821) 6. Adjusting the brightness (11.419) 7. Table to show information (10.835) 8. Display information on a page (10.104)	18.983
2	quick access to information and proper display	1. View past information (17.507) 2. Special graphic symbols (16.106) 3. Search information and display it (15.351) 4. Time to display after user command (15.265) 5. View present information (13.001) 6. Change user view (11.858) 7. Show paths (10.909)	16.796
3	the ability to change the type of vision to data	1. Graphical summary (17.516) 2. Annotation (17.246) 3. Change scale of charts (16.291) 4. Display on mobile and tablet (13.277) 5. Top-down and bottom-up view change (13.057) 6. Capabilities of highlighting the information (11.955) 7. Show information in separated pages (10.754)	15.374

4	display the appropriate graphic symbols	1. Display as 3D (19.448) 2. Handling elements on the page (18.235) 3. Special color for elements (17.642) 4. Display as 2D (17.358) 5. Changeability of the graphical layout (15.037) 6. Change the name of field and display based on it (12.277)	15.244
5	group decision making and emphasis on important information of future	1. Display future information (23.354) 2. Reconfigure of settings (22.319) 3. Team participation (21.598) 4. Weighting elements (18.464) 5. Sort information (14.263)	11.739
6	refining the information and display it	1. Adjust the level of abstract (39.112) 2. Layout and type of graphical representation (37.799) 3. Refining and clustering (23.087)	8.351
7	full display of information	1. Show all information on display (100)	6.918
8	Color	1. Use multicolor (54.526) 2. Using one color (45.473)	6.591

Conclusion

According to the results of this study, the effective factors of visualization on decision-making for using in business intelligence of electronic stores were extracted and classified with exploratory factor analysis in 8 key factors and 39 sub-factor. Eight key factors are: the use of information display devices (such as graphs and Tables), quick access to information and proper display, the ability to change the type of vision to data, display appropriate graphic symbols, group decision making and emphasis on important upcoming information, refining the information and displaying it, full display of information and color. To provide and analyze a conceptual model structural equation modeling is applied. It is concluded that there is a positive and significant relationship between the variables at 95 percent confidence level.

Prioritizing effective factors of visualization on decision-making is based on factor load. According to the results obtained, information display devices (graphs and Tables), quick access to information and proper display, the ability to change the type of vision to data, display the appropriate graphic symbols, group decision making and emphasis on important future information, refining and displaying information, full display of information and color have allocated the priority of first to eighth respectively.

References

Ahokas, T. (2008). Information visualization in a business decision support system.

Bashiri, M., Sadeghi, H., Shafi'i, S. (2013). *An analysis of the impact of business intelligence on strategic decisions.* Seventh National Conference and the first international conference on electronic commerce and economy. Iran Electronic Commerce Association.

Butler, D. M., Almond, J. C., Bergeron, R. D., Brodlie, K. W., & Haber, R. B. (1993, October). Visualization reference models. In *Proceedings of the 4th conference on Visualization'93* (pp. 337-342). IEEE Computer Society.

Card, S., Mackinlay, J. D., & Shneiderman, B. (2009). Information visualization. *Human-computer interaction: Design issues, solutions, and applications*, *181*.

Craft, M., Dobrenz, B., Dornbush, E., Hunter, M., Morris, J., Stone, M., & Barnes, L. E. (2015, April). An assessment of visualization tools for patient monitoring and medical decision making. In *Systems and Information Engineering Design Symposium (SIEDS), 2015* (pp. 212-217). IEEE.

Friedman, T. (2005). Gartner says more than 50 percent of data warehouse projects will have limited acceptance or will be failures through 2007. *Retrieved February*, *21*, 2007.

Freitas, C. M., Luzzardi, P. R., Cava, R. A., Winckler, M., Pimenta, M. S., & Nedel, L. P. (2002, May). On evaluating information visualization techniques. In *Proceedings of the working conference on Advanced Visual Interfaces* (pp. 373-374). ACM.

Işık, Ö., Jones, M. C., & Sidorova, A. (2013). Business intelligence success: The roles of BI capabilities and decision environments. *Information & Management*, *50* (1), 13-23.

Kellen, V. (2005). Decision making and information visualization: research directions. *Retrieved November*, *11*, 2005.

Khan, M., & Khan, S. S. (2011). Data and information visualization methods, and interactive mechanisms: A survey. *International Journal of Computer Applications*, *34*(1), 1-14.

Kowalski, G. J., & Maybury, M. T. (2006). *Information storage and retrieval systems: theory and implementation* (Vol. 8). Springer Science & Business Media.

Momeni, M., *and* Faal Ghaiyoomi, *A. (*2007). The *statistical analyzes using SPSS.* Ketab No Publication, First Edition, Tehran.

Raisinghani, M. S. (Ed.). (2003). *Business Intelligence in the Digital Economy: Opportunities, Limitations and Risks: Opportunities, Limitations and Risks*. Igi Global.

Rezai Dolatabady, H., Khorasani, M. (2015). *Providing successful solutions of business intelligence as a powerful tool in organizational entrepreneurship*. The first International Conference on Management, Economics, Accounting and Educational Sciences. Research and consulting company of Ayandesaz, PNU Neka.

Shneiderman, B., & Plaisant, C. (2006, May). Strategies for evaluating information visualization tools: multi-dimensional in-depth long-term case studies. In *Proceedings of the 2006 AVI workshop on BEyond time and errors: novel evaluation methods for information visualization* (pp. 1-7). ACM.

Spence, R. (2001). *Information visualization* (Vol. 1). Reading: Addison-Wesley.

Teyseyre, A. R., & Campo, M. R. (2009). An overview of 3D software visualization. *IEEE transactions on visualization and computer graphics*, *15*(1), 87-105.

Ward, M. O., Grinstein, G., & Keim, D. (2010). *Interactive data visualization: foundations, techniques, and applications*. CRC Press.

Ware, C. (2012). *Information visualization: perception for design*. Elsevier.

Yi, J. S. (2008). *Visualized decision making: development and applications of information visualization techniques to improve decision quality of nursing home choice*. Georgia Institute of Technology.

Zaima, A., & Kashner, J. (2003). A data mining primer for the data warehouse professional. *Business Intelligence Journal*, *8*, 44-54.