CONCEPTUAL DESIGN FRAMEWORK FOR INFORMATION VISUALIZATION TO SUPPORT MULTIDIMENSIONAL DATASETS IN HIGHER EDUCATION INSTITUTIONS

AKANMU SEMIU AYOBAMI

DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
2016

Awang Had Salleh
Graduate School
of Arts And Sciences

Universiti Utara Malaysia

PERAKUAN KERJA TESIS / DISERTASI
(Certification of thesis / dissertation)

Kami, yang bertandatangan, memperakukan bahawa
(We, the undersigned, certify that)

AKANMU SEMIU AYOBAMI

calon untuk Ijazah PhD
(candidate for the degree of)

telah mengemukakan tesis / disertasi yang bertajuk:
(has presented his/her thesis / dissertation of the following title):

"CONCEPTUAL DESIGN FRAMEWORK FOR INFORMATION VISUALIZATION TO SUPPORT MULTIDIMENSIONAL DATASETS IN HIGHER EDUCATION INSTITUTIONS"

seperti yang tercatat di muka surat tajuk dan kulit tesis / disertasi.
(as it appears on the title page and front cover of the thesis / dissertation).

Bahawa tesis/disertasi tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan, sebagaimana yang ditunjukkan oleh calon dalam ujian lisan yang diadakan pada : *31Julai 2016.*
That the said thesis/dissertation is acceptable in form and content and displays a satisfactory knowledge of the field of study as demonstrated by the candidate through an oral examination held on: ***July 31, 2016.***

Pengerusi Viva: *(Chairman for VIVA)*	**Prof. Dr. Suhaidi Hassan**	Tandatangan *(Signature)*
Pemeriksa Luar: *(External Examiner)*	**Prof. Dr. Abdul Azim Abd Ghani**	Tandatangan *(Signature)*
Pemeriksa Dalam: *(Internal Examiner)*	**Assoc. Prof. Dr. Haslina Mohd**	Tandatangan *(Signature)*
Nama Penyelia/Penyelia-penyelia: *(Name of Supervisor/Supervisors)*	**Prof. Dr. Zulikha Jamaludin**	Tandatangan *(Signature)*

Tarikh:
(Date) ***July 31, 2016***

Permission to Use

In presenting this thesis in fulfilment of the requirements for a postgraduate degree from Universiti Utara Malaysia, I agree that the Universiti Library may make it freely available for inspection. I further agree that permission for the copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or, in their absence, by the Dean of Awang Had Salleh Graduate School of Arts and Sciences. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to:

Dean of Awang Had Salleh Graduate School of Arts and Sciences
UUM College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM Sintok

Ikhtisar

Visualisasi maklumat (InfoVis) digunakan dalam pelbagai aplikasi kerana keupayaannya menyelesaikan masalah lambakan maklumat dalam data institusi. Para pembuat polisi dan pembuat keputusan di institusi pengajian tinggi (IPT) juga tidak terlepas daripada masalah lambakan maklumat semasa berinteraksi dengan data pelajar disebabkan oleh kepelbagaian dimensinya. Hal ini mengekang proses pembuatan keputusan dan kerana itu satu kerangka kerja reka bentuk konsep InfoVis tersendiri diperlukan untuk menghasilkan alatan InfoVis khusus domain. Sehubungan itu, matlamat kajian ini adalah untuk mereka bentuk kerangka kerja InfoVis yang dilengkapi dengan teknik penyampaian kandungan dan proses sistematik dalam menzahirkan InfoVis khusus domain bagi menangani data pelajar IPT. Terdapat empat fasa yang terlibat dalam kajian ini: 1) kajian pengguna untuk mengkaji, mendapat dan memberi keutamaan pada data pelajar yang menjadi pilihan kepada polisi IPT. Dimensi data pelajar yang sepadan kemudiannya dikategorikan, 2) kajian tinjauan melalui analisis kandungan terhadap kepustakaan reka bentuk InfoVis, dan padanan terhadap dapatan daripada kajian pengguna untuk mencadangkan teknik visualisasi, interaksi dan herotan yang sesuai, 3) pembangunan reka bentuk kerangka kerja secara konsep yang menyepadukan model teknik tersebut dengan proses reka bentuk berpandukan penyesuaian kejuruteraan perisian dan model reka bentuk InfoVis, 4) penilaian terhadap kerangka kerja yang dicadangkan melalui tinjauan pakar, prototaip, penilaian heuristik, dan penilaian pengalaman pengguna. Bagi sebuah InfoVis yang mampu menyampai dan mewakili pilihan pengetahuan eksplisit, serta menyokong kepelbagaian dimensi data pelajar dan proses pembuatan keputusan, kajian mendapati bahawa 1) *mouse-on*, *mouse-on-click*, *mouse on-drag*, *drop down menu*, *push button*, kotak semak, dan *dynamics cursor hinting* adalah teknik yang sesuai untuk interaksi, 2) *zooming*, gambaran menyeluruh dengan perincian, penatalan, dan eksplorasi adalah teknik yang sesuai untuk herotan, dan 3) carta garis, *scatter plot*, *map view*, carta bar dan carta pai adalah teknik yang sesuai untuk visualisasi. Sokongan teori kepada kerangka kerja yang dicadangkan mengesyorkan bahawa ketetapan dalam *preattentive processing theory*, *cognitive-fit theory*, dan *normative and descriptive theories* mesti diikuti bagi membolehkan InfoVis membantu persepsi, kognisi dan pembuatan keputusan. Kajian ini menyumbang kepada bidang InfoVis, proses pembuatan keputusan berpandukan data, dan proses penggunaan data pelajar.

Kata Kunci: Visualisasi maklumat, Institusi pendidikan tinggi, Kerangka kerja reka bentuk konsep, teknik penyampaian kandungan, proses pembuatan keputusan berpandukan data.

Abstract

Information Visualization (InfoVis) enjoys diverse adoption and applicability because of its strength in solving the problem of information overload inherent in institutional data. Policy and decision makers of higher education institutions (HEIs) are also experiencing information overload while interacting with students' data, because of its multidimensionality. This constraints decision making processes, and therefore requires a domain-specific InfoVis conceptual design framework which will birth the domain's InfoVis tool. This study therefore aims to design HEI Students' data-focused InfoVis (HSDI) conceptual design framework which addresses the content delivery techniques and the systematic processes in actualizing the domain specific InfoVis. The study involved four phases: 1) a users' study to investigate, elicit and prioritize the students' data-related explicit knowledge preferences of HEI domain policy. The corresponding students' data dimensions are then categorised, 2) exploratory study through content analysis of InfoVis design literatures, and subsequent mapping with findings from the users' study, to propose the appropriate visualization, interaction and distortion techniques for delivering the domain's explicit knowledge preferences, 3) conceptual development of the design framework which integrates the techniques' model with its design process –as identified from adaptation of software engineering and InfoVis design models, 4) evaluation of the proposed framework through expert review, prototyping, heuristics evaluation, and users' experience evaluation. For an InfoVis that will appropriately present and represent the domain explicit knowledge preferences, support the students' data multidimensionality and the decision making processes, the study found that: 1) mouse-on, mouse-on-click, mouse on-drag, drop down menu, push button, check boxes, and dynamics cursor hinting are the appropriate interaction techniques, 2) zooming, overview with details, scrolling, and exploration are the appropriate distortion techniques, and 3) line chart, scatter plot, map view, bar chart and pie chart are the appropriate visualization techniques. The theoretical support to the proposed framework suggests that dictates of preattentive processing theory, cognitive-fit theory, and normative and descriptive theories must be followed for InfoVis to aid perception, cognition and decision making respectively. This study contributes to the area of InfoVis, data-driven decision making process, and HEI students' data usage process.

Keywords: Information Visualization, Higher Education Institutions, Conceptual Design Framework, content delivery techniques, data-driven decision making process

Acknowledgement

First and foremost, I give all thanks to Allah for providing me with the spiritual and intellectual strength needed to accomplish this study. I also appreciate all individuals who contributed to the successful completion of this study. Without you all, this journey would not have been rewarding.

I would like to express my deepest gratitude to my supervisor; Prof. Dr. Zulikha Jamaludin, for her excellent mentorship, motherly care, patience and unflinching financial and moral support throughout this study.

My sincere appreciation is to Universiti Utara Malaysia. The award of Postgraduate Scholarship and PhD Incentive Schemes greatly aided my study. The effect of the financial support towards the necessary emotional stability during the scholarly journey cannot be overemphasised. Also, I want to thank all experts who shared their experiences with me in view of actualizing a reliable outcome.

On a personal note, I want to thank my parents, parents-in-law and all members of our family for their love and prayers. I would also like to extend special appreciation to my wife; Mutiat Folasade, and my kids; Habeebulah and Aadiyatulah, for their perseverance, understanding and love.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

2D	Two Dimensional
3D	Three Dimensional
ACM	Association of Computing Machineries
BI	Business Intelligence
DSS	Decision Support System
EDA	Exploratory Data Analytics
HCI	Human Computer Interaction
HEI	Higher Education Institution
HSDI	HEI Students' Data InfoVis
ICT	Information Communication Technology
IEEE	Institute of Electrical and Electronic Engineers
InfoVis	Information Visualization
JSON	JavaScript Object Notation
UCD	Users-centered Design

CHAPTER ONE
BACKGROUND OF THE STUDY

1.1 Introduction

This chapter espouses the need for Information Visualization framework to support students' data-related decision making process of higher education institutions. It provides the overview of the study, motivation, and the preliminary investigation. This chapter discusses the problem statement, enlists the research questions and the research objectives of this study. It highlights the scope which signifies the boundary of the research conducted. The research deliverables, the study's contributions, research design that explains the research framework and the thesis structure are also included. Lastly, a summary of the chapter is presented.

1.2 Overview of the Study

Information Visualization (InfoVis) is a branch of Visualization if seen as a field of study (Spence, 2007; Sheneiderman & Plaisant, 2010). In this respect, there is also scientific visualization which borders on representation of scientific data such as tensor data, unsteady flow, model and software using appropriate technique and tools (Wright, 2007).

Ware (2000), however, defines visualization as a graphical representation of concepts and data in a manner that supports decision making. Visualization, as human activity, had been in existence far before the computing era. It characterises the period of cave painting, imagery of human and all forms of ancient artistic

The contents of the thesis is for internal user only

REFERENCES

Alavi, M., & Joachimsthaler, E.A. (1992). Revisiting DSS implementation research: a meta-analysis of the literature and suggestions for researchers, *MIS Quarterly, 16* (1), 95–116

Ankerst, M., Keim, D. A., & Kriegel, H.-P. (1996). Circle segments: A technique for visually exploring large multidimensional datasets, *in Proc. Visualization 96*, Hot Topic Session, San Francisco, CA, 1996.

Ariffin, M. (2009). *Conceptual Design of Reality learning Media (RLM) Model Based on Entertaining and Fun Construct.* A PhD Thesis submitted to College of Arts and Science, Universiti Utara Malaysia.

Aris, A., & Shneiderman, B. (2007). Designing semantic substrates for visual network exploration, *Journal of Information Visualization*, *6* (4), 281–300.

Arkhipenkov, S., & Goluber, D. (2001). *Oracle Express Olap*., USA: Charles River Media.

Ayres, L. (2007). Qualitative Research Proposal – Part I: Posing the problem. *Journal of Wound Ostomy Continence Nursing, 34,* 30–32.

Babbie, E. (2010). *The Practice of Social Research*, 12th Edition. USA: Wadsworth Cengage Learning.

Baker, D., Bridges, D., Hunter, R., Johnson, G., Krupa, J., Murphy, J. & Sorenson, (2002). *Guidebook to Decision-Making Methods*, WSRC-IM-2002-00002, USA: Department of Energy.

Balakrishnam, N., Render, B. & Stair, M.R. (2012). *Managerial Decision Making with Spread sheet*, 2nd Edition. USA: Pearson International.

Barab, S., & Squire, K. (2004). Design-based research: putting a stake in the ground. *Journal of the Learning Sciences*, 13, 1-14. DOI: 10.1.1.128.5080

Battista, V., & Cheng, E. (2011). Motion Charts: Telling Stories with Statistics. *In Section on Statistical Graphics*, JSM 2011. Retrieved from http://www.bls.gov/osmr/pdf/st110110.pdf on 3rd October, 2016.

Benoit, G. (2012). Measuring Relevance Theory's Effects in an Image-Driven Explorative Information System, *Proceedings of iConference, 2012*, Toronto, Canada. ACM, pp. Pages 438 – 440.

Bier, E. A., Stone, M. C., & Pier, K., Buxton, W., & DeRose, T. (1993). Toolglass and magic lenses: The see-through interface, *in Proc. SIGGRAPH '93*, Anaheim, CA, 1993, pp. 73–80.

Bogard, M., & Green, B. (2013). *A Data Driven Analytic Strategy for Increasing Yield and Retention at Western Kentucky University Using SAS Enterprise BI*

and SAS Enterprise Miner, Paper 044, presented at SAS Global Forum, 2013, pp. 1 – 12.

Bonner, N. (2008). *Acceptance of Systems Development Methodologies: Testing A Theoretically Integrated Model.* PhD Thesis. The University of Texas Arlington.

Bowen, J.P. (2013). Online Communities: Visualization and Formalization, *Proceedings of the Second International Workshop on Cyberpatterns: Unifying Design Patterns with Security, Attack and Forensic Patterns*. Abingdon, UK, 8-9 July 2013

Boy, J., Detienne, F., & Fekete, J-D. (2015). Can Initial Narrative VisualizationTechniques and Storytelling help Engage Online-Users with Exploratory Information Visualizations? *2015 Association for Computing Machinery, CHI 2015*, April 18 - 23 2015, Seoul, Republic of Korea http://dx.doi.org/10.1145/2702123.2702452

Bresfelean, V.P., Ghisoiu, N., Lacaurezeanu, R., & Sitar-Taut, D.A (2009). Towards the Development of Decision Support in Academic Environments, *Proceedings of International Conference on Information Technology Interfaces,* ITI, '09, pp. 343- 348

Brooke, J. (2009). *SUS: A quick and dirty usability Scale*, In Jordan, P.W., Thomas, B., Weerdmeester, B.A., & McClelland, I.L. (Eds) Usability Evaluation In Industry. London: Taylor & Francis.

Buja, A., Cook, D., & Swayne, D. F. (1996). *Interactive High-Dimensional*. UK: Wiley

Card, S.T., Mackinlay, J. & Shneiderman, B. (1999). *Readings in Information Visualization: Using Vision to Think*, United States of America: Morgan Kaufmann Publishers.

Carrasco, J-A., Hogan, B., Wellman, B., & Miller, E. J. (2006). Collecting Social Network Data yo Study Social Activity-Travel Behaviour: An Egocentric Approach, presented at the 85th *Transportation Research Board Meeting*, Washington DC, January 22-26, 2006.

Carroll, J. M. (2000). *Making use scenario-based design of human-computer interactions.* Cambridge, MA: MIT Press.

Chan, Y.H., Correa, C.D., & Ma, K-L. (2013). The Generalized Sensitivity Scatterplots. *IEEE Transaction on Visualization and Computer Graphics*, IEEE computer Society 19(10), pp. 1768 - 81

Chenail, R. J. (2012). Conducting Qualitative Data Analysis: Reading Line-by-Line, but Analyzing by Meaningful Qualitative Units. *The Qualitative Report*, 17 (1), 266 – 269. Retrieved from http://www.nova.edu/ssss/QR/QR17-1/chenail-line.pdf on 4th December, 2015.

Chi, h H. (2000). A taxonomy of visualization techniques using the data state reference model. *In Proceedings of the IEEE Symposium on Information Visualizations 2000*, INFOVIS '00, pages 69 – 76 Washington, DC, USA, 2000. IEEE Computer Society.

Chin, J.P., Diehl., V.A., & Norman, K.L. (1988). Development of an Instrument Measuring User Satisfaction of the Human Computer Interface. *ACM CHI* '88 proceedings, pp. 213-218

Christina, N., Julian, A., & Micheal, S. (2016). Visual Exploration of Media Transparency for Data Journalists: Problem Characterization and Abstraction, Retrieved from: http://www.validproject.at/wp--content/uploads/2015/11/151031_AusserhoferGutounigOppermann--Dubrovnik_Dubrovnik.pdf, 15 August, 2016.

Chuah, M. C., & Roth, S. F. (1996). On the Semantics of Interactive Visualizations, *Proceedings of IEEE Symposium on Information Visualization*, San Francisco, CA, pp. 29- 36.

Codd, E.F., Codd S.B., & Salley G.T. (1993). *Providing OLAP (Online Analytical Processing) to User-Analysis: AN I.T Mandate.* Hyperion Solution Corporation. Retrieved from: http://www.hyperion.com/solution/whitepapers.cfm on 15/08/13

Cohen, J. W. (1988). *Statistical power analysis for behavioural sciences* (2nd edn). Hillsdale, NJ: Lawrence Erlbaum Associates

Collier, K. (2015). You've Got the Data, Now What? Data Driven Decisions for School Improvement. Retrieved from http://engage.ok.gov/wp-content/uploads/2015/07/98-Data-Driven-Decision-Making-PPT-June-8-2015.pdf on 15th August, 2016.

Connolly, T. & Begg, C. (2010). *Database Systems: A Practical To Design, Implementation, and Management.* Fifth Edition, Boston: Pearson Education Inc.

Conrad, C., Gasman, M., Lundberg, T., Nguyen, T-H., Commodore, F., & Samayoa, A.C. (2013). *Using Educational Data to Increase Learning, Retention, and Degree Attainment at Minority Serving Institutions (MSIs).* A Research Report of Penn Graduate School of Education, GSE.

Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). *About Face: Essentials of Interaction Design,* Fourth Edition. USA: Wiley.

Cordeiro, R.L., Traina, C., Traina, A.J.M., Lopez, J., Kang, U. & Faloutsos, C. (2011). Clustering Very Large Multi-dimensional Datasets with MapReduce, *in Proceedings of KDD, ACM,* San-Diego, California, USA.

Crapo, A.W., Waisel, L.B., Wallance, W.A. & Willemain, T.R. (2000). Visualization and The Process of Modelling: A Cognitive-theoretic View, *Proceedings of KDD*, USA, ACM.

Creswell, J.W. (2009). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches.* Third Edition, United States of America, Sage.

Croll A. (2013). *Big Data Is Our Generation's Civil Rights Issue and We Don't Know It (*In Eds) Big Data Now: A Collection of O' Reilly Perspectives on Big Data.

Delavari, N., Phon-Amnuaisuk, S., & Beikzadeh. M.R. (2008). Data Mining Application in Higher Learning Institutions, *Vilnus, 7*(1), 31-54.

Denscomber, M. (2014). *The Good Research Guide: For Small-Scale Social Research Projects.* UK: Open University Press

Dix, A. & Ellis, G. (1998). Starting simple: adding value to static visualisation through simple interaction, *In the Working conference on Advanced visual interfaces* (AVI '98), L'Aquila, Italy, pp. 124-134, 1998.

Druin, A. (2002). The Role of Children in the Design of New Technology. *Behaviour and Information Technology*, 21(1), 1-25. DOI: 10.1080/01449290110108659

Druzdzel, M., & Flynn, R. (2002) *Decision Support System*. Encyclopedia of Library and Information Science, Second Edition, Allen Kent (ed.) New York: Marcel Dekker, Inc.

Dumbill, E. (2012). *Big Data Now: A Collection of O' Reilly Perspectives on Big Data In Eds).*

Eduventure Inc. (2013). *Predictive Analytics in Higher Education: Data-Driven Decision Making for the Student Life Cycle,* White Paper Publication by Eduventure Inc., Boston.

Ehlers, K., Joubert, M., Kinghorn, J., & van Zyl, A. (2009). Decision Support System for Institutional Research Management in Higher Education: Data Mining to determine Research Focus, Intensity and Synergy, *Proceedings of International Conference on Computational Science and Engineering*, pp. 885-890

El-Fattah, M.A. (2012). Visual Model for Managing Educational Capacity Utilization in Egyptian Universities, *in Proceedings of International Conference on Information Technology Based Higher Education and Training*, pp. 1-4.

Elmqvist, N., Stasko, J., & Tsigas, P. (2007). DataMeadow: A Visual Canvas for Analysis of Large-Scale Multivariate Data, *Proc. IEEE Symposium in Visual Analytics Science and Technology* (VAST '07), pp. 187-194

Elmqvist, N., Dragicevic, P., & Fekete, J.-D. (2008). Rolling the dice: Multidimensional visual exploration using scatterplot matrix navigation. *IEEE Transaction on Visualization &. Computer Graphics,* 14 (6), 56 – 60.

Elo S, Kyngäs H. (2008). The Qualitative Content Analysis Process. *Journal of Advanced Nursing, 62,* 107–115.

Ewell, P.T. (2012). Using Information in Higher Education Decision-Making: Modes, Obstacles, and Remedies. Retrieved from: www.spencer.org/resources/content/3/3/8/documents/Ewell-paper.pdf on Aug. 18, 2013

Faisal, S., Craft, B., Cairns, P. & Blandford, A. (2008) Internalization, Qualitative methods, and Evaluation, *In Proceedings of the 2008 conference on Beyond time and errors: novel evaluation methods for Information Visualization*, pp. 1-8

Fekete, J-D. & Plaisant, C. (2002). Interactive Information Visualization of a Million Items, *Proceedings of the IEEE Symposium on Information Visualization* (InfoVis '02), pp. 117-124.

Fekete, J-N., van Wijk, J.J., Stasko, J.T. & North, C. (2008). The Value of Information Visualization. *Information Visualization: Human-Centred Issues and Perspectives* (E.d.), pp. 1-18.

Fishkin, K., & Stone, M. C. (1995). Enhanced dynamic queries via movable filters, *Proceeding Human Factors in Computing Systems*, CHI '95, pp. 415–420

Forsell, C. (2012). Evaluation in Information Visualization: Heuristic Evaluation, In *Proceedings of 16th International Conference on Information Visualization*, pp. 136-142

Frankel, L. & Racine, M. (2010). The Complex Field of Research: for Design, through Design, and about Design. In E.S. David Durling, Rabah Bousbaci, LinLin Chen, Philippe Gauthier, Tiu Poldma, Seymour Roworth-Stokes (Eds.), Design & Complexity: *International Conference of the Design Research Society*.

Friendly, M. & Denis, D. (2005). The Early Origins and Development of the Scatter plot. *Journal of the History of the Behavioural Sciences*, *14* (2), 103-130.

Gelman, A. & Unwin, A. (2012). *Infovis and Statistical Graphics: Different Goals, Different Looks.* Readings from a departmental seminar held at University of Kentucky.

Gill, B., Borden, B.C., & Hallgren, K. (2014). *A Conceptual Framework for Data-Driven Decision Making*. Final Report of Research conducted by Mathematica Policy Research, Princeton, submitted to Bill & Melinda Gates Foundation, Seattle, WA.

Goss, P., & Hunter, J. (2015). *Targeted Teaching: How better use of data can improve student learning.* A White Paper Publication of Gratian Institute. Retrieved from http://grattan.edu.au/wp-content/uploads/2015/07/827-Targeted-Teaching.pdf on 15 August, 2016

Graham, D. (2005). Information Visualization Theory and Practice, *Proceedings of the Ninth International Conference on Information Visualization* pp. 3-8

Greenberg, S. (2002) Working through Task-Centered System Design, *in Diaper, D. and Stanton, N. (Eds) The Handbook of Task Analysis for Human-Computer Interaction*. Lawrence Erlbaum Associates.

Hackos, J. T., & Reish, J. C. (1998). *User and Task Analysis for Interface Design*. Canada: Wiley.

Halverson, C. A. (2002). Activity Theory and Distributed Cognition: or What does CSCW need to do with Theories? *Computer Supported Cooperative Work, 11,* 243–267

Hao, M. C., Dayal, U., Sharma., Keim, D., & Janetzko, H. (2010). Visual Analytics of Large Multi-Dimensional Data Using Variable Binned Scatter Plots, *in Visualization and Data Analysis Proceedings of IS & T/SPIE Electronic Imaging, Science and Technology*, Belligham.

Hao, M., Rohrdantz, C., Janetzko, H., Keim, D., Dayal, U., Haug, L. & Hsu, M. (2012). Integrating Sentiment Analysis and Term Association with Geo-Temporal Visualization on Customer Feedback Streams, *Proceedings SPIE 8294, Visualization and Data Analysis*, 2012

Harrison, K., Bowen, J.P. & Bowen, A.M. (2013). Electronic Visualisation in Chemistry: From Alchemy to Art, *Proceedings of EVA London 2013 Conference, Electronic Workshops in Computing (eWiC)*, British Computer Society, 29-31 July 2013.

Healey, C.G. (1996). *Effective Visualization of Large Multidimensional Datasets*. A PhD Thesis in Partial Fulfilment for the Degree of Doctor of Philosophy (Ph.D). The University of British Columbia.

Hecksel, D. (2004). *Methodology evaluation and selection*. Sun Microsystems. Retrieved Jan 15, 2014 from http://www.davidhecksel.com/projectcontext/whitepaper.html

Hevner, A. R., March, T. S., Park, J., & Ram, S. (2004). Design science research in information systems. *Management Information Systems Quarterly, 28* (1), 75-105. DOI: 10.2307/249422

Hollan, J. D., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction. *ACM Transactions on Computer-Human Interaction, 7* (2), 98 - 104

Hollingworth, L., Sullivan, A.M., Condon, C., Bhatt, M. & Brandt, W. C. (2012). Data-Driven Decision Making in Higher Education: One University's Process of Revamping the Superintendent Licensure Program, *Journal of Research on Leadership Education, 7* (1), 78–97.

IBM Data Profile (2012). *IBM Big Data Success Stories*. A White Paper Publication of IBM Inc.

Inselberg, A., & Dimsdale, B. (1990). Parallel coordinates: A tool for visualizing multi-dimensional geometry, *in Proc. Visualization 90, San Francisco*, CA, pp. 361- 370.

Institute for Higher Education Policy (IHEP). (2009). *Impact of College Rankings on Institutional Decision Making: Four Country Case Studies*. Retrieved at: http://www.ihep.org/publications/publications-detail.cfm?id=126 on August, 18, 2013.

Isenberg, P., Tang, A., & Carpendale, S. (2008). An Exploratory Study of Visual Information Analysis, *CHI Proceedings: Visualization to Support Information Work*, pp. 1217-1226

Jackson, S. S. (2013). *A continuous Improvement Framework: Data Driven Decision-Making in Mathematics Education*, A White Paper Publication of Data-Driven Innovation Consulting, Inc.

Janetzko, H., Hao, M.C., Mittelstadt, S., Dayal, U. & Keim, D. (2013). Enhancing Scatter Plots Using Ellipsoid Pixel Placement and Shading, *Proceedings of the 46th Annual Hawaii International Conference on System Science*, IEEE Computer Society, pp. 1522- 1531.

Johansson, J., Nest, T.S. & Linner, B. (2010). Evaluating Climate Visualization: An Information Visualization Approach, *Proceedings of IEEE 2010 14th International Conference on Information Visualization*, pp. 156- 161.

Julie, A., Marsh, J. F., & Laura S. H. (2006). *Making Sense of Data-Driven Decision Making in Education.* Rand Occasional Paper, RAND Corporation.

Kaufman, T., Graham, C. R., Picciano, A. G., Wiley, D., & Popham, J. A. (2014). Data-driven decision making in the k12 classroom. *In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of research on educational communications and technology* (4th ed., pp. 337–346). New York, NY: Springer

Karine, T., Diane, L., & Deborah, R. (2012). *Assessment of Higher Education Learning Outcomes*. Feasibility Study Report. Volume 1. OECD Better Policies for Better Lives. Retrieved from http://www.oecd.org/education/skills-beyond-school/AHELOFSReportVolume1.pdf, on 3rd October, 2016

Keim, D. & Ward, M. (2002). *Visual Data Mining Techniques. Published in Intelligent Data Analysis: An Introduction*/ Micheal Berthod (eds), Berlin. Springer.

Keim, D. A. (2002). Information Visualization and Visual Data Mining, *IEEE Transactions on Visualization and Computer Graphics, 8*, 1-8

Keim, D. A., Kriegel, H.-P., & Ankerst, M. (1995). Recursive pattern: A technique for visualizing very large amounts of data, in Proc. Visualization 95, Atlanta, GA, pp. 279–286.

Keim, D., Andrienko, G., Fekete, J-D., Gorg, C., Kohlhammer, J. & Melancon, G. (2008). Visual Analytics: Definition, Process, and Challenges. A Kerren et al. (Eds): *Information Visualization, LNCS* 4950, pp. 154-175. Springer-Verlag Berlin Heidelberg.

Keim, D., Hao, M.C., Daya., U., Janetzko, H., & Bak, P. (2009). Generalized Scatter Plots. *Information Visualization*, pp. 1-11, Macmillan Publishers Ltd.

Keim, D., Kohlhamer, J., Ellis, G. & Mansmann, F. (2010a). *Mastering the Information Age: Solving Problems with Visual Analytics.* Germany, Eurographics Association.

Keim, D., Pras, A., Schonwalder, J., Wong, P.C. & Mansmann, F. (2010b). Report on the Datgstuhl Seminar on Visualization and Monitoring of Network Traffic, *Journal of Network and Systems Management*, *18* (2), 232-236.

Keim, D.A., Mansmann, F., Oelke, D. & Ziegler, H. (2008). Visual Analytics: Combining Automated Discovery with Interactive Visualization, *Proceedings of the 11th International Conference on Discovery Science* (DS,2008), pp. 2-14

Kerzner, H. (2006). *Project Management: Best Practices: Achieving Global Excellence*. USA: Wiley.

Koh, L.C., Slingsby, A., Dykes, J., & Kam, T.S. (2011). Developing and Applying a User-centred Model for the Design and Implementation of Information Visualization Tools, *Proceedings of 15th IEEE International Conference on Information Visualization*, IEEE Computer Society, pp. 90-95.

Kohlhammer, J., Ruppert, T., Darvey, J., Mansmann, F. & Keim, D. (2010). Information Visualization and Visual Analytics for Governance and Policy Modelling, *CROSSROAD Call for Contribution on Future Internet on ICT for Governance and Policy Modelling*, 2010, pp. 251-252

Kopáčková, H. & Škrobáčková M. (2006). *Decision Support Systems or Business Intelligence: What Can Help In Decision Making*?

Krstajic, M., Najm-Araghi, M. Mansmann, F. & Keim, D. (2012). Incremental Visual Text Analytics of News Story Development, *Proceedings of Conference on Visualization and Data Analysis* (VDA '12), pp. 308-323

Kucuktunc, O., & Ferhatosmanoglu, H. (2013). λ-Diverse Nearest Neighbours Browsing for Multidimensional Data, *IEEE Transaction on Knowledge and Data Engineering*, *25* (3), 481-493

Lam, H., Bertini, E., Isenberg, P., Plaisant, C. & Carpendale, S. (2012). Empirical Studies in Information Visualization: Seven Scenario, *IEEE Transaction on Visualization and Computer Graphics*, *18* (9), 1520-1536

Lange, C., Range, B., & Welsh, K. (2012). *Conditions for Effective Data Use to Improve Schools: Recommendations for School Leaders*. Retrieved at: http://cnx.org/content/m45021/latest/ on August, 18, 2013

Lau, A. & Moere, A. V. (2007). Towards a Model of Information Aesthetics in Information Visualization, *in Proceedings of 11th International Conference on Information Visualization,* IEEE Computer Society

LeBlanc, J., Ward, M. O., & Wittels, N. (1990). Exploring n-dimensional databases, *in Proc. Visualization '90, San Francisco*, pp. 230–239.

Lee, B., Czerwinski, M., Roberston, G. & Bederston, B.B. (2005). Understanding Research Trend using PaperLens, *Proceedings CHI 2005*, Portland, Oregon, USA.

Leventhal, L., & Barnes, J. (2007). *Usability Engineering: Process, Products and Examples*. USA: Pearson

Lewis, J.R. (1995). IBM computer usability satisfaction questionnaire: Psychometric evaluation and instruction for use. *International Journal of Human-Computer Interaction, 7* (1), 57-58

Li, I., Hook, K., Dey, A., Forlizzi, J., & Medynskiy, Y. (2011). Personal Informatics and HCI: Design, Theory and Social Implications, *Proceedings of CHI, 2011*, Vancouver, Canada. ACM.

Lin, X. (1997). Map displays for information retrieval. *Journal of the American Society for Information Science, 48* (1), 40–54

Lirong, X., Mengium, W. & Jing, F. (2011). A Visualization System for Web Retrieved Credit Information, *Proceedings of seventh International Conference on Natural Computation,* pp. 728-732.

Liu, Z. & Stasko, J. (2010a). Theories in Information Visualization: What, Why and How, VisWeek 2010, The Role of Theory in Information Visualization. ACM Workshop.

Liu, Z., & Stasko, J. (2010b). Mental Models, Visual Reasoning and Interaction in Information Visualization, *IEEE Transaction on Visualization and Computer Graphics, 16* (6), 999- 1008

Liu, Z., Nersessian, N. J. & Stasko, J. T. (2008) Distributed cognition as a Theoretical Framework for Information Visualization, *IEEE Transactions on Visualization and Computer Graphics, 14* (6), 1173 – 1180

Luna-Reyes, L. F., & Andersen, D. L. (2003). Collecting and Analysing qualitative data for system dynamics: methods and models. *System Dynamics Review, 19* (4), 271-296. DOI: 10.1002/sdr.280

Maciejewski, R., Rudolph, S., Hafen, R., Abusalah, A., Yakout, M., Ouzzani, M., Cleveland, W.S., Grannis, S.J., & Ebert, D.S. (2010). A Visual Analytics Approach to Understanding Spatiotemporal Hotspots, *IEEE Transactions on Visualization and Computer Graphics, 16* (2), 205-220.

Mandinach. E.B., Gummer, E.S & Muller, R.D. (2012). *The Complexities of Integrating Data-Driven Decision Making into Professional Preparation in Schools of Education: It's Harder than You think.* A Report Summary

Mansmann, F., Fisher, F., Keim, D.A. & North, S.C. (2009). Visual Support for Analyzing Network Traffic and Intrusion Detection Events using TreeMap and Graph Representations, *Proceedings of the 3rd ACM Symposium on Computer Human Interaction for the Management of Information Technology* (CHiMiT '09), page 19-28.

Matsui, K., Yamanouchi, M., & Sunahara, H. (2011). A Proposal of Framework for Information Visualization in Developing of Web Application, *Proceedings of 2011 IEEE/IPSJ International Symposium on Application and the Internet*, pp. 457- 462, IEEE Computer Society

Mazza, R., & Berre, A. (2007). Focus Group Methodology Evaluating Information Visualization Techniques and Tools (2007). *Proceedings of IEEE 11th International Conference on Information Visualization*, 2007. IV '07, pg. 74-80., Zurich.

Merriam-Webster, Inc., Merriam-Webster Online Dictionary, First published on 2007, retrieved from http://www.m-w.com/, on 22nd, September, 2013

Meyer, M. (2012). *Designing Visualization for Biological Data*, A Keynote talk at 3rd Leonardo Satellite Symposium of Arts, Humanities and Complex Networks (NetSci, 2012)

Microsoft Inc. (2004). *Data Driven Decision Making in Higher Education*. Discover, A White paper publication of Microsoft Incorporation, released in February, 2004.

Modified Assured Career Progression Scheme (MACPS) (2009). *Government of lndia Ministry of Personnel, Public Grievances and Pensions (Department of Personnel and Training)* North Block, New Delhi, the 19th May, 2009.

Neuman, L.W. (2007). *Basics of Social Research: Qualitative and Quantitative Approaches,* 2nd Edition. Pearson International, USA.

Nielsen, J. (1993). *Usability Engineering*, Boston, Massachusetts: Academic Press, Inc.

Ning, Z., Jiaxin, W., Bing, W., & Shaolong, Z. (2008). A Visualization Model for Information Resources Management, *in Proceedings of 12th International Conference on Information Visualization,* pp. 57- 62, IEEE Computer Society

Ning, Z., Wenxing, H., Siting, Z. & Li, T. (2012). A Solution for an Application of Information Visualization in Telemedicine. *Proceedings of the 7th International Conference on Computer Science & Education (*ICCSE, 2012), Melbourne, Australia, pp. 407-411.

Norman, D. (2002). *The Design of Everyday Things*, New York: Basic Books.

O'Reilly Media (2012). B*ig Data Now: A Collection of O' Reilly Perspectives on Big Data*. O'Reilly Strata Making Data Work

Oelke, D., Bak, P., Keim, D.A., Last, M. & Danon, G. (2008). Visual Evaluation of Text Features for Documents Summarization and Analysis, *Proceedings of IEEE Symposium on Visual Analytics Science and Technology*, Columbus, Ohio, USA

Oelke, D., Hao, M., Rohrdantz, C., Keim, D.A., Dayal, U., Haug, L.E. & Janetzko, H. (2009). Visual Opinion Analysis of Customer Feedback Data, *Proceedings of the 2009 IEEE Symposium on Visual Analytics Science and Technology* (VAST '09), pp.187-194

Oelke, D., Janetzko, H., Simon, S., Neuhaus, K., & Keim, D. (2011). Visual Boosting in Pixel-based Visualizations, *Eurographics/IEEE Symposium on Visualization*, 30 (3), 6- 15.

OLAP Council (1998). APB-1 OLAP Benchmark Release II. Retrieved from http://www.olapcouncil.org/research/bmarkco.html on August 15, 2013 .

Oracle Data Sheet (2011). Oracle Higher Education Constituent Hub (HECH). Retrieved on 6th June, 2013 from http://www.oracle.com/us/products/applications/master-data-management/education-research-hech-ds-164687.pdf

Parsons, P., & Sedig, K. (2011). Human-information interaction: An emerging focus for educational cognitive tools, *Proceedings of FORMATEX, in Education in a technological world: communicating current and emerging research and technological efforts, A.Medez-Vilas (Ed)*, pp. 245- 251

Pinto, M., & Carvalho, D. (2014). U-TRACER: *The Use of Communication Technology in Higher Education*, Universidade de Aveiro, Ano, 2014. Retrieved from https://ria.ua.pt/bitstream/10773/13140/1/u%20tracer_%20o%20uso%20das%20tecnologias%20da%20comunicacao%20no%20ensino%20superior.pdf on 3rd October, 2016.

Pinto, M., Raposo, R. & Ramos, F. (2012). Comparison of Emerging Information Visualization Tools for Higher Education, *Proceedings of 16th International Conference on Information Visualization*, pp. 100-105

Playfair, W. (1801). *The Statistical Breviary; Shewing, on a Principle Entirely New, the Resources of Every State and Kingdom in Europe*, Wallis.

Pocius, K. & Reklaitis, V. (2000). Web-based Services for Technology Education Management and Planning, *Proceedings of International Workshop on Advanced Learning Technologies, IWALT, 2000*, pp. 284- 285.

Protheroe, N. (2009). *Improving Teaching and Learning with Data-Based Decisions: Asking the Right Questions and Acting on the Answers*. Education Research Centre, Research Report.

Protheroe, N. (2010). *Schools as Effective Data Users*. Research Report of www.naesp.org, October/November, 2010.

Purao, S. (2002). *Design research in the technology of Information system: Truth or Dare*. GSU Department of CIS working paper. Atlanta, GA.

Purchase, H. C., Andrienko, N., Jankun-Kelly, T., & Ward, M. (2008). *Theoretical foundations of information visualization*. In Information Visualization - Human-Centered Issues and Perspectives

Quigley, A.J. (2002). Experience with FADE for the Visualization and Abstraction of Software Views, *Proceedings in 10th International Workshop on Programme Comprehension*, IWPC '02

Quinlan, P. T. & Humphreys, G. W. (1987). Visual search for targets defined by combinations of color, shape, and size: An examination of task constraints on feature and conjunction searches, *Perception & Psychophysics, 41* (5), 455-472.

Reigeluth, C. M. (2008). Instructional-design theories and models: Building a common knowledge base, pp. 83.

Ren, L., Cui, J., Du, Y., & Dai, G. (2013). Multilevel Interaction Model For Hierarchical Tasks in Information Visualization, *In VINCI 2013*, Tianjin, China, pp. 11- 15

Reshef, D.N., Reshef, Y.A., Finucane, H.K., Grossman, S.R., McVean, G., Turnbaugh, P.J., Lander, E.S., Mitzenmacher, M., & Sabeti, P.C. (2011). Detecting Novel Associations in Large Data Sets. *Journal of Science Mag*, *33* (4), 1518- 1524

Robertson, W., & DeFerrari, C. (1999). Systematic approaches to visualization: is a reference model needed? Retrieved from http://www.siggraph.org/education/materials/HyperVis/concepts/ref_model.htm on 30th August, 2016

Robinson, A. C., Chen, J., Lengerich, E. J., Meyer, H. G. & MacEachren, A. M. (2005). Combining Usability Techniques to Design Geovisualization Tools for Epidemiology, *Cartography and Geographic Information Science, 32* (4), 243–255

Rogers, Y., Sharp, H. & Preece, J. (2011). *Interaction Design: Beyond Human Computer Interaction*, 3rd Edition, United Kingdom. John Wiley & Sons, Limited

Roth, R. E., Ross, K. S., Finch, B. G., Luo, W., & MacEachren, A. M. (2010). A user-centered approach for designing and developing spatiotemporal crime analysis tools, in *Sixth International conference on Geographic Information Science*

Sabri, A., Hela, L., & Mounir, B. A. (2015). Towards an intelligent evaluation method of medical data visualizations, *2015 15th International Conference on Intelligent Systems DeSign and Applications* (ISDA), pp. 673 - 678

Sarker, Farhana, Davis, Hugh, Tiropanis, & Thanasis (2010). The Role of Institutional Repositories in addressing Higher Education Challenges, *The Second International Workshop on Semantic Web Application in Higher Education,* University of Southampton, UK

SAS (2011). *Data Visualization Techniques: From Basics to Big Data with SAS® Visual Analytics,* SAS (The Power To Know), White Paper.

Schaefer, M., Wanner, F., Kahl, R., Zhang, L., Schreck, T. & Keim, D.A. (2011). A Novel Explorative Visualization Tool for Financial Time Series Data Analysis, *Proceedings of VAW,* University College London, UK

Schmidt, S., Sch¨ogl, O., Kirchberger, R., Doleisch, H., Muigg, P., Hauser, H., Grabner, M., Bornik, A. & Schmalstieg, D. (2005). Novel visualization and interaction techniques for gaining insight into fluid dynamics in internal combustion engines, *In Proc. of the NAFEMS World Congress Conference* 2005

Sedig, K., Parson, P. & Babanski, A. (2012). Towards a Charaterization of Interactivity in Visual Analytics. *Journal of Multimedia Processing and Technologies, Special Issue on Theory and Application of Visual Analytics, 3* 1), 12-28.

Sedlmair, M., Meyer, M., & Munzner, T. (2012). Design Study Methodology: Reflections from the Trenches and the Stacks, *IEEE TVCG, 18*, 2431-2440

Semiu A. & Zulikha J. (2015a). Measuring InfoVis' Decision Support Effectiveness: From Theory to Practice. *Proceeding of Science and Information Conference,* pp. 560-564. July, 28 - 30, 2015, London, United Kingdom

Semiu A., & Zulikha, J. (2015b). A Theoretical Approach towards Designing InfoVis for Decision Support Effectiveness. *Special Issue of Jurnal Teknologi (In print)*

Semiu, A. & Zulikha J. (2014). Towards Developing An Instrument In Measuring The Need for InfoVis, i*n Proceeding of Knowledge Management International Conference,* Langkawi, pp. 628-631, Malaysia- KMICe 2014, Aug., 12-15, 2014

Semiu, A. & Zulikha, J. (2013). Information Visualization Techniques Usage Model, *in Proceeding of 4th International Conference on Computing and Informatics*, Sarawak, Malaysia- ICOCI, 2013, pp.247 - 252, Aug., 28-30, 2013.

Semiu, A. & Zulikha, J. (2015c). A Conceptual Framework for Students' Data-Driven Decision Making Process in Higher Education Institutions. *Advanced Science Letters, 21* (7): 2256-2260. DOI:10.1166/asl.2015.6275, American Scientific Publishers.

Semiu, A., & Zulikha, J. (2015d). Structural Components of Students' Data-focussed Information Visualization, in *Proceeding of 5th International Conference on Computing and Informatics*, Istanbul, Turkey- ICOCI, 2015, pp. 665 – 670. Aug. 22-24, 2015.

Semiu, A., & Zulikha, J. (2016). Students' Data-driven Decision Making in HEI: The Explicit Knowledge Involved. *International Journal of Information and Education Technology, 6* (1), 71 - 75.

Sheneiderman, B. & Plaisant, C. (2010). *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 5th Edition, U.S.A. Pearson Higher Education.

Sherwood, C., & Rout, T. (1998). A structured methodology for multimedia product and systems development, *in Proceeding of the ASCILITE98 Conference*

Shneiderman, B. (1996). The eyes have it: a task by data type taxonomy for information visualizations, *IEEE Symposium on Visual Languages, 1996*, Boulder, CO, USA, pp. 336-343.

Simon, S., Oelke, D., Landstorfer, R., Neuhaus, K. & Keim, D. (2011). Visual Analysis of Next-Generation Sequencing Data to Detect Overlapping Genes in Bacterial Genomes, *Proceedings of IEEE Symposium on Biological Data Visualization*, October 23-24, Providence Island, USA, page 47- 54

Soukup, T., & Davison, I. (2002). *Visual Data Mining: Techniques and Tools for Data Visualization and Mining*, United States of America, John Wiley & Sons, Inc.

Spence, R. (2007). *Information Visualization: Design for Interaction*, 2nd Edition, England. Pearson Education Limited.

Stacey, M., Salvatore, J. & Jorgensen, A. (2013). *Visual Intelligence: Microsoft Tools and Techniques for Visualizing Data.* Indianapolis, John Wiley & Sons, Inc

Stasko, J. (2008). Visualization for Information Exploration and Analysis, *Proceedings of IEEE Symposium on Visual Languages and Human-Centric Computing* (VL/HCC '08)

Stoffel, A., Spretke, D., Kinnemann, H. & Keim, D.A. (2010). Enhancing Document Structure Analysis using Visual Analytics, *Proceedings of the 2010 ACM Symposium on Applied Computing* (SAC'10), pp. 8-12, 2010

Stoffel, A., Zhang, L., Weber, S.H. & Keim, D.A. (2012). AMPLIO VQA- A Web-Based Visual Query Analysis System for Micro Grid Energy Mix Planning, *Proceedings of International Workshop on Visual Analytics, the Eurographics Association, 2012*

Strobelt, H., Oelke, D., Rohrdantz, C. & Stoffel, A. (2009). Document Cards: A Top Trumps Visualization for Documents. *IEEE Transaction on Visualization and Computational Graph, 15* (6), 1145 - 52. doi: 10.1109/TVCG.2009.139.

Syamsul, B.Z. (2011). *Mobile Game-Based Learning (mGBL) Engineering Model*, an Unpublished PhD Thesis submitted to Awang Had Salleh Graduate of Arts and Sciences, Universiti Utara Malaysia.

Tan, P-N, Steinbach, M. & Kumar, V. (2006). *Introduction to Data Mining*, 1st Edition, U.S.A. Pearson Education, Inc

Tatu, A., Albuqerque, G., Eisemann, M., & Bak, P. (2011). Automated Analytical Methods to Support Visual Exploration of High-Dimensional Data, *IEEE Transaction on Visualization and Computer Graphics, 17* (5), 584- 596

Teegavarapu, S., & Summers, J.D. (2008). Case Study Method for Design Research, *Proceedings of International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, August 3-6, 2008, New York city, New York, USA, pp. 1-9

Teets, J.M., Tegarden, D.P., & Russell, R.S. (2010). Using Cognitive Fit Theory to Evaluate the Effectiveness of Information Visualizations: An Example Using Quality Assurance Data, *IEEE Transactions on Visualization and Computer Graphics, 16* (5), 841-853

Tekir, S., Mansmann, F. & Keim, D. (2011). Geodesic Distances for Web Document Clustering, *Proceedings of IEEE Symposium on Computational Intelligence and Data Mining (CIDM, 2011)*

Thacker, B.H., Doebling, S.W., Hemez, F., M., Anderson, M.C., Pepin, J. E., & Rodrigues, W., A. (2004). *Concepts of Model Verification and Validation,* South Research Institute & Los Alamos National Laboratory

Thomas, J.J., & Cook, K.A. (2005). *Illuminating the Path: The Research and Development Agenda for Visual Analytics*, Richland, WA: IEEE Press.

Thomsen, E. (2002). *OLAP Solutions: Building Multi-dimensional Information Systems.* John Wiley & Sons

Toker, D., Conati, C., Steichen, B., & Carenini, G. (2013). Individual User Characteristics and Information Visualization: Connecting the Dots through Eye Tracking, *In CHI 2013*, pp. 295-303

Tongco, M.D.C (2007). Purposive Sampling as a Tool for Informant Selection, *Ethnobotany Research & Applications*, *5*, 147-158

Tory, M. & Staub-French, S. (2008). Qualitative Analysis of Visualization: A Building Design Field Study, *ACM Proceedings of BELIV*, 2008, Florence, Italy, pp. 1-8.

Tory, M., & Moller, T. (2005). Evaluating Visualizations: Do Expert Reviews Work? Visualization Viewpoints, *IEEE Computer Graphics and Application,* September/October, 2005 Edition pp. 8-11

Triesman, A. (1985). Preattentive Processing in Vision. *Computer Vision, Graphics and Image Processing,* 31, 156- 177

Truckenbrod, J. R. (1981). Effective Use of Color in Computer Graphics, *Computer Graphics, 15* (2), 83-90

Tullis, T., & Albert, B. (2008). *Measuring The User Experience: Collecting, Analyzing and Presenting Usability Metrics*. USA: Morgan Kaufmann Publishers

Turban, E. (1998). *Decision Support Systems and Intelligent System*. USA: Prentice Hall.

Turban, E. Sharda, R. & Delen, D. (2010). *Decision Support and Business Intelligent Systems,* 9th Edition. USA: Prentice Hall.

Vaishnavi, V., & Kuechler, W. (2007). *Design Science Research Methods and Patterns: Innovating Information and Communication Technology*. New York: Auerbach Publications.

Wagner, E. & Ice, P. (2012). Data Changes Everything: Delivering on the Promise of Learning Analytics in Higher Education, *EduCause Review,* July/August pp. 33- 42.

Wang, H. (2013). *Asynchronous Visualization of Spatiotemporal Information for Multiple Moving Targets*, an unpublished PhD Dissertation in School of Information Sciences, University of Pittsburgh.

Wang, H., Zhao, G., Wang, W. & Chen, C. (2012). The Design and Implementation of the Platform of Interactive Information Visualization on Aircraft Product Development, *Proceedings of 3rd International Conference on System Science, Engineering Design and Manufacturing Informatization*, pp. 180-184

Wanner, F., Rohrdantz, C., Mansmann, F., Stoffel, A., Oelke, D., Kristajic, M., Keim, D.A, Lou, D., Yang, J. & Atkinson, M. (2009). Large-Scale Comparative Sentiment Analysis of News Articles, *Proceedings of InfoVis Conference* '09.

Ward, M., Gristein, G., & Keim, D. (2010). *Interactive Visualization: Foundations, Techniques, and Applications.* India: A.K. Peters, Ltd

Ware, C. (2000). *Information Visualization: Perception for Design*. United States of America: Morgan Kaufmann Publishers

Web Center for Social Research Publication. Available at: https://www.syr.edu/gradschool/pdf/assessmentpdfs/Evaluation%20Defined.pdf. Retrieved on 19th January, 2015.

Wen-ting, W., Heng-yu, Z., Yi, R., Mi-mi, T., & Li-rong, X. (2009). Study on Plant Landscape Information Visualization and Its Key Technologies, *in Proceedings of International Conference on Management and Service Science*, pp. 1- 4

White, S. (2008). Interaction and Presentation Techniques for Situated Visualization, *UIST'08*, pp. 3-7, October 19-22, 2008

Wiegers, K. E. (2002). Seven Truths about Peer Reviews. *Cutter IT Journal*, 15(7).

Wilkinson, L. (2005). *The Grammar of Graphics*, 2nd ed. New York, NY, USA: Springer.

Willems, N., H. van de Wetering, J.J., & van Wijk. (2009). Visualization of Vessel Movements, *Proceedings of EuroVis*, *28* (3), 959-966.

Williams, N. & Amin, G. (2006). Higher Education in Sudan and Knowledge Management Application. *Information and Communication Technologies,* 2(1), 60-65

Wolfe, J. M. & Cave, K. R. (1989). Deploying Visual Attention: The Guided Search model, *In AI and the Eye, Troscianko, T. and Blake, A., Eds*., 79-103. John Wiley & Sons, Inc., Chichester, United Kingdom

Wright, H. (2007). *Introduction to Scientific Visualization*. United Kingdom. Springer Science and Business Media, LLC.

Wu, X. & Ren, F. (2010). Mechanism and Methods of Outdoor AR Spatial Information Visualization Representation, *in Proceedings 2010 Second International Conference on Computer Modelling and Simulation*, pp. 272-276, IEEE Computer Society

Xie, Y., Hofmann, H., & Cheng, X. (2014). Reactive Programming for Interactive Graphics. *Statistical Science, 29* (2), 201 – 213. DOI: 10.1214/14-STS477

Yanosky, R. (2009). *Institutional Data Management in Higher Education*. A Report from EduCause Centre for Applied Research. Retrieved on 6th June, 2013 from http://net.educause.edu/ir/library/pdf/EKF/EKF0908.pdf

Yi, J. S. (2010). Towards Practical Information Visualization Theory: Lessons from the History of Decision Science, *VisWeek 2010, The Role of Theory in Information Visualization.* ACM Workshop.

Yi, J.S., Kang, Y., Stasko, J.T., & Jacko, J.A. (2007). Toward a deeper understanding of the Role of Interaction in Information Visualization, *IEEE Transactions on Visualization and Computer Graphics*, *13* (6), 1124–1231.

Yu, C., Yurovsky, D. & Xu, T. (2012). Visual Data Mining: An Exploratory Approach to Analyzing Temporal Patterns of Eye Movement, *Infancy*, *17* (1), 33-60.

Zadrozny, P. & Kodali, R. (2013). *Big Data Analytics Using Splunk: Deriving Operational Intelligence from Social Media, Machine Data, Existing Data Warehouses and Other Real Time Streaming Sources*. Apress

Zalta, E. N., Nodelman, U., Allen, C. & Perry, J. (2013). The Problem of Induction, *Standard Encyclopedia of Philosophy*, *36* (7), 1-5

Zhao, D. & Zhou, N. (2008). Analysis of the Present Applications of Information Visualization in E-commerce Websites

Zheng, X-Z., Wang, S-L., Luo, J-H., Cao, Y., & Qing, D-Z. (2011). Research on the Framework of Information Visualization System of Equipment Support Decision-making. *Proceedings of 2011 International Conference on Computational and Information Science*, pp. 780- 784. IEEE Computer Society

Zhong, C., Wang, T., Cairns, S., & Arisona, S.M. (2012). Using an Interactive Dymaxion Map to Convey Research Information through Visualization, *Proceedings of 16th International Conference on Information Visualization*, IEEE Computer Society

Ziegler, H., Nietzschmann, T. & Keim, D. (2008). Visual Analytics on the Financial Market: Pixel-based Analysis and Comparison of Long-Term Investments, *Proceedings of the 12th Conference on Information Visualization (IV 2008), IV-VDM Symposium on Visualization and Data Mining*, pp. 287- 295

Ziemkiewicz, C., Ottley, A., Crouser, R.J., Chauncey, K., Su, S.L., & Chang, R. (2012). Understanding Visualization by Understanding Individual Users, IEEE *Journal of Computer Graphics and Applications*, *32* (6), 88-94

Zikmund, W.G., Babin, B.J., Carr, C.J., & Griffin, M. (2010). *Business Research Methods*, 8th Edition, Canada. South-Western Cengage Learning Centre

Zikopoulous, P., Eaton, C., Deutsch, T., Deroos, D., & Lapis, G. (2012). *Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data.* USA, IBM.

Zins, C. (2007). Conceptual Approaches for Defining Data, Information, and Knowledge. *Journal of the American Society for Information Science and Technology*, 58(4), 479–493