How to cite this paper:

Semiu A. Akanmu & Zulikha Jamaludin. (2017). A process model for designing information visualization in Zulikha, J. & N. H. Zakaria (Eds.), Proceedings of the 6th International Conference of Computing & Informatics (pp 276-281). Sintok: School of Computing.

A PROCESS MODEL FOR DESIGNING INFORMATION VISUALIZATION

Semiu A. Akanmu[1] and Zulikha Jamaludin[2]

[1,2]Universiti Utara Malaysia, Malaysia,
[1]ayobami.sm@gmail.com; [2]zulie@uum.edu.my

ABSTRACT. Information Visualization (InfoVis) employs interactive visuals, graphical presentation, and exploratory data analysis abilities to actualize actionable data insights that are both task and user-centred. In delivering user-centred design (UCD) in InfoVis, studies have been conducted and different but similar UCD models have been proposed. However, these studies, though consist of prototyping, did not elaborately describe the prototyping phase, especially into its constituent stages. As a result of this, InfoVis designers are not armed with a dependable process model of translating InfoVis conceptual design framework to its corresponding physical artifact. To attend to this, we adapted Soukup and Davidson's (2002) visual data mining project methodology and Rogers, Sharp & Preece's (2010) software product engineering model to propose an iterative process model for designing InfoVis. The proposed process model was evaluated using expert review. Also, it was used as design guide in prototyping our students' data-focused InfoVis; StudentViz. The findings from the expert review and the actualization of our InfoVis prototype showed that the proposed process model is functional and practicable.

Keywords: process model, information visualization, user-centred design, prototyping

INTRODUCTION

Information Visualization (InfoVis), as a research domain, employs interactive visuals, graphical presentation and exploratory data abilities for data analysis and knowledge discovery. It presents, based on these abilities, actionable data insights, and supports tasks and domain users' needs. Studies carried out by Robinson et al. (2005), Roth et al. (2010), Koh et al. (2011), Meyer (2012), and Semiu and Zulikha (2014), in view of developing InfoVis that meets domain users' needs, have proposed different but similar user-centred design (UCD) models. Each of the past related studies on InfoVis UCD models has prototyping as a design phase, but with no elaborate description and sufficient understanding that can guide InfoVis designers through the process of translating conceptual design model to physical artifact. This paper presents a summary of an iterative process model proposed to attend to this important but missing gap. The second section of this paper reviews past related studies for proper contextual understanding; the third section presents the proposed process model; and the fourth section presents the evaluation of the process model which was done through expert review and prototyping. The fifth section, i.e. last section, concludes this paper.

PAST RELATED STUDIES

InfoVis user-centred design (UCD) studies, with proposed UCD models, are Robinson et al. (2005), Roth et al. (2010), Koh et al. (2011), Meyer (2012), and Semiu and Zulikha (2014). These studies proposed phases and stages of developing InfoVis to meet domain users' needs and attend to its required tasks. The purpose of the models, though with varying flows, is that target users must be involved in the development lifecycle of the InfoVis tools. Robinson et al. (2005) addressed the problem of designing usable InfoVis for the researchers in the field of geovisualization. It is stated that two techniques that must be included in the geovisualization design methodology for a wide range of geographical issues are protocol analysis and in-depth case study. Interaction design techniques and usability methods are also adapted with extract from the existing design guides to realize the geovisualization-centered InfoVis design guide. The important note made by the work is that, diverse application of InfoVis necessitates domain-specific design guide.

Roth et al. (2010), in improving Robinson et al.'s (2005) InfoVis UCD model, suggested that work domain analysis should not be in isolation. In their improved model, Roth et al. (2010) delivered a user-centered approach for designing and developing spatiotemporal crime analysis InfoVis tool. However, Roth et al. (2010) suggested that "work domain analysis" stage should be part of the iterative chain of processes. Also, prototyping was placed as a starting point of the design process for the purpose of exposing the users to the InfoVis prototype as the early stage, though with no elaborate description of its constituent processes.

Koh et al. (2011) in their work on health care-based InfoVis tool also proposed a UCD model that targets a larger users' community. Their design model features visualization awareness and domain visualization as stages to expose the novices among the prospective users to InfoVis. It maintains the procedural sequence in Robinson et al. (2005), but added visualization awareness and domain visualization as new stages. The introduction of these two stages aligns with the suggestion of Roth et al. (2010). The visualization awareness is a workshop session designed to introduce the general concepts of InfoVis to the users. Domain visualization expresses the need to showcase paper prototypes to the domain experts and prospective users for early feedbacks.

Meyer (2012), who principally worked on visualization of biological data, presented an iterative three-phase and nine-stage design framework for designing visualization. The first phase called Precondition is of three stages, namely; learn, winnow and cast. The second phase called Core contains discovers, design, implement and deploy as the stages involved. The last stage; Analysis, is of two stages. They are reflects and writes. The InfoVis design framework acknowledges the problem-driven and technique-driven nature of InfoVis research studies, and the need for pre-design and in-study collaboration with domain experts. The Precondition phase of the design framework is the stage that informs the involvement of collaborators. The collaborators are the experts in the field of study where the InfoVis is sought. Though with a similar procedure, Meyer (2012) proposed an InfoVis UCD model that presents an expansive scope for attending to target users of InfoVis. Our previous study (Semiu & Zulikha, 2014) also contributed to InfoVis UCD model by introducing formative and summative evaluation stages, among other components, in view of making such models adoptable for academic and research degree researches.

In sum, this study observes that none of the previous studies on InfoVis UCD models elaborated the process of prototyping itself. This arguably limits the ability of developers, especially neophytes, in InfoVis design, to translate conceptual design model into physical artifacts.

THE PROPOSED PROCESS MODEL

The proposed process model of designing InfoVis is into iterative three phases, namely; pre-development, development, and post-development. Each of these phases has its respective stages. The pre-development phase contains domain analysis and data collection, data preparation (which includes data cleaning and modelling), and users' tasks elicitation. The development phase contains InfoVis content development, coding and core system development, InfoVis features integration, and heuristics evaluation. The last phase; post-development, has InfoVis deployment, InfoVis testing and users' experience evaluation.

Pre-Development Phase

The objective of this phase is to conceptualize the InfoVis design model. The conceptualized design model would be applied in the InfoVis development phase. This phase contains three different stages. These are domain analysis and dataset collection, data preparation, and users' tasks elicitation. At the domain analysis and dataset collection phase, the domain users' needs to achieve a goal-oriented design and the domain explicit knowledge preferences are identified. Also, the work practices of the domain users and how InfoVis could suitably be deployed to support the decision making activities would be identified. The process of dataset collection also entails assuring data quality and its conformity with the domain business value.

The data preparation stage involves data cleaning and modeling. It also ensures the data structure and dimensionality address the domain need. Missing data values, incoherent data dimensions, and noise, are treated and modeled. At the users' tasks elicitation stage, the tasks that will achieve the earlier identified users' needs are conceptualized, and the core InfoVis' tasks, according to Sheneiderman's InfoVis' information seeking mantra, are fundamentally enumerated (Sheneiderman, 1996). These tasks are essentially supported by the InfoVis' interaction and distortion techniques.

Development Phase

The objective of this phase is to actualize the physical product of the conceptualised design model. This phase would produce the InfoVis that is usable for the exploration and visualization of the domain data, and supports its decision making processes. The stages in this phase are InfoVis component development, coding and core content development, InfoVis features integration, and heuristic evaluation. InfoVis Component Development entails the design of the prototype, starting with a low-fidelity form. This can be done with paper sketching or prototyping software. The coding and core system development is an extension of this, and exclusively deals with the process of developing the components (visual interface, data binding and visual exploratory mechanism, and database) (Semiu & Zulikha, 2015). The content delivery techniques, using the suitable programming language frameworks and libraries, are also developed. This must be done to achieve related perceptual, cognitive and decision supports functionalities.

InfoVis features integration stage is to perfect the prototyping process, by bringing all the peculiar InfoVis characteristics into reality. Developers can use any back-end technology; such as MySQL, and PHP library. For a web-based InfoVis, most likely, Hyper Text Markup Language (HTML) is used for the body structure and Cascading Style Sheet (CSS) for the rendering. Data Object Manipulation (DOM) functionality and Data-Driven documents; D^3, which is also a JavaScript library for creating data visualization, are used for the data binding and visualization. Closure, a new Google-created JavaScript library, is used for the interface element and features design. A review of the technical aspects of the HSDI is also done to actualize an InfoVis prototype of high fidelity. The heuristic evaluation is a formative evaluation stage to receive feedback from usability/HCI and data analysts/administrators.

Post-Development Phase

The objective of this phase is to review the technical aspect of InfoVis and ensure that its workings and operations are in order. The phase consists of InfoVis deployment, InfoVis testing, and Users' experience evaluation. At the InfoVis deployment, a cross-browser assessment would be done to check the compatibility InfoVis design with the major web browsers. A software engineering approach of system checking for debugging and error tolerance control are to be implemented during the InfoVis testing. InfoVis techniques overview (with details), zooming, filtering and mouse-touch interactivity, and scrolling are tested, and the underlying code is thoroughly debugged. Lastly, the summative evaluation which is the users' experience evaluation experiment would be conducted.

The proposed process model of designing InfoVis is presented in Figure 1 below. The iterative process, as shown by the feedback arrows in certain stages and phases, suggest a repetition of the preceding stage/phase if the feedback obtained in the current stage/phase is suboptimal.

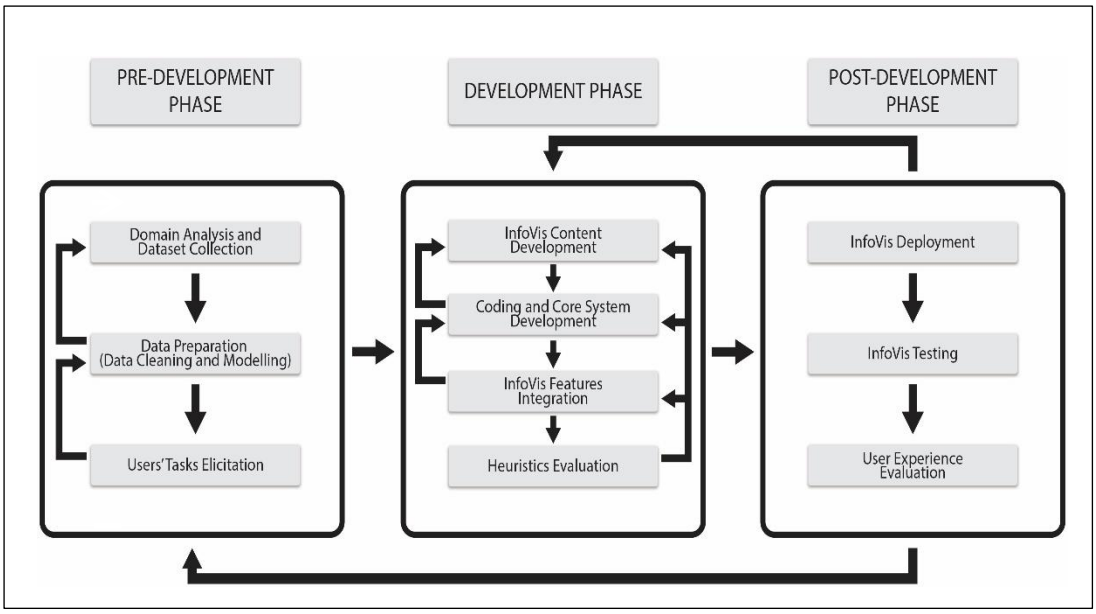

Figure 1. A Process Model for Designing InfoVis

EVALUATION: EXPERT REVIEW AND PROTOTYPING

Expert review (Wiegers, 2002) and prototyping (Rogers et al., 2010) are used in evaluating the proposed process model. The experts are academics and industry-based experts in the areas of HCI and InfoVis with prior experience in developing data visualization tool. This study used five (5) experts (Nielsen, 1993) drawn from both academics and industry, in no particular order of preference. The dimensions, adapted from Syamsul (2011), to verify the proposed process model are visibility, complexity, compatibility, flexibility, clarity, effectiveness, manageability and evolutionary. The prototype of our students' data-focused InfoVis; StudentViz, is actualized using the process model proposed. The logical assumption in using prototyping as method of evaluation is that, if the physical artifact can be actualized through the proposed process model, it suggests the practicability of the model. Table 1 presents the dimensions used in verifying the proposed process model

Table 1. Dimensions Used and the Findings from the Expert Review

Dimensions	Description	Mean Value (over 10)
Compatibility	It is compatible (consistent) with the existing values of software engineering and InfoVis development.	8.80
Visibility	The phases and stages are visible to the InfoVis designers and developers.	8.75
Simplicity	It is simple to understand and use.	8.96
Effectiveness	It enhances productivity, effectiveness and the quality of InfoVis development.	8.92
Evolutionary	It provides a dynamic process that evolves continuously with feedback from users. The model has the capability for incremental change and could cope with new ideas. It provides the opportunity for communication and collaboration with end users	8.98
Flexibility	It provides flexible development phases with negligible rigour. It is adaptive and responsive to users' needs, and flexible for future use.	8.96
Clarity	Its phases with steps and activities included are easily followable. It gives a guide on how InfoVis can be developed.	8.90
Manageability	The processes and activities in the model are manageable and controllable. It provides a good guide for project management.	8.20

The experts' reviews are graded on a scale of 1 (minimum) to 10 (maximum). Items used in measuring each of the dimensions are adapted from Syamsul (2011). Frequency, as a descriptive statistics technique, is used, and the mean scores are calculated using SPSS. The highest mean score among the dimensions is evolutionary with 8.98, and the lowest is manageability with 8.20. The mean value for the scores of all the dimensions is 8.80. This implies that proposed process model is functional in terms of the dimensions used. Figure 2 presents the interface of our InfoVis study where the process model was also implemented.

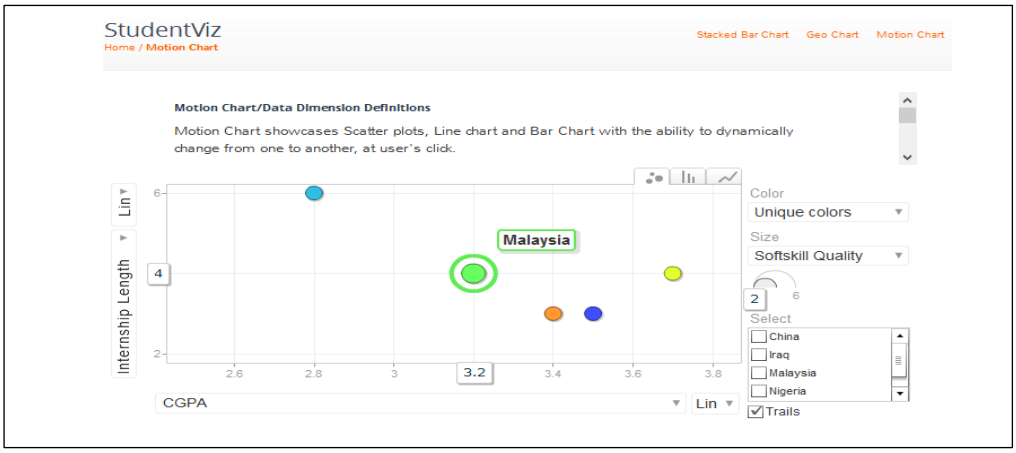

Figure 2. Interface of our students' data-focused InfoVis; StudentViz.

DISCUSSION AND CONCLUSION

The findings from the expert review showed that the process model is satisfactory and functional. It showed it is (a) compatible with generic software development process, and (b) clear with understandable phases and stages. The strength of the model, as shown in the find-

ings, is its ability to be adaptable and extendable to meet different or peculiar design types. Also, the ability to implement the phases and stages proposed in the process model in designing our students' data-focused InfoVis implies the practicability of the model. This therefore suggests that InfoVis designers, especially the newbies, can now be guided through the phases of translating conceptual design model to physical artifact.

The process model presents an iterative three-phase and ten-stage sequential approach to designing InfoVis which collectively attended to the missing gap highlighted in previous related studies. The phases are pre-development, development, and post-development, consisting of three, four, and three respective stages. Though extra reference books and websites, especially on using and implementing data visualization programming libraries and frameworks, must be consulted in the development phase, this process model presents an easy guide to actualizing functional and usable InfoVis tool.

REFERENCES

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.

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

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

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*

Semiu, A**.** & Zulikha, J. (2014). A User-centred Design Methodology for Students' data-focused InfoVis *Proceeding of 3rd International Conference on User Science and Engineering*, pp. 115 – 118. Sept., 2-5, 2014, UiTM Shah-Alam, Malaysia.

Semiu, A., & Zulikha, J. (2015). 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.

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

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.

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

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.