Understanding Business from Business Report Visualization*

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ABSTRACT

The visualization of business reports has received greater attention from information system scholars. Tables, graph and charts are often used to represent vast amount of complex numerical data and spreadsheet visuals become a de facto standard in business. This study suggests the use of individual's cognitive differences on business report visualization instead of providing "one visual fits all type of reports." It is argued that reports with data augmented by appropriate visuals will affect the efficiency and effectiveness of an individual's learning outcomes and subsequently his or her decision making processes. It is argued here that report visualization can augment the usefulness of contents and enhance many desirable features of reports as specified in those proposed models.

Key words : Visualization, Business Report, Experimental Design, Interpretation

The increase in computational power of modern computers has made the representation of data through graph, chart, or picture easier and faster. Thus, visualization of business reports has received greater attention from information system scholars. Although it was recognized that business has a large amount of complex information, according to the NIH/NSF Visualization Research Challenges Report [30], less funding was allocated to research in business visualization by the US government. Thus, there is a greater development of visualization research in the physical science and biology than in the social science disciplines. A recommendation was made toward the interdisciplinary development of visualization research with special attention to business cases so that the findings can create competitive advantage for the country.

Business reports are important to business operations. When an organization is small and its operations are not as complex, reports might not be as important because communications among a few users can be done verbally. By adding one or two users into the system, the communications links can climb up the exponential curve very quickly. Therefore tables, graph and charts are often used to represent vast amount of complex numerical data and spreadsheet visuals

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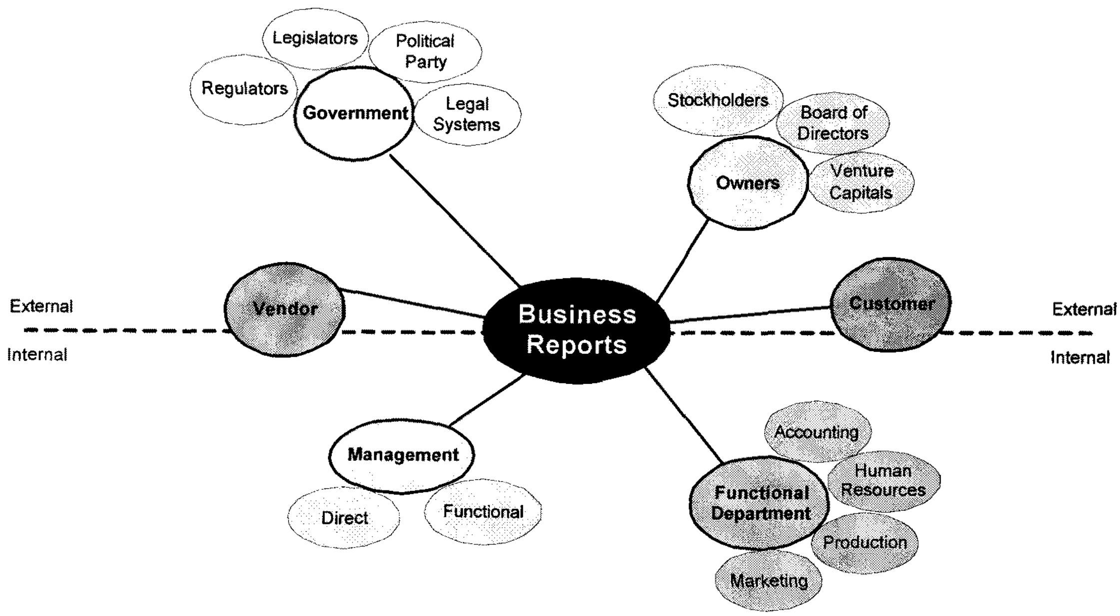
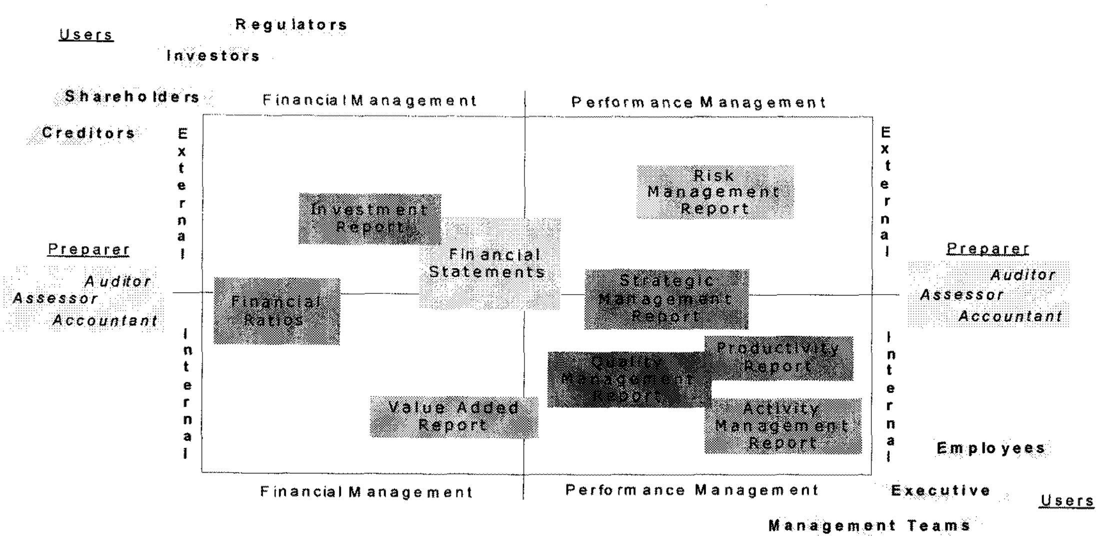
become a de facto standard in business.

With many stakeholders involved, business reports can be grouped by their respective requirements. As shown in Figure 1, business reports can be classified further by the needs of internal and external users. While different groups may want reports with different contents, different individuals within the same group may need the information presented in different formats depending upon their cognition and learning capability. Huang et al. (2006) reviewed the cognitive fit theory and argued that the value of representing data in visual form will lead to effective and efficient way of



〈Figure 1〉 Stakeholders of Business Reports

Source: Adapt from the Stakeholder Map VIZ (http://visual-literacy.org/periodic_table/peruiduc_table.html)



〈Figure 2〉 Classification of business reports understanding large amount of data. However, what format the data should represent depends on the kind of tasks that person is working on [27].

The grouping of business reports into their functional uses, financial performance and non-financial performance, lends itself to represent the subsequent reports differently. In practice, however, it is challenging to find the criteria used to separate these two types of reports. Figure 2 depicts a two-by-two scheme of classifying business reports with some examples of typically reports used in business by different stakeholder groups.

The fact that organizations tend to provide the "one visual fits all" type of reports may not be as efficient or as effective for the stakeholders to perform their respective tasks. Thus, the objective of this study is to add to the body of knowledge by based on individual's cognitive differences on business report visualization. It is argued that reports with data augmented by appropriate visuals will affect the efficiency and effectiveness of an individual's learning outcomes and subsequently his or her decision making processes. With many types of business reports in use, the focus of this exploratory research is only on financial report visualization since these reports appear to be ubiquitous to all users.

The contents and forms of financial reports have been scrutinized by both theorists and practitioners for a long time. For example, the "New reporting models for business" study from the "Information for Better Markets" Series carried out by The Institute of Chartered Accountings in England and Wales examines the concepts of reporting financial performance [28]. The study reviews 11 models used to solve financial reporting problems such as serving multiple stakeholders, meeting decision-making needs, reporting intangibles, achieving transparency in business reporting, and so on. One of the solution models deals with the concern about relevancy and usefulness of business reports. Here a unified business report with ten components was recommended by Jenkins, who was later elected as the Chairman of the US Financial Accounting Standards Board. The Jenkins Report suggests disclosure of financial and nonfinancial data and its management analysis as well as forward-looking information on top of information about management, shareholders and detailed background of the company.

Similar concerns about the lack of disclosing non-financial performance, Kaplan & Norton offered The Balanced Scorecard model to report business performance in four perspectives.

In the same report, a review of other models including, for example, the "Tomorrow's Company" report and "The 21st Century Annual Report" by The Royal Society for Encouragement of Arts, Manufactures & Commerce (RSA). Many of these models were proposed in order to get businesses to produce the reports that would reflect the relationships between different groups of stakeholders. Building public trust from Value Reporting TM was also proposed so that valid, transparent, and real financial position of the firm can be reported promptly at all time [28]. It should be noted that although much has been said about the contents and processes of reporting business performance, hardly any of the proposed models consider the visualization aspect of these reports. It is argued here that report visualization can augment the usefulness of contents and enhance many desirable features of reports as specified in those proposed models.

1. Research Question

Since the present research is exploratory in nature, one of the objectives is to investigate the current development of visuals in financial reports, the extent of visual usage, the type information systems employed to produce those visuals and the involvement of various groups of stakeholders in the development of financial report visualization. After getting a feel of what type of visuals are used in existing financial reports, a set of alternative visuals will be developed by using the characteristics of information processing tasks as outlined in the Cognitive Fit Theory [53]. Another objective is to examine whether the proposed alternative visuals will be accepted by users and preparers as compared to a traditional data representation in tabular or spreadsheet graphics.

Finally, the acceptable visuals will be tested whether they will affect the learning performance of financial report users.

The basic question asked in this study is what kind of visuals that will fit with the information processing tasks of financial report users and whether these visuals can affect their learning performance. To answer these questions, the proposed research will focus on three main constructs, Cognitive Fit, Self Efficacy in Visualization, and Perceived Learning Performance.

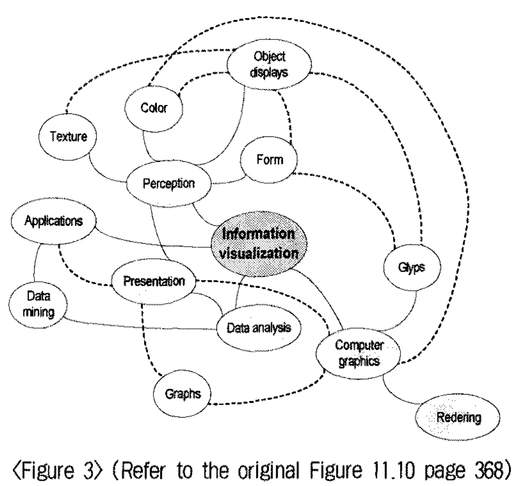
2. Literature Review

The development of visualization research is in multidisciplinary fields. As Chen (2002) pointed out in the debut of Information Visualization journal, prior to become a field of its own, there have been related studies in scientific visualization, information retrieval, geographic information, and so on [11]. One can easily argue that the representation of scientific knowledge with graphics and images has played an important role in advancing the sciences in general. For information retriever researchers [37] [45], visual representation of the data retrieval outputs can increase the efficiency of the retrieval processes.

2.1 Visualization Research

It is difficult to actually count the exact strands of research relating to visualization since it deals with so many aspects of human-being. Therefore, visualization research is found in arts and sciences, health sciences, nerve sensing, brain activity, visual field, information processing and so on. Also, visualization has a very long history in physical science research. Edward R. Tufte (2001) had assembled various types of visuals in the book, The Visual Display of Quantitative Information [50], for example, data map of population statistics, weather forecast, and visuals of thermal conductivity of tungsten. The author also gave a philosophical theory for the design of graphic representation, "Graphical elegance is often found in simplicity of design and complexity of data" [50, p. 176]. Different aspects of graphic design were reviewed: scope of visual representation, data-ink, chart junk, density and size, graph and sub-graphs, color principle, line thickness, visual positioning, and authenticity as well as proportion and direction (vertical and horizontal) of graph design, visual composition of numbers, tables, texts, and pictures [50, p. 191].

Beside graphic design, visualization research in science and computer technology entails the evolution and development of visuals in scientific areas, such as data mining, can bridge the gap between pure science and social science as well as business applications where large amount of complex business data are in place. Another book written by Howard Wainer (2005) has been cited a lot in visualization research -Graphic discovery: A trout in the milk and other visual adventures [55]. There, the author made specific observations about the "spinning and slicing" of data based on individual's cognition and perception. This concept is used extensively by developers of BI applications. The author pointed out that the art of data presentation is not new because the concept was dated back to the work of William Play fair and John Wider Tukey, the renowned statistician in the past.



<Figure 3> (Refer to the original Figure 11.10 page 368) A Concept Map of Information Visualization

Research that integrate Cognition and Visualization has spin off to different lines of research in recent years, A book by Colin Ware (2004), Information

Visualization, has become one of the top most referenced piece in recent years [57]. Besides trying to provide a collection of all theoretical concepts of the visualization and meanings, the author, instead dig into the physiology of an eye and discussed how the eyes see light, color, brightness, contrast, consistency, movement, pattern, attraction process, perception and realization under different settings. Though it is very difficult to find a mental image to represent the exact development of visualization research, the author has concluded by drawing a map of information visualization as seen in Figure 3 [56, Figure 11.10, p. 368]. The thickness of line shows the intensity of linkages between those research areas. Ware also pointed out the cost of representing data in visual forms can reduce the total cost of information processing since visual thinking is the closest to assimilating information in natural setting.

2.2 Types of Visuals and Visualization

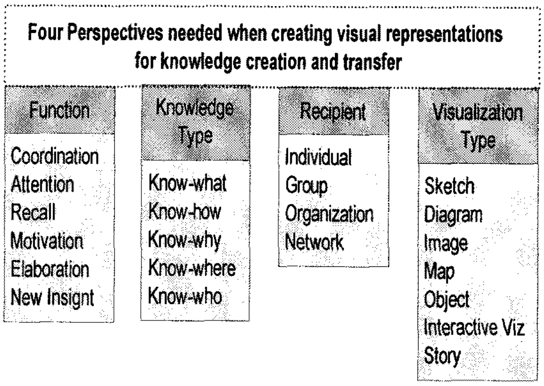
Spatial and temporal dimensions are the most typically criteria used in taxonomy development. Within spatial dimension, there can be unlimited numbers of classification schemes depending on the perspectives or theories employed. In the research notes on multi-dimensional visuals for data mining, Sachinopoulou (2001) classify the data mining tools that will lend itself to the types of visuals being produced, for example, Geometric technique[1], Icon technique[2], hierarchical technique[3], distortion technique in three dimensional space[4], Distortion Techniques used in business applications are and two and three dimension graphs. Scatter-plot and matrices were found to take less time for learning than other visuals like tree or other basic graphs [41, p. 27]. To position glyphs, Ward (2002) classified their placement strategy according to the characteristics of data (raw or derived data) and to the structural characteristics of placement (sequential, hierarchical, or network) [56].

With a different conceptualization, Thomson et al. (2005) proposed the typology of visualizing uncertainty [49]. The uncertainty is caused by factors such as granularity of data, data collection method, data processing, transformation, distribution or communication processes. All these factors can affect the way users would perceive the uncertainty and reliability of data, especially when the source of data is from personal report or person-to-person communication. To reduce the uncertainty, one can try to obtain data from different sources, cross check the assumption of each data source. The author suggested a framework used to differentiate visuals for meta data and made reference to the work of Butternfield who had classify data into discrete, categorical, and continuous data where the quality of data is important. Visual characteristics that are useful to cognition are as follows: accuracy/error, precision, completeness, consistency, lineage, currency/timing, credibility, subjectivity, and interrelatedness. Ward also reviewed the work of Gershon in his book about the cause of imperfect knowledge. The argument for the cause of imperfection is the insufficient, incomplete, incoherence, uncertain, complex, and inadequate presentation of data, resulting in an incomplete knowledge [49].

To represent scientific data, much effort has been made to represent the N-Dimensional data with 2D or 3D. for example, the use of Spherical self-organizing feature map to represent the visuals of many years of snow falls on a surface map of different parts on earth [43]. In order to discover knowledge through data mining technique, different types of visuals are used, for example, representing Time series data with Cluster method, Spiral method, or VizTree method [35]. One of the perhaps most effective application of using 2D and 3D representation of vast amount of data is the use of

1) Geometric Techniques use coordinates to construct visuals based on geographical space, including techniques such as (1) Plots and Matrices, (2) Hyperslice, (3) Prosection Views (4) Surface plots, Volume plots, Contours, (5) Parallel Coordinates, and (6) Textures and Rasters.
2) Icon Techniques are known as the data representation as (1) Stick Figure, (2) Chernoff Faces, 3) Color Icon, (4) Autoglyph, and (5) Glyphs.
3) Hierarchical Displays are (1) Hierarchical axes, (2) Dimension stacking, (3) Trees (Tree Maps, Cone Tree), (4) Worlds within worlds, and (5) Info Cube.
4) Distortion Techniques used in business applications are (1) Perspective wall, (2) Pivot Table and Table Lens, (3) Hyperbolic Trees.

A Periodic Table of Visualization Methods [25]. This is an interesting visual since it incorporates color, abbreviation, icon, and even short text messages. Since it shows on a website, layers responding to mouse movement are added with corresponding picture file for each individual visualization method depicted. A combination of six classes of methods with3 pairs of method attributes (process and structure; overview and detail; and convergent and divergent thinking) has made the representations quite complex but the clever use of familiar periodic table concept does help simplify the difficulty to comprehend such complexity. The six methods include Data Visualization, Information Visualization, Concept Visualization, Strategy Visualization, Metaphor Visualization and Compound Visualization.



Source: Buckhard's Knowledge Visualization Framework (p. 245)

<Figure 4> Conceptual Framework for Knowledge Visualization

Topology of visualization can keep on expanding if we link those in science, social science and humanity together. In the latest work by Buckhard (2005), he offered a framework of Knowledge Visualization within the knowledge management context [8]. The framework was based on the concepts derived from the research in individual perception, specifically visual information processing in both bottom-up (direct perception) and top-down (constructive perception). The conceptual framework entails four components as shown in Figure 4. The framework was employed by the author and his associate to develop a new type of visual, the Project Tube Maps, to be used as an alternative to the known Gantt Charts. A pilot study was done to test whether this alternative visual would be accepted by the users who are managers, students, employees in large organization. They found that the users of the Project Tube Maps were more effective in performing their work than the Gantt Charts users [9]. This is because the alternative visual can trigger the interest of users who appeared to have better understanding of how to manage the entire project. However, Gantt chart was still found to represent the structure and the timeline for each project task better.

2.3 Visualization in Business Reporting Environment

The recent business information system applications, Business Intelligence (BI) in particular, have incorporated visualization technique extensively in their presentation of analytic results. Geographical information system that focuses on the transformation of symbolic data into spatial information has also been integrated into the BI applications rather seamlessly. The visuals used to represent vast amount of complex business data can help enterprise users be more confidence in making their decisions [24]. Note that visualization research in business discipline deals with people and how they see things, thus, it is inevitable that business visualization must take into accounts social and psychological constructs such as cognition, decision making performance, and other factors relating to human information processing.

Though much has been said about the benefits of visualization [51], especially in scientific inquiry [7], there are quite a few research reports the role of graph, chart, multidimensional depiction, and even the use of virtual reality in business and management area [38] [19] [52], [33] [5] [14]. There are different ways of utilizing visualization in business applications, for example, for modeling stakeholders[20], for evaluating pros and cons of alternatives and prioritization of user's needs from multiple criteria [2], for risk mapping [10] [34], visualization of cash flow statement [13], and so on. Visualizations enable sense-making and understanding of business information right away. Visual data enables our brain to be stimulated and the retrieval of data from our short and long term memory can be quicker.

Computer generated charts and graphs have been used to augment texts and numbers since the very beginning because they are efficient and effective representations of business information [38] [19] [39]. After proliferation of personal computers and the sharp taking off of spreadsheet software in early 1980s, visualization research started to receive attention as well, especially in the area of the effect of using 3D pictures in management tasks. Quite a few studies on when to use table and when to use graph was also studied with variations in the use of different graph types and the manipulation of patterns and colors [23]. Geographical information systems that used to be in scientific research have also seen more and more in business research [33] [5] [17].

Although visualization appears to be very useful in business operations, some would argue that there are so many visuals in today's media, advertisement, and public communications. Sadler-Trainor (2005) pointed out that these visual overdoses can downplay creative thinking process. He argued that textual data requires more brain activities. When texts are read, the brain will have to create an image or mental model of some kinds and through this process the brain will be constantly stimulated --a good training for creative thinking [42].

Research on the usability of products/ services is similar to the studies of the usefulness of information. Both deal with the needs to satisfy user's requirements [40] [18] [47]. An overly designed information systems might end up with more functionalities than what a user needs or produce excessive reports that may never be used. As Ackoff (1967) pointed out in his classic article that the more is not always the better [1]. Managers might not always know what they want when being asked by an information system designer. Thus, in many cases, the designer tends to put some buffers in his design. For example, having all possible types of graphs available, providing subtotals at every level of calculation even though only a single total number is needed, and adding so many customized routines or spreadsheet macros that any upgrade means having to redo everything from the start. The fact that a computer processor can easily do the work very quickly might not help a manager at all. This is because it will take time to scrutinize and extract what might be needed from the vast amount of detailed data, graphs and charts including. Even though a manager gets the information he/she needs, there is no guarantee for the making of a better decision since the process itself is very complex and the system might not be able to produce the needed information every step along the way.

Decision makers tend to use past experience and spatial inference to understand the decision making environment. Visualization can trigger the ability to use metaphor to see the links between different system components of the same abstract domain. However, spatial reference of individuals varies because of they have different perceptual or cognitive biases. Visualization can bring to an individual's attention the salient characteristics of information without much concentration. Also, visual representation of data can increase the efficiency in decision making performance. Visuals such as graphs and charts will give spatial perspective that could trigger the thought process to generate better insights to a problem domain.

Business visualization research has long been focusing on decision making performance and has not considered user's learning performance. This line of research assumes the success of an information system to be synonymous to intention or use of the system itself. However, information usage may or may not promote or enhance the leaning capability of the information user. Start with knowledge, users can move up to higher level of learning process, from just remembering, to understanding and applying. A learned user should be able to analyze & synthesize as well as to evaluate and eventually be able to create new knowledge or new procedures [3].

2.4 Cognition and Visualization

Individuals differ in their cognitive processes and their spatial visualizing capability. Zimowski & Weothke (1986) assembled examples of spatial test items and used them to examine variation in spatial visualizing abilities. The authors differentiate two types

〈Table 1〉 Level of Learning, Cognitive domain, and outcomes

Levels of Learning	Aims/ Outcomes	Cognitive Domain
Evaluation	Know/ Distinguish between	Judge, appraise, evaluate, compare, assess
Synthesis	Understand/ Choose	Design, organize, formulate, propose
Analysis	Determine/ Assemble	Distinguish, analyze, calculate, test, inspect
Application	Appreciate/ Adjust	Apply, use, demonstrate, illustrate, practice
Comprehension	Grasp/ Identify	Describe, explain, discuss, recognize
Knowledge	Become familiar/ Solve, apply, list	Define, list, name, recall, record

Source : Adapt from D'Andrea (2003, Table 3.3 & 3.4, p. 35)

of information processing abilities, analogy ability of structural visualization and the nonanalog ability of verbal analytic reasoning. They found the former to involve holistic gestalt-like processing of visuospatial information and the latter to the test of general intelligence and verbal processing abilities [58]. Both of these two spatial problem solving techniques are quite common in critical thinking research where different strands of research existed to study human reasoning and mental model construction [31] and the link between performance and thinking styles [48] [32].

Mixed research results were found on the effect of data representation on decision performance using tables versus graphs [5] [53] [54]. Sometimes table representation results in better decision other times graphs better. This line of research examines the information processing tasks as important factors that influence the cognitive fit of decision makers. It is argued that the types of information processing tasks must fit the types of data representations [53]. For unstructured problems where innovative idea is needed to reach alternative solutions, Stoyanov & Kirschner (2007) found student subjects who have the Cognitive Style of an innovator type to be able to generate novel ideas more than adaptor type[46]. By arguing that an individual's decision performance depends on the matching between data representation and the information processing tasks required, Iris Vessey in her landmark article proposed the cognitive fit theory. She classified information representation and the information processing tasks into two types, spatial and symbolic. The cognitive fit occurs if the task type is spatial and the decision maker is given visuals with spatial data representation [53].

2.5 Outcome-based Learning

In general, the definition of "learning" is quite broad. Learning process allows one to acquire experience and expertise from performing a given task again and again. The experience gain will help a person develop higher level learning, for example, greater understanding and better insights. A measurement of different level of learning performance is known as outcome-based learning. Basing on the work of Bloom (1956), there are six levels of learning [6]. A shown in Table 1, different vocabularies are used to describe the aims or outcomes of different levels of learning that in turns relate to the cognitive domain of a person [15, p.35]. Although these vocabularies can serve as a good guideline to differentiate one level of learning from another, careful consideration must be done to test the reliability and validity of these measurements.

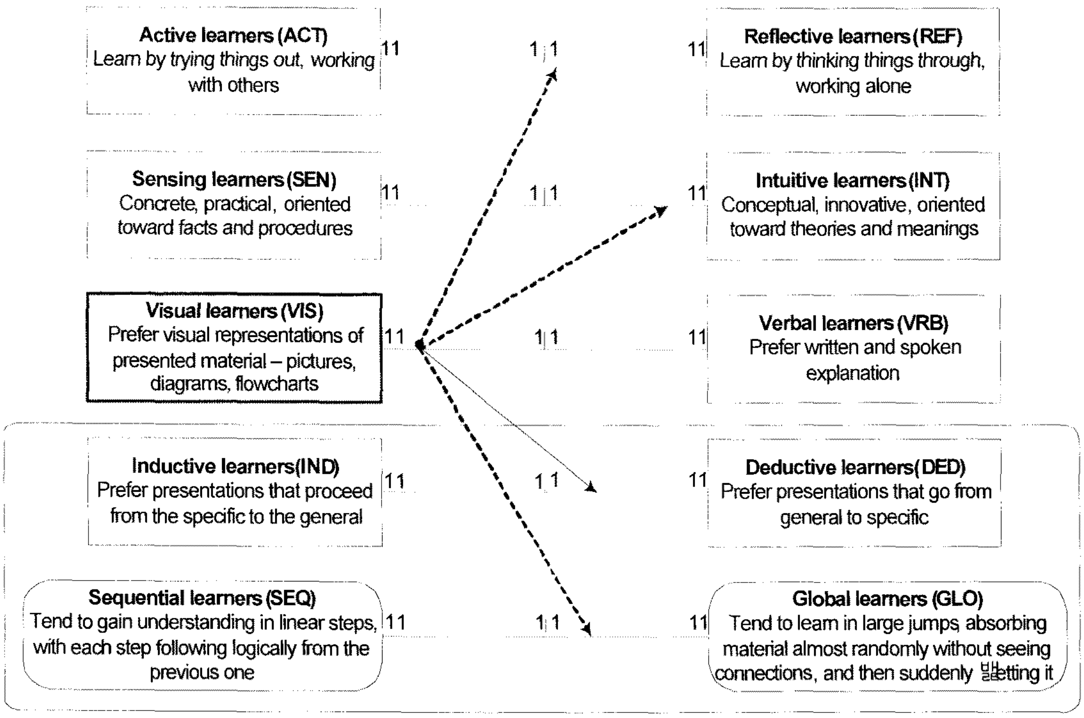
It is apparent that learning style research relates closely to visualization. R.M. Felder & L. K. Silverman (1988), proposed the definition of learning style and for years tested the measurements of this construct in different contexts [22]. As seen from Figure 5, the authors and their colleagues have changed some of the sub-constructs so as to keep up with the on-going changes in business environment. The four original dimensions are active/reflective, sensing/intuitive, visual/verbal and inductive/deductive. A decade later, Felder and other colleague replaced the dimension inductive/deductive with sequential/global to keep up with the advent of digital and online communications [21]. Index of Learning Styles - ILS was developed and distributed online, comprising 11 questions for each dimension. Students are believed to learn better if the instructional design is aligned with their learning style and cognitive processes. Students with visual oriented learning style were found to prefer the use of visual representation than verbal representation and all active learners in his study are visual learners [36]. Also, students with high visual style tended to rate the lecture based instruction as less beneficial to their learning performance.

2.6 Self-efficacy and Leaning Outcome

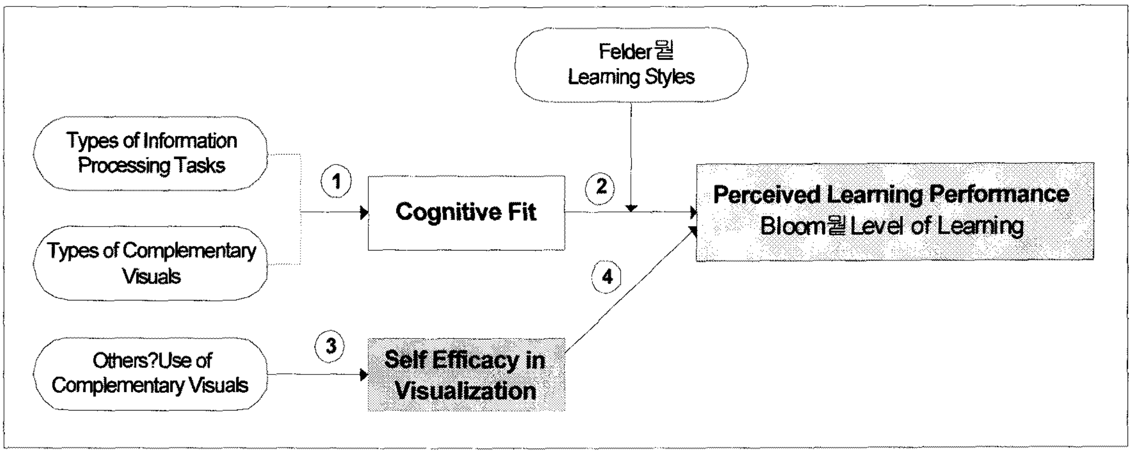
Self-efficacy is an important construct that has been studied within the learning performance research. Since self-efficacy is the variable that can change from one context to another, it is the construct that capture the differences between individuals regarding their learning processes. There is a large inventory of research available on different aspects of individual differences; quite a few of these research focuses on the self-efficacy construct using experimental design and student-teacher samples [44]. Following Bandara's Social Cognitive Theory stream of research, self-efficacy has been found to positively relate to performance [4]. Self-efficacy of computer operators was found to relate to work performance [26]. Students who received an encouraging note as an experimental variable to increase their self-efficacy tended to have better learning outcome than those who did not [29].

3. Conceptual Framework

Visualization research in business setting needs to go back to its fundamental quest, whether or not the information provided to users fit their needs, in this case, whether the way the information being presented will fit the information processing tasks of users. As in an old saying, "Seeing is Believing," one would expect that report users would be able to attain a higher level of learning if they see the information that fits their thought processes. Thus, how to come up with the visuals that are familiar, meaningful, and thought provoking such that new insights can come to the report users is one challenging quest worth exploring



<Figure 5> Felder's Leerning Styles



〈Figure 6〉 Conceptual Framework

by information system researchers. The present research framework for business report visualization is based on cognitive fit theory and learning outcome literature. As shown in Figure 6, the three main constructs of interest are Perceived Learning Performance, Cognitive Fit, and Self-efficacy. Types of Information Processing Tasks and Types of Complementary Visuals are included as the antecedent variables to the Cognitive Fit construct. Learning Styles variable is added as a control variable for the relationship between Cognitive Fit and Perceived Learning Performance. Another variable, Others' Use of Complementary Visuals, is also incorporated into this preliminary conceptual model because both Self Efficacy and individual's learning process are socially dependent variables [12].

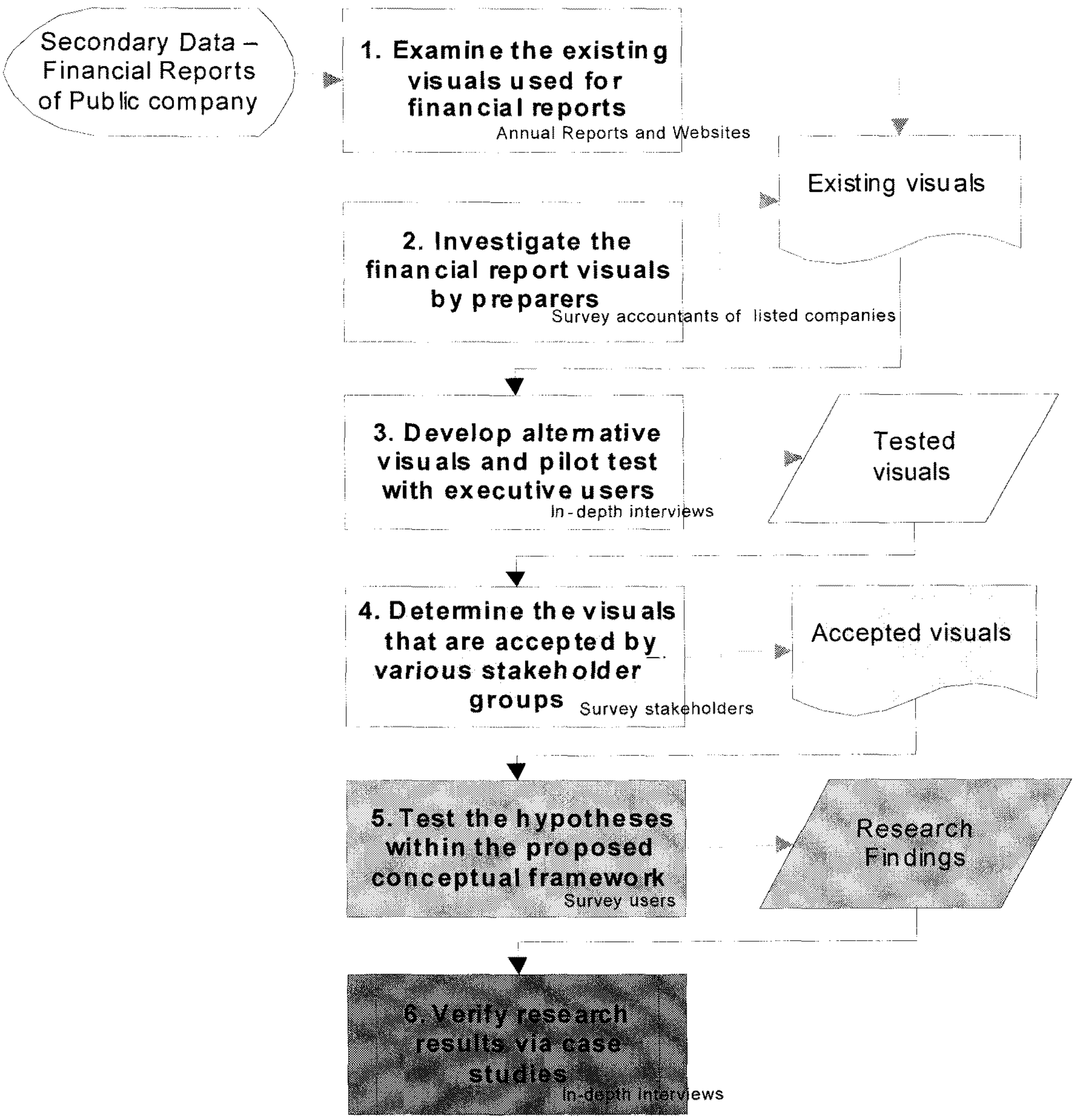
Current research issues in business visualization are focus on the relationship between Cognitive Fit and Decision Making Performance. However, a priori to decision making is having an understanding and gaining insights into the problem domain itself. Also, visuals are used to complement other information in a business report. Therefore, the study of what complementary visuals will fit with what tasks and in turns allow them to understand the information better can definitely add another angle to the existing body of business visualization literature. Besides gaining insights into the information received, management may be able to come up with more innovative ideas and greater number of alternative solutions [46]. To use Perceived Learning Performance instead of Decision Making Performance in business context can also contribute to the existing body of knowledge.

The study of Self-efficacy and Perceived Leaning Performance in business visualization context can have a great deal of practical contribution, especially to software vendors. This is because many commercial software packages have extended the visualization capability to their applications a great deal. Many of these visuals are made available just for the sake of having them there; at time they are "chartjunk" and might result in more harm than being useful for report users. Configuration cost increase in order to make these unnecessary visuals available to the users can be reconsidered with the insights from findings of the present exploratory research.

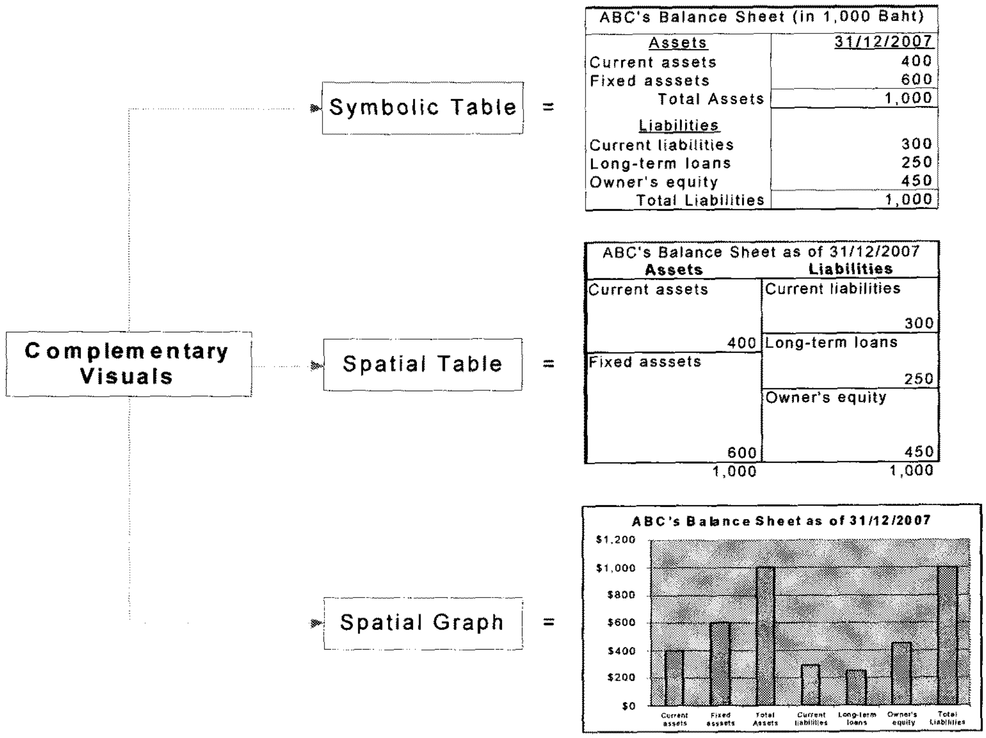
4. Research Design

Both qualitative and quantitative research methods will be used in the present study. Data will be collected from multiple sources so that triangulation of results can be done in order to increase the reliability and validity of the research findings. Since accessing to needed information can be a major limitation to the study, thus, the scope of data collection will only be with stakeholders in Thai business environment. A brief step-by-step research process is depicted in Figure 7. In essence, the first two steps are to assess the existing visuals of financial reports; the third and forth steps are to obtain the visuals accepted by various stakeholders, and finally the fifth and sixth steps are to investigate and test the conceptual model of the study.

To develop the research instruments for each step of the research plan and for every construct in the conceptual framework, a validated measurement will be used. As shown in the steps above, the acceptable Complementary Visuals will be developed anew. Some example visuals are shown in Figure 8-9. Since the present research is at the beginning step, no result is available at the time of this writing. The author welcomes any comments.



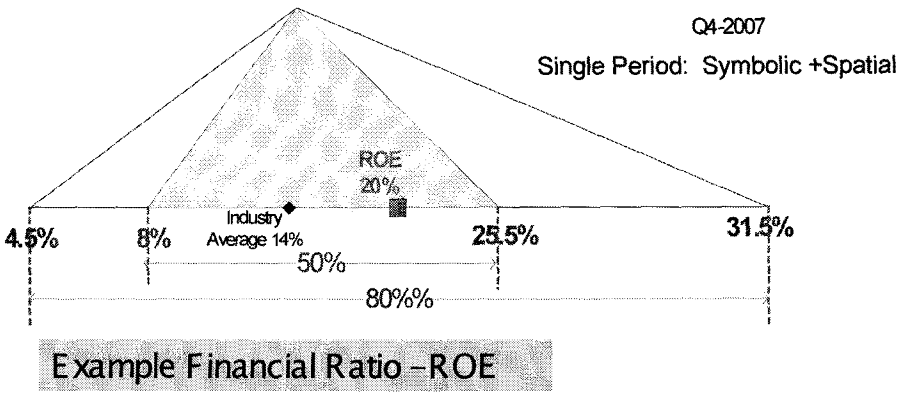
〈Figure 7〉 Overall Research Plan



〈Figure 8〉 Example Visuals for Balance Sheet Report

Period	ROE	Industry Average	Lower 50%	Upper 50%	Lower 80%	Upper 80%
Q2-2007	12	14.4	8.5	24	5	31
Q3-2007	15.5	15	9	25	5	32
Q4-2007	20	14	8	25.5	4.5	31.5
Q1-2008	14.5	15	8.5	24.5	4.5	32
Q2-2008	22	15.5	8	25	5	33

Symbolic



〈Figure 9〉 Example Visuals for Financial Ratio

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