

Financial Data Assessment Using Table-Graph-Mixed Reality Visualization

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Abstract

Usability and knowledge drawn from utilizing various ways of representing accounting data were examined. Classroom experiments were conducted to compare students' assessment of financial data using table of numbers, 2-dimensional column graphs (2D), 3-dimensional column graphs (3D), and mixed reality visualization of true 3-dimensional graphs (MR). The results showed that in assessing the financial status and performance of a firm, Table of numbers and MR took longer than 2D and 3D graphs. The time spent on true 3D graphs using MR technology was about the same as Table of numbers. When compared the assessment scores of the firm's financial status and performance between participants and experts, the difference was the least when participants used 2D graphs. However, MR was seen as being a new way to provide data of greater complexity and was very useful for financial information.

Keywords : Financial Accounting Data Visualization, Mixed Reality, Usability of 3D Graphics with 3D Reality

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1. Introduction

Users of financial data are used to see table of numbers and spreadsheet graphs. There are many studies examining the effective use of tables versus graphs, especially those being used as decision aids. Mixed results were reported. Some found tables to be more effective than graphs; others found graphs to be better. Also, two dimensional (2D) and three dimensional (3D) graphs were often examined to see which type would outperform the other. Some studies found 3D graphs to be associated with slower decision times and reliable performance decrements [Fischer, 2000, Carswell, 1991]. 3D rotational visuals were found to make the best prediction in terms of decision accuracy by novice users who dealt with complex, multidimensional accounting data [Brath and Peters, 2005; Dull and Tegarden, 1999; Helweg-Larsen and Helweg-Larsen, 2007]. However, Kumar and Benbasat [2004] found 3D line graphs consistently outperformed their equivalent 2D graphs [Kumar and Benbasat, 2004]. The 2D and 3D graphs in the majority of previous studies were static and the 3D graphs were 3D on a 2D plane. The question as to whether a true 3D graph representation would outperform the other types of data representations has yet to be explored.

Using Mixed Reality (MR) or Augmented Reality technology, a true 3D object can be created. Introduced by Paul Milgram [Milgram and Kishino, 1994] to combine real and virtual worlds through the use of computer technology, the concept of mixed reality has evolved and

changed rapidly to cover a wide range of applications. MR technology being utilized in this study includes the use of computer hardware with a webcam and markers or barcode cards that will be detected by the systems and eventually project the 3D images in the form of hologram look alike on a computer screen.

2. Financial Report Visualization

Spreadsheet graphs have been used extensively in financial reports. Previous studies found limited types of graphs being used in annual reports of public companies [Tanlamai and Tangsiri, 2010]. Financial data users appeared to have mixed learning outcomes from their exposure to spatial graphs or spatial tables and symbolic tables [Tanlamai and Soongswang, 2009; Tanlamai and Soongswang, 2011]. The study of whether tables or graphs can be more useful in presenting numerical data was dated back over five decades [Carter, 1947] and regained its momentum when spreadsheet software became part of normal business practices in the mid 1980s and 1990s [Remus, 1984; Coll and Coll, 1989; Coll and Coll, 1993]. Also, many studies focused on proper presentation of information and the accuracy of information as seen by decision makers [Kirner and Kirner, 2006; Tufte, 2001].

In recent years, studies of graphic representations still focused on decision making environment. Amer [Amer and Ravindran, 2010] used the Latency-Correction theory that was offered by Changizi and colleagues to explain why 3D graphs (especially those being pro-

duced in traditional spreadsheet software) would create a cognitive illusion with a split-second of real world object deception [Amer and Ravindran, 2010; pp. 25–26]. They found that gridlines for 2D and 3D graphs could mitigate decision biases. Huysmans and associates [2011] studied the accuracy, answer time, and answer confidence of alternative representation formats, i.e., decision tables, decision trees, propositional rules, and oblique rules, in the classification of a new loan application [Huysmans et al., 2011]. They found decision tables to outperform other representation formats. By comparing tables with MR technology, Tanlamai and associates [2011] found MR to be easy and useful and required shorter amount of time and more learning gain than tables [Tanlamai et al., 2011].

3. Methodology

The objective of study is to examine the acceptance and usability of different types of visualizations, including tables, two and three dimensional graphs, and three dimensional graphs constructed by Mixed Reality technology.

3.1 User Experiment

As Chang et al. [2010] pointed out: quasi-experimental approach to collect data in small groups was a simple and effective method of learning-based evaluation. He also pointed out that “learning in visualization use is learning about the dataset being visualized” [Chang et al., 2010; p. 2]. The present study was a within-subject experimental design study. There were 3 hospital data sets being used in the

experiment. The four types of data representation being included were Table (T), 2-dimensional column graphs (2D), 3-dimensional column graphs (3D), and a true 3-dimensional graph using mixed reality visualization (MR).

The subjects were students in the second year and fourth year who were studying in the Bachelor of Accountancy program in a large public university. The participants received class credit and a small souvenir for participation. Booklets containing detailed instructions and questionnaires were created with distinct color coding for each condition. Participants were asked to record the beginning and ending time of each task.

In <Table 1>, there were 124 subjects participated in the experiment. Each subject was randomly assigned to four types of questionnaire booklets (Q1–Q4). H0, H1 and H2 stood for three sets of hospital data, hospital#0, hospital#1, and hospital#2. The affix after each type of data representations, Table (T), 2D graphs (2D), 3D graphs and 3D in MR format (MR) denoted the dataset being exposed. Since Table was the most common way to show financial data, the same hospital data, T0, was used across all conditions. Then each subject was asked to assess the data of the next hospital—either 2D1 or 2D2 graphs or 3D1 or 3D2 graphs. Finally, the subject was asked to assess the MR graphs, either MR1 or MR2. By swapping data sets as well as graphic representations, the present data collection was designed to reduce biases from serially exposure to the same dataset.

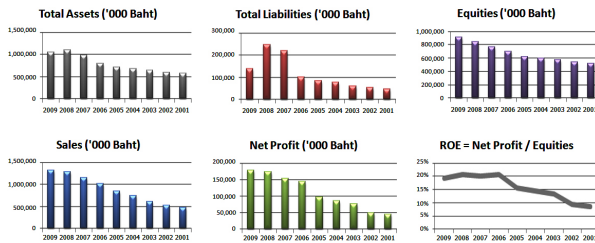
(Table 1) Subjects and Responses/Answers in Experiment-1 (Table versus 2D versus 3D graphs)

Questionnaire	Table	2D		3D		Mixed Reality		#Subjects
Representation	T0	2D1	2D2	3D1	3D2	MR1	MR2	
Q1 (T0-2D2-MR1)	30		30			30		30
Q2 (T0-2D1-MR2)	32	32					32	32
Q3 (T0-3D2-MR1)	30				30	30		30
Q4 (T0-3D1-MR2)	32			32			32	32
Sum	124	32	30	32	30	60	64	124
Number of Responses	124	62		62		124		

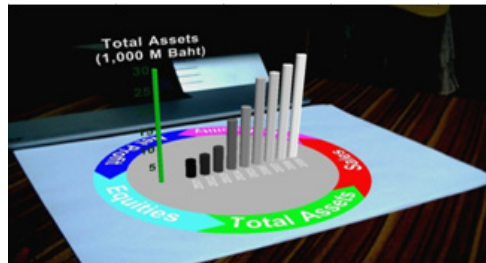
Table Format

Company Highlight																			
Symbol		Train																	
Period																			
Account Period																			
Yearly																			
Fiscal Year																			
Year																			
To																			
ITEMS		2009		2008		2007		2006		2005		2004		2003		2002		2001	
		Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg	Jan - Dec	%Chg
Total Assets	('000 Baht)	1,052,870.00	-3.41	1,090,052.00	11.34	979,043.00	23.29	794,111.00	12.61	705,203.00	4.48	674,995.00	6.67	632,788.00	7.41	589,108.00	3.9	567,015.00	0.63
Total Liabilities	('000 Baht)	136,908.00	-44.49	246,618.00	13.3	217,673.00	118.21	99,756.00	20.99	82,448.00	5.38	78,238.00	29.76	60,294.00	13.09	53,315.00	17.65	45,316.00	-45.23
Equities	('000 Baht)	915,962.00	8.6	843,434.00	10.78	761,370.00	9.65	694,355.00	11.5	622,755.00	4.36	596,757.00	4.24	572,494.00	6.85	535,793.00	2.7	521,699.00	8.53
Sales	('000 Baht)	1,318,992.00	3.1	1,279,321.00	12	1,142,219.00	12.73	1,013,216.00	20.04	844,065.00	14.68	736,009.00	20.79	609,335.00	16.87	521,378.00	9.37	476,729.00	13.48
Net Profit	('000 Baht)	176,948.00	1.61	174,149.00	13.73	153,126.00	7.03	143,070.00	48.65	96,248.00	12.22	85,767.00	12.28	76,384.00	52.96	49,938.00	10.99	44,992.00	18.32
vol: ROE = Net Profit / Equities		19.32%		20.65%		20.11%		20.60%		15.46%		14.37%		13.34%		9.32%		8.62%	

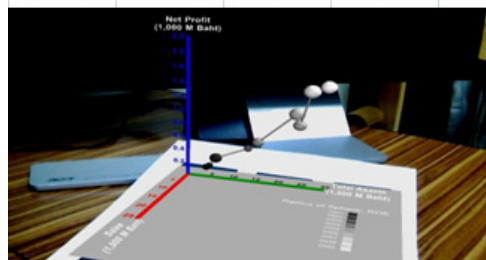
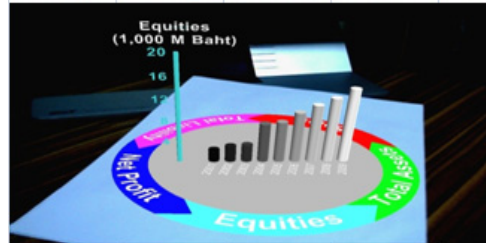
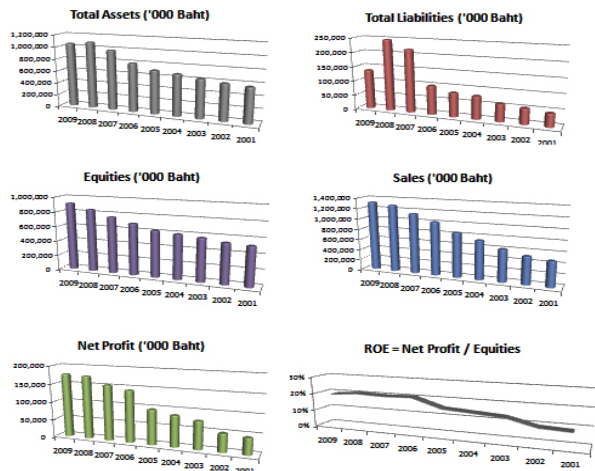
2 Dimensional Graph (2D)



3D Graph using Mixed Reality (3D-MR)



3 Dimensional Graphs (3D)



(Figure 1) Table, 2D Graph, 3D Graph, and MR Graph Visuals

Each questionnaire booklet starts with collecting demographic data and participant's familiarity with different accounting terms and MR technology. They then proceeded to assess hospital's financial status (solvency) and performance using Table in an Excel file as their first task. The second task was to assess the next hospital data using either 2D or 3D format. Before performing the third and last task, the participants were trained on the use of MR tool for 20 minutes. Then they were asked to assess another hospital's data in MR format. Before and after each task, the subject was asked to record the beginning time and the ending time of each task. The last section of the questionnaire booklet contained post-test questions that were designed to capture user's relative preference toward all three methods of data representation.

The experiment was done in a computer lab. The experimental data were presented in four types of visual representations in an Excel file with different sheets containing Table, 2D or 3D and a link to MR program [Larngear Technology]. For MR interface, paper-based markers were used. Equal data items were given in table, 2D or 3D graphs and 3D with MR image projection. As shown in <Figure 1>, every type of data representations was based on the same 10 years of five financial accounting items : Sales, Net profit, Total assets, Total Liability, Equities and only one financial ratio, ROE, being included.

Eight experts who had already received a master in accountancy or were in the final year of their master degree in accountancy were asked to participate in the same way as the student subjects. They were familiar with fi-

ancial statement analysis but none of them were financial analysts by profession. A few had worked in public accounting firms. None of these experts had any experience with MR before. Their ratings were used to compare with those rated by the participants. Absolute different scores (or congruence between participants' rating and experts' rating) were used as the knowledge drawn measures.

3.2 Study Constructs and Hypotheses

Built on previous study [Tanlamai and Tangsiri, 2010], the present study relied on participant's self-reported assessment and used the same constructs as follows :

- Cognitive processing measures (the amount of time spent and the complexity of information).
- Perception measures of each type of data representation (ease of use and usefulness).
- Knowledge drawn from the data representation measures (congruence between participants' rating and experts' rating on the financial status and performance of the experimental data set).

Although previous study found that MR outperformed Table in terms of knowledge drawn (Ibid.), however, no evidence has been found to date that MR would also outperform 2D and 3D graphs representations. While graphs and diagrams are used to amplify cognition and represent complex information, no conclusive result of which type of representations would be easier and more useful as well as required less or

more amount of time to process by users of accounting data. These lead to the following null hypotheses :

H1 : There is no difference in the amount of time spent and level of complexity being perceived among different types of data representations.

H2 : Table, 2D, 3D and MR are equally useful and easy to use in assessing a firm's financial status and performance.

H3 : There is no difference in the knowledge drawn from Table, 2D, 3D, or MR in the assessment of a firm's financial status and performance.

4. Results

The majority of the respondents are female (82%) and were in the sophomore year (62%). None of them had experience with Mixed Reality technology. About half (52%) indicated that they

had not assessed financial data before. This section included the analysis of cognitive process measures—actual amount of time, perception of time spent and perceived complexity of the way the data were presented. Ease of use and usefulness of each type of data representations were reported next and followed by the analysis of the knowledge drawn from the use of each type of data representation to assess firm's status and performance.

4.1 Cognitive Process

For cognitive and perception measures, participants rated Table to be more complex and required more time to process than 2D, 3D, and MR representations. As shown in <Table 2>, there was no difference in the actual time spent, perceived time, and perceived complexity regarding the use of 2D and 3D. Therefore, data for 2D and 3D were combined for further analysis. The four methods of representing financial accounting data had affected the participant's in-

<Table 2> T-test on Means Difference of Actual Time Spent, Perceived Time Spent and Perceived Complexity

Type of Data Representation	Actual Time Spent	Perceived Time	Perceived Complexity
Means Difference and t-statistics (a)			
2D-3D	1.76, 1.85 t = -0.68	2.90, 2.94 t = -0.16	2.83, 2.85 t = 0.78
Means (Standard Deviation) (b)			
Table	2.81(1.4)	4.39(1.3)	4.14(1.6)
2D3D	1.81(0.79)	2.92(1.1)	2.85(1.1)
MR	2.88(1.4)	4.19(1.6)	3.99(1.6)
t-statistics (c)			
T-2D3D	t = 7.78***	t = 10.65***	t = 8.99***
2D3D-MR	t = -8.70***	t = -7.88***	t = 7.26***
T-MR	t = -0.61	t = -1.02	t = 0.68

Note) (a) Independent t-test with degree of freedom 1, 61.

(b) Number of observations for all types of representation = 124; 2D and 3D were combined.

(c) *** p < .001, ** p < .01, * p < .05.

<Table 3> Perceived Ease of Use and Usefulness for Table, 2D, 3D and MR Representation

Perception	Means				t-statistics		
	Table (N = 124)	2D (N = 62)	3D (N = 62)	MR (N = 124)	Table versus 2D3D	2D3D versus MR	Table versus MR
Ease of Use	3.86(1.4)	5.59 (1.1)	5.40(0.9)	4.64(1.6)	-10.77***	5.51***	3.62***
Frustrating to Use	4.07 (1.4)	2.69(1.1)	2.79(1.2)	3.79(1.6)	8.67***	-6.96***	-1.38
Complicate to Use	4.15 (1.5)	2.71(1.2)	2.68(1.0)	3.81(1.6)	9.44***	-7.43***	-1.68
Useful format for showing data	4.99(1.2)	5.66(1.1)	5.40(1.1)	5.78 (1.0)	-4.23***	-2.39*	5.47***
Useful format for assessment	5.07(1.2)	5.59(1.2)	5.50(1.1)	5.76 (1.1)	-3.58***	-1.93	4.56***

Note) *** $p < .001$, ** $p < .01$, * $p < .05$.

formation processing process differently. Subjects spent the lowest amount of time with 2D and 3D representations. Table and MR required about the same amount of time. Thus, the pairwise differences of Table-2D3D (t -actual time = 7.78, t -perceived time = 10.65, t -complexity = 8.99) and 2D3D-MR (t -actual time = 8.70, t -perceived time = 7.88, t -complexity = 7.26) were at .001 levels of statistically significant. Similar significant results were found with perceived complexity. Except between Table and MR, Hypothesis 1 was not supported because there were some differences in the amount of time spent and level of complexity being perceived by other pairs.

4.2 Ease of Use and Usefulness

In terms of perceive ease of use and usefulness, participants found 2D to be the easiest (Mean = 5.59), followed by 3D (Mean = 5.4), MR (Mean = 4.64), and finally Table (Mean = 3.86). The most frustrate and complicate to use was Table and MR was perceived as the most useful format for showing data and performing assessment. There were differences in means of each pair of data representations : table and 2D3D, 2D3D and MR, and Table and MR. Thus, Hypothesis 2 was not supported.

4.3 Knowledge Drawn

In performing the tasks using data from three hospitals, the experts took longer times than the participants in almost all cases except that they spent less time than participants in the case of 2D and 3D. The means and standard deviations of knowledge drawn from spreadsheet table and MR are shown in <Table 4>. When 2D and 3D were used, the participants rated the solvency and performance of H2 higher than H1 (2D : 5.50 > 4.37, 5.60 > 4.69; 3D : 5.00 > 4.41, 5.33 > 4.53). However, when MR was used, the ratings of participants and experts were inconsistent. Thus, Hypothesis 3 was not supported.

To further analyze the knowledge drawn, congruency measures were calculated as the absolute differences between participant's and expert's rating scores. As shown in <Table 5>, the disparity ratings that was statistically significant were between Table of Numbers and 2D ($T = 1.15$, $2D = 1.59$, $t = -2.18$, $p = .033$) and 3D with MR ($2D = 1.59$, $MR = 1.01$, $t = 3.28$, $p = .002$). Thus, the results showed participant differed from experts in the 2D mode more than Tables of Numbers and Mixed Reality. The extent of participant-expert rating difference was

<Table 4> Time Spent (minutes) on Each Task and Means (Std. Dev.) of the Firm's Solvency and Performance

Data Representation	Actual Time Spent			Solvency			Performance		
	Subject	Expert	t-statistic	Subject	Expert	t-statistic	Subject	Expert	t-statistic
Table-H0	2.81(1.38)	3.13	-2.62**	4.88(1.5)	6.00	-8.32***	4.77(1.4)	5.63	-6.75***
2D-H1	1.72(0.89)	2.00	-1.79	4.37(1.5)	6.00	-5.89***	4.69(1.3)	6.00	-5.58***
2D-H2	1.80(0.71)	1.00	6.13***	5.50(1.1)	7.00	-7.23***	5.60(1.1)	7.00	-6.96**
3D-H1	1.91(0.82)	2.50	-4.11***	4.41(1.8)	5.00	-1.84	4.53(1.4)	5.50	-3.82***
3D-H2	1.80(0.76)	1.50	2.16*	5.00(1.3)	5.50	-2.17*	5.33(1.1)	4.50	4.06***
MR-H1	3.07(1.42)	3.25	-0.99	4.92(1.4)	5.50	-1.59	5.33(1.4)	5.25	1.51
MR-H2	2.72(1.33)	3.25	-3.20**	4.63(1.4)	6.00	-7.63***	5.64(1.2)	6.50	-10.99***

Note) *** $p < .001$, ** $p < .01$, * $p < .05$.

<Table 5> Absolute Value : t-tests of the Congruency Rating of Table, 2D, 3D and MR

Paired Comparison	T-2D	T-3D	T-MR	2D-3D	2D-MR	3D-MR
Congruence of solvency ratings	1.15, 1.59 -2.18, $p = .033$	1.43, 1.25 1.15	1.29, 1.13 1.19	1.59, 1.28 1.48	1.59, 1.01 3.28, $p = .002$	1.25, 1.25 0.00
Congruence of performance ratings	1.11, 1.35 -1.39	1.30, 1.29 0.09	1.35, 1.29 0.56	1.35, 1.16 1.02	1.35, 1.19 0.94	1.29, 1.08 1.18

Note) *** $p < .001$, ** $p < .01$, * $p < .05$.

First-line shows Mean for Data Rep 1-Mean for Data Rep 2; Second-line shows the t-test statistic and p-value if significant.

<Table 6> Percentage of Participant's Selection

Responses	T : 2D	2D : MR	T : MR	T : 3D	3D : MR	T : MR
Ease of Use	10 : 90	61 : 39	26 : 74	15 : 85	61 : 39	26 : 74
Usefulness	42 : 58	15 : 85	26 : 74	37 : 63	21 : 79	35 : 65
Complexity	87 : 13	21 : 77	58 : 42	77 : 23	16 : 84	52 : 48
Faster to Use	5 : 95	58 : 40	27 : 73	11 : 89	58 : 42	26 : 74
Preference for Assessment	18 : 82	40 : 60	18 : 82	21 : 79	31 : 69	19 : 81

lower when MR and Table were employed. 2D graphs discriminated experts from participants.

4.4 Post-test Analysis

In the post-test questionnaire, participants were asked about their overall perception and preference between different modes of data presentation. The result in <Table 6> showed that 2D and 3D were easier to use than Table of numbers; MR was more useful than 2D and 3D. In terms of complexity, Table and MR were

perceived as more complex than graphs, thus, graphs were faster to use. Also 2D, 3D and MR graphs were preferred mode of presentation for financial assessment. These responses were shared by the experts with no conclusive results. All in all, experts found 2D and 3D graphs to be easier to use, less complex, and faster to comprehend than Table and MR. However, MR were chosen to outperform Table and in some cases 3D graphs. These experts had experiences in analyzing financial data. However, none of them is a financial analyst by profession.

5. Discussion and Conclusion

Accounting numbers and derived numbers (e.g., various financial ratios) represent the abstraction of firm's financial position and performance. The typical representations are in the form of tables of numbers and 2D and 3D graphs. Recent MR technology allows a true 3D representation and flexible user interfaces. The present empirical study investigated the learning gain and usability of alternative representations – tables, 2D, 3D, and MR. The results showed that 2D was the most efficient modes of representation. The respondents were able to make the assessment with less amount of time and complexity when 2D was used than when any other representations were used.

Knowledge drawn from MR appeared to be higher than those from tables, 2D, and 3D. By using MR, the congruence measures for firm's assessment were lower than other modes of presentations. Participants who are accounting students were able to have a closer rating to that of the experts in almost all cases. By adding mix-reality layer to the 3D graphs, the present research found novice users to be able to comprehend the abstractions of financial data faster and be able to assess the information closer to what an expert may have done. Unlike previous studies that compared table with graph [2], the MR graphs were seen as complex and difficult to use. Both tables and MR were rated as being useful but difficult to use. The added value of realism promised by AR and VR as found in Maad et al. [2008] was not embraced by subjects and experts in the present study. It was apparent

that subjects took the time to engage in the actual rotation of 3D graphs and that hands-on activity resulted in perceived usage difficulty. It is possible that the innovativeness of technology may affect the present results. Despite the great potential of MR, 2D was still the preferred mode of representation. 3D was seen as being the same as 2D. However, since the study only used student subjects, future research should investigate whether the present conclusions also hold for real users like management, audit committee, financial analysts and investors.

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