DATA DATA EVERYWHERE AND NOT A DROP TO THINK: A CASE STUDY IN DEVELOPING AN EFFECTIVE RESEARCH METHODS COURSE

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ABSTRACT

This paper chronicles the development of a new business research methods course. The primary focus was on training MBA students to develop their own research problem definitions in preparation for the Masters Projects

INTRODUCTION

After several decades of combined teaching and Masters' project supervision, the authors concluded that something is fundamentally wrong with the way research methods are taught to MBA students. The problem was not that students didn't have the quantitative or statistical horsepower to analyze data (although that was a problem too). The problems seemed more fundamental than that. It seemed that students did not understand the research process itself. While they might have interesting subjects to study, related either to their current or future businesses, they seemed unable to adequately formulate research questions, choose appropriate research designs, or even understand what it means to analyze data.

That led us to rethink the way business research methods should be taught to graduate students in semesters preceding the Masters' thesis course. Rather than having the students actually carry out a research study, for which previous cohorts of students had proven to be ill equipped, the authors decided to teach a course that would simulate the trials and tribulations of the research process that all academics are familiar with. We decided to pool our resources, in terms of our own research work, to create a new type of research methods course. Rather than to totally pre-package the course from the beginning, we decided to use the creation of the course itself to demonstrate the research process. Our story is akin to a Wagnerian Opera: the chorus spends six hours building a gallows on stage in front of the audience before the actual hanging. We wanted to test our hunches about why we had been getting such poor research projects by using the current crop of Masters' students as test subjects. Thus, the goal of our course was not to have the students conduct or execute a research project: rather, the goal was to help the students DESIGN a research project from the ground up and identify the stages at which problems might occur.

IN THE BEGINNING

Research is often best performed as a collaborative effort. Students were told on the first day of class that they would be working in teams of two throughout the semester. To model the benefits of collaboration, we decided that the course would be team taught by two individuals with very different teaching styles and personalities. The students were at first skeptical about having to please two different graders. They feared that each faculty member would demand different things and it would be difficult to please two masters. Indeed, the authors are very different individuals, which the students quickly noticed. One of us is detail oriented, the other a big picture thinker. One of us is very structured while the other has a very free-wheeling style. One of us is male, the other female. One is older, the other is younger. One is a republican, the other a democrat. One is yin, the other yang. Most of these differences, however, were not necessarily in the direction that the students might have anticipated.

Right from the start, the students were impressed at how well coordinated a joint lecture we could give. One commented "you really must have rehearsed this lecture." We didn't. Rather, we explained, after years of coordination, our differing styles complement each other so well that we have a natural rhythm that coordinates our joint efforts. We explained that the best research partnerships are composed of equally strong oppositely talented individuals.

The two instructors graded all student assignments separately. They met weekly to compare graded assignments. The students began to see that while the grades might be different across instructors, they were fairly close. In most cases, both instructors noticed the more obvious deficiencies of each assignment. Occasionally one instructor noticed a flaw that was un-caught by the other. As the semester progressed, the students noticed that despite our obvious personality and stylistic differences, one of us was not necessarily an easier grader than the other and that on balance our grades were fairly close and consistent. This helped us impress upon the students of assessing inter-rater reliability when qualitatively analyzing data.

PROBLEM DEFINITION

As any research course and text states, the first step in the research process is to define the problem being researched. Too often, students dismiss this as an obvious step commenting "duh, of course you have to know what it is you're researching." The problem is, even if the student researchers know what it is they are trying to study, they most often have a very difficult time succinctly stating their research questions.

Rather than open the field of inquiry too broadly, the instructors decided to frame the entire course around one research topic with which they were very familiar: social time and management. The instructors have published numerous articles on time and management, time and marketing, cross cultural attitudes toward time, and academic time. Several of their articles were made available electronically for students to reference.

Since this is a business research methods course, and not a marketing research course, it seemed reasonable that students focusing in any area of business – human resources, operations management, or accounting, could find some type of time-related management question worth studying. The first assignment given to the students, working in teams of two was as follows:

> Provide a one-page statement of a research problem involving some aspect of time and management (or business).

Based upon Leedy & Ormrod's (2005) text, which included numerous examples, students were asked to succinctly state the problem, two or three sub-problems, operational definitions of any constructs or terminology, and delimitations of the research.

The students had a very difficult time accomplishing this task the first time around. They proposed hypotheses, told us about how they were going to test correlations in the data, and told us what they expected to find. Clearly, they were disappointed in their initial grades. Although they were given the opportunity to redo the assignments, they complained that the instructors were not explicit about what was expected. Several of them assumed that the problem was that they had chosen the research topic and were considering changing their topics altogether to something more 'researchable.' The problem, as the instructors explained in the text of email in Exhibit 1, not that the topic was not researchable, but rather, the research question was poorly stated.

Exhibit 1:
e-mail to a Distressed Student

I would certainly not discard the topic. While I was not in class last week, from reading the assignments, I would disagree that yours was the most specific. More than one dealt with just one organization. We never meant to mislead you in any way. In the syllabus, which we sent ahead of time we tried to be very explicit about the assignments. In your Masters Project course, you will actually conduct a research project; this course is designed to give you the tools to do well on that project. But our emphasis is on process, not the topic content.

Your research problem was not well defined, which has contributed to the difficulties you are having. You already indicated the methodology and analytical tools, which are further down the line. While there was much background information given, there was not a clear statement of what you planned to research. The closet you came was in the "how" section, where you suggested you would conduct an analysis of the time commitment of the Board. This could be converted into a problem statement, with some editing, but I am not sure that is really what you want to do.

Don't abandon this ship because you have not as yet learned how to sail. You may find the next one poses very similar problems, so I encourage you to work on what you have. Just about anything CAN be researched, but you must learn the process of developing the research.

LITERATURE REVIEW

In general, the students seemed quite eager to jump right into the research process and get right down the business of collecting data by 'doing surveys' and 'crunching numbers.' Few of our students have strong statistical analysis skills beyond basic descriptive statistics and fewer still have any experience designing survey instruments. At this point in the course, the focus turned to preliminary research including literature reviews and other secondary research. Students were asked to prepare a literature review of articles relevant to answering their particular research questions.

As a starting point, students were encouraged to use our online articles in their attempts to create a bibliography. They were shown various ways of creating literature reviews, including the effective use of tables to organize the literature by date, topic, or methodology used. The Leedy & Ormrod (2005) text assignment also covers how to perform a review of the related literature and gives examples. The students were told to prepare a 2-3 page literature review justifying their choices of the eight articles they had selected, a proper bibliography correctly cited, and, if they wanted, a table.

Several students found themselves at a loss. They worried that since they were only studying the practices of one organization and studying their particular issue for the first time, they would not be able to find any published studies. They needed to be shown that looking at industry-sponsored studies or best practices might be useful ways to benchmark their organization's problem with others. The challenge was to get them to generalize their problem and think of it in broader terms.

RESEARCH DESIGN

After several weeks of struggling with the problem definition stage and some measured success with the literature reviews, it was time for the students to choose a methodology. This issue was framed for them in terms of choosing a design appropriate to their research question. As mentioned previously, by their own admission, few of the students considered themselves to have particularly strong quantitative skills and almost none of them had any experience with primary data collection using surveys.

It was around this time of the semester that we introduced the students to qualitative research methods, including observation, structured in-depth interviews, and focus group interview techniques. Further, we had already begun to emphasize the importance of conducting secondary data collection as a vital step in the research process. Since many of the problems had been stated in such a way as to suggest that the students were interested in studying phenomena about which they knew little, we expected them to choose some sort of qualitative or secondary research design.

Instead, they jumped directly to the conclusion that it would be necessary to write surveys, collect a lot of data, and do some correlation analysis. One team stated that first they would collect and analyze their data quantitatively so that they could then propose some hypotheses. This frightened us. A lot.

After a few revisions of the research design, the students began to see the value in research techniques that might precede the collection of survey data. This is because most of them had concluded that they had not decided exactly which questions they might ask respondents and had been made to realize that it might just be easier to look at secondary sources. However, it became clear to us that, in spite of well-written textbooks, students were still confused about the nature of different types of research approaches to take. They were mixing up the qualitative/quantitative with the primary/secondary dimensions of research data.

QUALITATIVE DATA ASSIGNMENT

Both authors have extensive experience conducting qualitative analysis. Indeed, both had completed numerous projects for the university related to year-round operations, scheduling, and academic time. Several of these time-related studies and papers were among those posted electronically for the students to read early in the semester.

Rather than training the students to collect qualitative data by conducting their own focus groups, the instructors decided to save time by letting the students analyze some existing raw qualitative data. The student teams were given copies of a sixty-two-page transcript of a focus group conducted among university faculty and staff about meeting the challenges of moving to year round operations. The following assignment was printed on the syllabus:

> **Analyze and present the data from the transcript in a paper no longer than 3 pages.**

The students were not pleased. They wondered what the instructors expected of them. How would they organize their discussion? Should they analyze the data, or merely summarize it? The instructor clarified: "In three pages, summarize the data and explain what it means. I don't think you can summarize that which you haven't analyzed."

The students handed in fairly well written assignments. Some spent a good deal of time mentioning the names of the participants, their titles, and what they each said and commented about how Sandy (the moderator) conducted the focus group. These got the lowest grades. Others merely restated the interview questions as headings and provided synopses of how each question was answered without extracting meaning. Another group organized their discussions around the major themes that emerged through the discussion and interpreted the meanings of them. These received the highest grades.

By this time in the semester, the natives had begun to get restless. They were totally frustrated by the seemingly intentional vagueness of assignment instructions. One student commented that it would have been much easier to analyze and summarize the focus group transcript if they had been provided with a rubric to organize their papers in a way that the instructors would have found acceptable. Indeed, one of the instructors, facing a bit of a mutiny, explained that the papers that received high grades were not all organized the same way. What they all had in common, rather, is they had all extracted meaning. To stave off a revolution, the other instructor crafted another long email message to simultaneously assuage the students' fears while admonishing them to *analyze and extract meaning from,* rather than summarize the data.

Indeed, we had isolated one of the major problems with student research projects. Despite having given them numerous explanations and definitions of analyzing data, many of them were still having trouble moving beyond simply reporting data and learning to extract information and meaning from it.

SECONDARY RESEARCH

The preceding email missive alluded to an easier, more direct assignment that the students had been given. In fact, according to the Business Librarian, the day before the assignment was due several panicked MBA students had approached her for help. The assignment, taken from the Zagorsky (2003) text, was something of a secondary data scavenger hunt. Sample questions asked the students to find the five busiest US airports, and to report how many people in the Houston, Texas, earned between $50,000 and $75,000 annually.

The assignment was emailed to the students a few days before the secondary data lecture was given and lists of typical useful sources, such as Census.gov were explained. On a positive note, many of the students found their information using sources beyond or other than the ones presented in class, although some of the sources they chose proved to be less than accurate and up to date. Nonetheless, the students had almost two weeks to complete the assignment. While most of them ultimately completed the assignment successfully, most waited until the last minute and made minimal effort. This supported another of our informal research hypotheses.

While the students completed the secondary research assignment, the results were mixed. For example, when asked how many households in Houston earned between $50,000 and $75,000, several student teams indicated 1,112 as an answer. They neglected to report (or perhaps notice) that results were in 100's, which would indicate that there are 111,200 households in that income bracket, which, *prima facie* is a more reasonable number.

Others simply answered the questions by copying tables and charts directly from the internet onto their papers without so much as highlighting those numbers that actually answered the question

Thus, while they might have been able to locate relevant sources, many of the students had difficulty organizing the sources and extracting information from the data sources they had located.

Thus, with a world awash in data, data, data, many MBA students still lack the ability to find, process, interpret, and report what is already available to them. It is no wonder, then, that they have such difficulty completing meaningful research projects.

CONCLUSIONS AND FUTURE RESEARCH

While many research courses, which cover techniques (Anderson 1997) spend a large amount of time on writing questionnaires, collecting data, and running statistical analyses, this may not be the best allocation of effort. The students in these courses may perform well on the individual assignments, but can they develop a coherent research plan, analyze data or interpret findings on their own?

Our approach has been frustrating for both the students and the instructors. We have found trying to teach student to think beyond the box, to recognize patterns, and to interpret what they have is truly a learning experience for both them and us.

Selected References

Anderson, Beverlee B. (1997) "A Customer Analysis Course for the Marketing Curriculum" *Journal of Marketing Education.* Summer 1997, pp. 2 -15.

Leedy, Paul D. and Jeanne Ellis Ormrod (2005) *Practical Research: Planning and Design, 8th ed.* (Columbus, OH: Pearson Merrill Prentice Hall)

Zagorsky, Jay L. (2003) *Business Information: Finding and Using Data in the Digital Age.* (Boston: McGraw-Hill Irwin)

marketing, and especially direct mail – 'three things: testing, testing and testing.' ... It is rare to encounter a program that would not be enhanced by testing *some* of the items (if not many of them). When more than one item is tested, the prospect of *interaction effects* (i.e. "synergy") among the items must be considered." (p. 203)

These books, many of which are "professional" books rather than academic textbooks, discuss experimental design in more detail than the typical marketing research textbook. For example, Roberts and Berger (1999) have greater discussion of factorial designs and interactions than was found in any of the marketing research textbooks discussed above. They also include the vignette of Exhibit 1, which provides an example of the superiority of factorial designs in testing.

Costs of Testing: An Example

One of the major drawbacks to traditional experimental design has been the cost involved. Marketing experimentation has its roots in the social sciences, particularly the field of psychology, where testing "one subject at a time" can be time consuming and expensive. As Christensen (1994) states (p. 87):

"It is not unusual for the experimenter to have to go to extreme lengths to set the stage for, motivate, and occasionally deceive the subject.Then, when the experiment is actually conducted, the experimenter and perhaps one or two assistants are often required to spend quite some time with each subject."

With this type of effort, the number of subjects is typically few, resulting in testing which is limited to a few factors and levels of factors. Experiments utilizing databases, however, having hundreds of thousands of names on a computer list represents an entirely different situation, and one that may easily allow more complex experimental designs. An example derived from that provided by McDonald (1998, p. 182-183) illustrates a rough estimate of what a direct mail test may cost. The following fixed and variable costs apply:

- Consultants (research design and creative art) $20,000 (lump sum)
- Printing (brochures, inserts and return envelopes) $230 per thousand
- Mailing (list purchase, mail preparation and postage) $345 per thousand

Direct mail tests typically measure the responses to each mail offer. Typically an average response (offer acceptance) of 100 would yield the desirable accuracy (e.g. Roberts and Berger 1999). If the response rate averaged 5%, a commonly used figure, there would have to be 2000 mailings sent out to customers in each of the four treatment cells. Thus the cost for a minimum factorial design of two factors at two levels (resulting in four individual mailing categories or treatment cells) would be $24,600 (= $20,000 + $230 X 8 + $345 X 8). If the average response rate was only 2%, the number of mailings for each treatment cell would rise to 5,000 and the cost would increase to $31,500.

Full Factorial Design of Experiments

Simple factorial designs, even if not covered in many textbooks, are relatively easy to cover in class. The usual illustration is a matrix-type format showing the unique testing "cells", or combinations of factors. A four-cell cooking appliance example, with two levels of material and two levels of the timer feature is illustrated in Exhibit 1.

Each cell, numbered from 1 through 4, represents a unique combination of material and timer. While the usual method of analysis would be a two-way ANOVA, a regression approach to analysis would also be feasible, and be based on a regression model as follows, including the interaction term:

Purchase Willingness =
Timer + Material + Timer x Material + Error

Another format for illustrating experimental designs may be found in the engineering-science discipline, and is especially useful for more complex experimental designs. Termed an "extended design matrix" (e.g. Moen, et al 1991), its columns follow the regression model and its rows form the unique test conditions, or "cells" of the traditional marketing format. The two levels of each factor are traditionally indicated by a "-" and a "+". The extended design matrix format for our kitchen appliance example would be as follows

Cell/Test	Timer	Material	Timer x Material
1	-	-	+
2	+	-	-
3	-	+	-
4	+	+	+

In this matrix, the factor columns (Timer and Material) constitute the "design" portion of the matrix, and the interaction column (Timer x Material) represents the "extension". While the signs in the factor columns symbolize the levels of the factors, the signs in the interaction columns are just computations, obtained by multiplying the signs of the factors which make up the interaction. For example, the sign of Test 1's interaction is the "-" of Timer multiplied by the "-" of the Material. These signs are used in the hand computation of the effects of each factor and interaction, and in the selection of the fraction (portion) of the full factorial design, discussed below.

A design with three factors could be illustrated in a similar way. The top illustration of Appendix 1 has three fictitious variables, #1, #2 and #3. Using the "extended design matrix" format, it indicates the three main effects of the variables, the three two-way interactions, and the three-way interaction. As usual, there are 8 "cells" or "tests" of the factors involved (i.e. 2 x 2 x 2), with unique combinations of the two levels of the three factors making up each test, as indicated in the "main effects" columns for variables #1, 2 and 3 (the design portion of the matrix).

It will further be noted that each of the main effects and interactions (the columns) has a unique combination of signs and each of the eight tests (the rows) has a unique combination of signs. Also, each column has an equal number of plusses and minuses, necessary for balance in the testing process. Analytically, the first three columns are used for the factorial design and would represent data in an ANOVA or regression analysis. A similar extended matrix approach may be used for efficiently illustrating experimental designs for any number of factors.

Another convention commonly used in the engineering-science field is that of indicating the number of factors and levels of each factor in an "x^k" notation format (e.g. Montgomery 1994), where the "x" is the number of levels and the superscript "k" is the number of factors. For example, the experiment discussed above, consisting of 3 factors of 2 levels each, would be indicated by the notation "2^3". The notation is not readily applicable to mixed-level experiments (e.g. two factors with 2 levels and one factor with 4 levels), but it does allow a convenient shorthand notation of fractions of uniform full factorial experiments.

With the possible exception of the "extended design matrix" format and notation, all of the above has been familiar to marketing educators since their grad school days. The following discussion may not be quite so familiar.

Fractional Factorial Design of Experiments

The purpose of using fractional factorial designs is to retain the important (useful) information contained in a full factorial experimental design, while reducing the costs. In the testing cost illustration discussed above, for example, there would a marginal cost of $1150 for each test performed (2000 mailings per test at $230+$345 per thousand). As usual, the experimenter would have to make the tradeoff decision regarding cost vs. information.

As marketing educators are aware, one of the problems with multiple factors in design of experiments is the difficulty of interpreting significant higher order interactions. While two-way interactions frequently yield very useful information, and three-way interactions are reasonably easy to interpret and may provide useful information, four-way and higher interactions are quite difficult to clearly interpret even when they are statistically significant. Thus, the fundamental thrust of the fractional factorial design philosophy is to select portions, or fractions, of the full extended design matrix using the higher order interactions as the basis for selection. While the information on these higher order interactions is lost, sufficient information remains to be useful, at substantial cost savings.

Appendix I illustrates an example of this process. The full three factor extended design matrix, discussed above, is shown in the top matrix. The middle matrix shows a half factorial design consisting only of tests which have a "+" in the three-way interaction column of the full factorial matrix. However, while all tests have equal numbers of plusses and minuses in each column, and each design matrix test is unique in its signs, the three-way interaction is now a constant, thus there is no information available on its significance. If selection of the "+" tests is arbitrary, then the "–" tests could just as well have been selected; however, researcher knowledge may indicate a preference for the selection of one of the two signs over the other. The notation for this design is "2^{3-1}".

Unfortunately, the three-way interaction is not all the information that is lost. Inspection of this half factorial extended design matrix will reveal that the two middle columns, the "Factor 3" and the "Interaction Factor 1&2", (indicated by an "x" under each column) are identical in their signs. Thus, the analysis of "Factor 3" is actually an analysis of "Factor 3 + Interaction Factors1&2". Similarly, common column sign identity results in the analysis of "Factor 2" actually being an analysis of "Factor 2 + Interaction Factors1&3", and the analysis of "Factor 1" actually being the analysis of "Factor 1 + Interaction Factors 2&3"; that is, in this design each Factor is confounded with a second order interaction. Clearly this also is a loss of information, which may or may not be important in any given research project. That is, if the interaction is not significant, then a main effect will show little difference in results from what it would if it was not confounded with the interaction.

Fortunately there is additional information available in this half factorial design, as indicated by the three bottom matrices of Appendix I. The data in the "2^{3-1}" design allows us to easily perform three separate full factorial "2^2" design analyses, which will provide much of the information lost by not utilizing a full "2^3" design. Using the same cost data as discussed above, the savings of the half fraction over the full factorial would be $4604 ($1150 x 4 tests). The researcher would have to determine the tradeoff of cost vs. information prior to undertaking the research.

One of the advantages of the fractional factorial approach is that designs with more than three factors do not lose as much useful information, while maintaining their cost savings. Appendix II presents two design matrices: the top is the full factorial "2^4" extended design (having 16 cells or "tests"), while the bottom matrix is the half-factorial "2^{4-1}" extended design, with 8 "tests". While we again observe the existence of confounding of column signs, we note that in this case each two way interaction is confounded with another two way interaction, and the main effects factors are only confounded with three way interactions. Thus, the researcher may have some confidence that any significant main effects found are significant in themselves and probably not as a result of the confounding third order interaction. The reader may verify that, as with the three factor half factorial extended designs, individual analysis may be made of full factorials, in this case full factorials with three factors (i.e. "2^3" designs using Factors 1, 2 & 3; 1, 3 & 4; and 2, 3 & 4). The half factorial savings in this case would be $9200 over the full factorial design ($1150 x 8).

Experimental designs with more factors also increase in usefulness, with concomitant savings. For example, the "2^{5-1}" design is so useful that Moen, et al (1991) note that "Because this design is so powerful, it is rare that a full '2^5' design would be used " (p. 177). This is because each main effect is only confounded with one four way interaction, and any four factors form a full "2^4" factorial design for further detailed analysis. Similarly, quarter or other fractional factorial designs for research using more than 5 factors would result in greater savings, with small declines in the provision of useful information. For example, a "2^{16-11}" design would allow the analysis of any "2^3" design, some "2^4" or "2^5" designs, and "2^{4-1}" or "2^{5-1}" designs for the other four or five factors not allowing the full "2^4" or "2^5" designs (Moen, et al, 1991, p. 181). The cost of this rather complicated "2^{16-11}" design would be $55,200 (for 32 tests) compared to the $24,600 cost of a simple two factor "2^2" design, such as that of the Timer and Material example discussed above.

Summary information on complex design is typically provided in engineering-science books on experimental design, e.g. Montgomery (1994), noting that a series of experimental designs would typically be undertaken. In that regard, Moen, et al (1991) suggest various fractional factorial designs based on level of researcher knowledge of the system being tested. The tables listed in Appendix III are based on their recommendations.

CONCLUSIONS

While the marketing discipline seems to have used true experimental design largely for hypothesis testing in theory development, the engineering-science discipline routinely uses experimental design in an applications context, especially for process optimization. The development of large customer and operations databases allows a similar application of large factorial and fractional factorial designs in marketing, especially in direct marketing applications.

However, while the past decade has seen increasing use of such designs in database marketing applications, marketing research textbooks, and presumably most classes that use those textbooks, have not seemingly changed from their traditional discussions of experimental designs. While all textbooks reviewed have a section on causal/experimental design, they rarely consider full factorial designs, usually confining their discussions to single factor designs; none even mention fractional factorial designs. Thus, as in other aspects of the expanding use of databases in marketing applications, the academe is not keeping abreast of the changes their students will encounter in the workplace.

Countering this industry-based need for a more complete coverage of experimentation in marketing research textbooks is a pedagogical problem: how will this complex topic be covered, and to what extent. In the author's experience, most students have a "full plate" with a thorough coverage of existing material in a one-semester marketing research class. Developing student skills in full factorial designs, including interactions, then going further into fractional factorial designs would probably be more than most undergraduate students could

handle. Even Master's students could probably not do much more than have guided hands-on experience with a simple application.
The answer might be, at least for undergraduate classes, to deal with the material in a lecture context, demonstrating the concepts of full and fractional factorial designs, their usefulness to industry, and the methodology of analysis. Some of the information in this paper may be of use in that regard, but a fully developed case application would be the ideal. Hopefully such an application for demonstration will be developed.

References, additional Appendices, and Exhibit are available from the author upon request.

Appendix I – Three Factor Designs

Full Factorial Extended Design With Three Factors (#1, #2, #3): 2^3

	Variable						
Test	1	2	3	12	13	23	123
1	-	-	-	+	+	+	-
2	+	-	-	-	-	+	+
3	-	+	-	-	+	-	+
4	+	+	-	+	-	-	-
5	-	-	+	+	-	-	+
6	+	-	+	-	+	-	-
7	-	+	+	-	-	+	-
8	+	+	+	+	+	+	+

Half Factorial Extended Design with Three Factors (#1, #2, & #3): 2^{3-1}

	Variable						
Test	1	2	3	12	13	23	123
2	+	-	-	-	-	+	+
3	-	+	-	-	+	-	+
5	-	-	+	+	-	-	+
8	+	+	+	+	+	+	+
			x	x			

Three Full Factorial Extended Designs with Two Factors: 2^2

	Variable		
Test	1	2	12
2	+	-	-
3	-	+	-
5	-	-	+
8	+	+	+

	Variable		
Test	1	3	13
2	+	-	-
3	-	-	+
5	-	+	-
8	+	+	+

	Variable		
Test	2	3	23
2	-	-	+
3	+	-	-
5	-	+	-
8	+	+	+