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An investigation into the nature and constructs of relative expertise in economic problem-solving

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The Ohio State University, 1994
AN INVESTIGATION INTO THE NATURE AND CONSTRUCTS OF RELATIVE EXPERTISE IN ECONOMIC PROBLEM SOLVING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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To Bethany
and To My Family
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TABLE OF CONTENTS

ACKNOWLEDGMENTS ...................................................................................................iii

VITA .........................................................................................................................................iv

LIST OF TABLES ................................................................................................................viii

LIST OF FIGURES ...........................................................................................................xi

CHAPTER PAGE

I. INTRODUCTION ............................................................................................................. 1
   Context of the Research ............................................................... 2
   Statement of the Problem ......................................................... 4
   Research Questions .................................................................. 8
   Methodology .............................................................................. 9
   Definition of Terms ................................................................... 18
   Assumptions of the Study ......................................................... 20
   Limitations of the Study ........................................................... 21
   Overview of the Study ............................................................... 22

II. REVIEW OF THE LITERATURE ........................................................................... 23
   Introduction .................................................................................... 23
   Economic Education and Economic Problem Solving .............. 23
   Research on Expert Novice Differences in Problem solving ....... 26
   Variables Studied ......................................................................... 36
   Methods Employed ....................................................................... 45

III. METHODOLOGY ...................................................................................................... 51
   Research Design ........................................................................... 51
   Selection of Participants ........................................................... 54
   Data Collection ............................................................................. 56
   Data Analysis ................................................................................ 66
IV. DATA ANALYSIS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>73</td>
</tr>
<tr>
<td>Statistical Significance and the Current Study</td>
<td>74</td>
</tr>
<tr>
<td>The Nature and Constructs of Relative Expertise in Economic Problem Solving</td>
<td>75</td>
</tr>
<tr>
<td>Relevant Indicators of Relative Expertise in Economic Problem Solving</td>
<td>77</td>
</tr>
<tr>
<td>Pitt Problem Solving Coding Variables</td>
<td>100</td>
</tr>
<tr>
<td>Percent Change Across Levels of Economic Education</td>
<td>112</td>
</tr>
<tr>
<td>Standardized Rank Data</td>
<td>115</td>
</tr>
<tr>
<td>Summary of the First Level of Analysis</td>
<td>122</td>
</tr>
<tr>
<td>Factor Analysis</td>
<td>124</td>
</tr>
<tr>
<td>Analysis Related to the Development of the EEPSSM</td>
<td>131</td>
</tr>
<tr>
<td>Expert Panel Ratings</td>
<td>153</td>
</tr>
</tbody>
</table>

V. SUMMARY, INTERPRETATION AND RECOMMENDATION FOR FURTHER RESEARCH

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>159</td>
</tr>
<tr>
<td>Summary of the Results of the Current Study</td>
<td>160</td>
</tr>
<tr>
<td>The Nature and Constructs of Relative Expertise in Economic Problem Solving</td>
<td>160</td>
</tr>
<tr>
<td>Analysis Related to the Development of the EEPSSM</td>
<td>165</td>
</tr>
<tr>
<td>Education and the Acquisition of Expertise in Economic Problem Solving</td>
<td>166</td>
</tr>
<tr>
<td>Interpretation</td>
<td>168</td>
</tr>
<tr>
<td>Conclusions</td>
<td>181</td>
</tr>
<tr>
<td>Recommendations for Further Research</td>
<td>182</td>
</tr>
</tbody>
</table>

APPENDICES

A. Hypothetical Models of the Acquisition of Expertise in Economic Problem Solving | 185

B. Standardized Participant Direction Sheet for 'Talk-aloud' Protocols | 187

C. Example of the Expertise in Economic Problem Solving Model (Miller and VanFossen, 1994) | 189

D. List of Economic Concepts Used by Participants | 191
E. List of Economic Models Used by Participants ............................................. 193
F. Expert Panel Materials ...................................................................................... 195
G. Correlation Matrix ......................................................................................... 200
H. Examples of Expert's Self-Rating ................................................................... 202

LIST OF REFERENCES ..................................................................................................... 205
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Summaries of Number of Relevant Statements by Level of Participant</td>
<td>79</td>
</tr>
<tr>
<td>2. One-way ANOVA: Number of Relevant Statements by Level of Participant</td>
<td>79</td>
</tr>
<tr>
<td>3. Correlation Coefficients: All Variables by Level of Participant</td>
<td>80</td>
</tr>
<tr>
<td>4. Summaries of Percentage of Relevant Statements by Participant Level</td>
<td>82</td>
</tr>
<tr>
<td>5. One-way ANOVA: Percent Relevant Statements by Level of Participants</td>
<td>82</td>
</tr>
<tr>
<td>6. Summaries of Number of Economic Concepts by Level of Participant</td>
<td>84</td>
</tr>
<tr>
<td>7. One-way ANOVA: Number of Economic Concepts by Level of Participant</td>
<td>84</td>
</tr>
<tr>
<td>8. Summaries of Number of Concept Maps Used by Level of Participant</td>
<td>87</td>
</tr>
<tr>
<td>9. One-way ANOVA: Concept Maps Used by Participant Level</td>
<td>88</td>
</tr>
<tr>
<td>10. Summaries of Number of Economic Models by Level of Participant</td>
<td>89</td>
</tr>
<tr>
<td>11. One-way ANOVA: Number of Economic Models by Level of Participant</td>
<td>89</td>
</tr>
<tr>
<td>12. Summaries of Problem Representation ERP by Level of Participant</td>
<td>92</td>
</tr>
<tr>
<td>13. One-way ANOVA: Problem Representation ERP by Level of Participant</td>
<td>92</td>
</tr>
<tr>
<td>14. Summaries of Causal Statement ERP by Level of Participant</td>
<td>95</td>
</tr>
</tbody>
</table>
15. One-way ANOVA: Causal Statement ERP by Level of Participant ...... 95
16. Summaries of Propositional Statement ERP by Level of Participant ...... 97
17. One-way ANOVA: Propositional Statement ERP by Level of Participant .................................................................................................................. 97
18. Summaries of Pitt GPS by Level of Participant .................................. 102
19. One-way ANOVA: Pitt GPS Statements by Level of Participant .......... 102
20. Summaries of Pitt H-D Statements by Level of Participant ............... 104
21. One-way ANOVA: Pitt H-D Statements by Level of Participant ........ 104
22. Summaries of Pitt PAT Statements by Level of Participant ............... 106
23. One-way ANOVA: Pitt PAT Statements by Level of Participant .......... 106
24. Summaries of Pitt FEED Statements by Level of Participants .......... 107
25. One-way ANOVA: Pitt FEED Statements by Level of Participants ...... 108
26. Summaries of Pitt EVAL Statements by Level of Participants .......... 109
27. One-way ANOVA: Pitt EVAL Statements by Level of Participants ...... 109
28. Correlation Coefficients for Mean Standardized Rankings of All Variables with Level of Participants .................................................. 118
29. Mean of the Mean Standardized Rankings for All Variables .......... 120
30. Initial Exploratory Factor Analysis: Final Statistics ....................... 124
31. Factor Correlation Matrix: Factor 1 with Factor 2 ......................... 125
32. Factor Structure Matrix: Loadings for All Variables on Factor 1 and Factor 2 .............................................................. 126
33. Calculated Attendant Z-Scores For MU 0-5 (All Independent Variables at Mean Levels) .......................................................... 135
34. Coefficients and Products of the Ordered Probit Analysis on All 13 Variables ........................................................................... 135
<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>52</td>
</tr>
<tr>
<td>2.</td>
<td>64</td>
</tr>
<tr>
<td>3.</td>
<td>99</td>
</tr>
<tr>
<td>4.</td>
<td>100</td>
</tr>
<tr>
<td>5.</td>
<td>111</td>
</tr>
<tr>
<td>6.</td>
<td>113</td>
</tr>
<tr>
<td>7.</td>
<td>114</td>
</tr>
<tr>
<td>8.</td>
<td>116</td>
</tr>
<tr>
<td>9.</td>
<td>117</td>
</tr>
<tr>
<td>10.</td>
<td>121</td>
</tr>
<tr>
<td>11.</td>
<td>130</td>
</tr>
<tr>
<td>12.</td>
<td>137</td>
</tr>
<tr>
<td>13.</td>
<td>141</td>
</tr>
</tbody>
</table>
14. Ordered Probit Probability Distribution for the Variable RELPER...... 144

15. Comparison of Mean of the Mean Standardized Rankings of All Thirteen Variables Versus the Mean of the Mean Standardized Rankings for the Variables RELPER and CONCEPTS............................. 152

16. Mean Expert Panel Ratings Across Level of Participant .......................... 156
Chapter I

Introduction

In providing a rationale for economic education, Miller (1988) noted that we live in an economic world and that many of the decisions that impact upon our daily lives are essentially economic in nature. Thus, Miller stated, economic education is an essential element of citizenship education. Indeed, the case for pre-collegiate economic education most often argues that economic literacy is critical to effective participation within our democratic system (Miller, 1988, p. 4). Central to this line of reasoning is the argument that the development of students' abilities to make more effective decisions about economic problems in turn improves democratic citizenship. This rationale may be traced to the 1961 Report of the National Task Force on Economic Education which "pointed to the need for more and improved economic instruction in elementary and secondary schools, (and) stressed the importance of taking a more systematic, reasoned approach to the study of economic problems" (Saunders, et al., 1993, p. 3).

Symmes and Gilliard (1981) noted that economic literacy requires students to be able to apply economic reasoning when making decisions about how to allocate scarce resources and to be able to identify economic problems, apply the necessary concepts, outline possible consequences and to take action based on subsequent economic decisions. A similar explication may be found in Schug (1985) (in Miller, 1988, pp. 3-4). Moreover, the National Council on Economic Education's *A Framework for Teaching The Basic Concepts*, the
primary curriculum document in pre-collegiate economic education, defined the objective of economic education as "enabling students, by the time they graduate from high school, to understand enough economics to make reasoned judgments about economic questions" (Saunders, et al., 1993, p.1).

Thus, the primary rationale for economic education stresses, in part, the importance of students' economic problem solving. Indeed, given that the rationale for economic education addresses the need for economic problem solving in democratic societies, one would assume that much effort has gone into research on economic problem solving. This, however, has not been the case.

**Context of the Research**

Miller and VanFossen (1994) noted the rationale for economic education outlined above assumed several important links in a chain leading to more responsible citizenship; namely, that more and better pre-collegiate economic education will lead to greater student economic understanding, which will lead to more responsible decisions, which will in turn lead to more effective citizenship. However, it remains to be demonstrated whether this assumed chain can be achieved as a result of pre-collegiate economic education.

To date, researchers in economic education have focused most of their attention on the first link between economic education and economic understanding (see Walstad and Soper, 1991). Research on the second link—between economic understanding and economic decision making—has largely been limited to examining students' economic understanding, as measured by test scores, with scores measuring how well student opinions match those of professional economists on some broadly described economic issues (Soper and Walstad, 1987).
Miller and VanFossen (1994) concluded that little research had been conducted that examined the second linkage, or student economic reasoning, in sufficient depth. As will be described shortly, theory drawn from cognitive psychology proposes that advanced knowledge and problem solving in a domain (e.g., economics) may be thought of as a highly developed, complex network of specialized knowledge, interconnections of that knowledge, and powerful analytic procedures for using that knowledge effectively. Miller and VanFossen noted that:

[T]his (research in cognitive psychology) has significant implications for research and practice in economic education and casts doubt on the simplistic link of greater economic knowledge--as narrowly measured by test scores--leading to better economic reasoning. Indeed, the notion of economic knowledge as highly developed schemata (interconnected cognitive structures) suggests a redefinition of economic knowledge as inextricably intertwined in a network that includes the linkages among bits of economic knowledge and the specialized procedures for using that knowledge (p. 3).

Moreover, this new conceptualization of economic knowledge suggested an approach to assessing economic literacy that was (1) more consistent with the stated objective of economic education and (2) based primarily on students' abilities to reason rather than on knowledge measurements as indicated by standardized test scores. Indeed, economic educators must understand not only what conclusions students reach about economic issues, but also how those conclusions have been reached. Along similar lines, Chi and Glaser (1980) have suggested "that studies be undertaken of the changes that take place as individuals attain increasing competence in various subject matters and that...these investigations should be designed to understand overt changes that appear as the competence level of individuals increases" from novice to expert (p. 38).
Toward this end, it seems crucial to know how closely, if at all, patterns of student reasoning resemble those of economic experts. With this knowledge, economic educators might be better able to design curriculum and instruction that address the development of expertise in economic reasoning and problem solving. Such curriculum would therefore be based on a firm research foundation established by the numerous studies in cognitive psychology on the differences between expert and novice problem solvers.

Statement of the Problem

This study investigated the nature and constructs of relative expertise in economic problem solving. This study also identified various relevant indicators of expertise in economic problem solving. Further, the study developed a model for scaling transcribed responses to economic problems, the Expertise in Economic Problem Solving Scaling Model (EEPSSM). Finally, this study used these relevant indicators to investigate the impact of various levels of economic education on the acquisition of expertise in economic problem solving.

While a preliminary study differentiating extreme examples of expert and novice economic problem solvers (Miller and VanFossen, 1994) has been completed, no study has examined relative levels of expertise in economic problem solving. That is, no attempt has been made to offer an analytical framework to describe (or discriminate among) relative levels of "expertness" or "noviceness" with respect to economic problem solving.

However, it is fundamental to study in this area that the representation of levels of expertise other than 'novice' or 'expert' be explored. Chi and Glaser (1980) have affirmed the importance of such research: "we need to analyze the
cognitive processes involved in transforming a novice into an expert, in terms of adequate theory of the nature of this transformation" (p. 38). Put another way, if study in this area is to proceed, it is necessary to develop a more detailed picture of the nature of expertise in economic problem solving and to provide a more complete description of the nature of the levels of expertise to be found between the extreme categories of "expert" and "novice." This need stems primarily from the fact that the implications of this field of study lie in identifying the salient factors that facilitate the acquisition of expertise in economic problem solving in general, and the acquisition of expertise by pre-collegiate students of economics in particular (Miller and VanFossen, 1994).

One essential aspect of study in this area, and for associated curricular change in economic education, is to determine what path the acquisition of expertise in economic problem solving takes. Does the acquisition of expertise in economic problem solving resemble a continuum with the categories of "novice" and "expert" at either end (See Appendix A, #1)? Is the path to expertise a continuous one, or does the acquisition of expertise require a discontinuous "leap" at which point the problem solver embarks on a qualitatively different path (Appendix A, #2)? Does the acquisition of expertise take a multi-directional route? Might the problem solver journey down a series of continua, each representing different attributes of expertise (e.g., knowledge, skills, experience, procedure, problem representation, etc.), more or less simultaneously (Appendix A, #3)? Is the nature of the acquisition of expertise linear? Or is the process curvilinear (Appendix A, #4)? These are but several potential constructs for representing the acquisition of expertise in economic problem solving. However, one may already begin to see that different implications for curriculum and instruction are associated with each construct,
and therefore describing the nature of relative expertise becomes the logical first step in this area of research.

In order to examine these, and other, questions, one must first identify a set of valid indicators of relative expertise. One approach to developing such a relevant indicator is to create a scaling model that provides a ranking of responses from various groups of economic problem solvers "along some underlying dimension (e.g., adequacy of performance)" (Golden, et al., 1980, p. 22). Indeed, this aspect of the study seemed perfect for the application of scaling theory (Reckase, 1980).

Therefore, this study also developed a scaling model called the Expertise in Economic Problem Solving Scaling Model (EEPSSM). Such a model must provide insight for differentiating among various levels of expertise by allowing for the scaling of participants' responses to different types of economic problems. The development of such a scaling instrument was crucial to investigating the questions outlined above. More importantly, such a model assisted in the preliminary investigation of the impact of various levels of economic education on the acquisition of expertise in economic problem solving.

This study used several other relevant indicators of expertise in problem solving. One technique successfully employed in other studies of problem solving (Ennis and Safrit, 1991; Pitt, 1983) was the Pitt Problem Solving Coding System (PPSCS). Pitt (1983) argued that the coding system developed in her study provided a "comprehensive, empirical instrument to code heterogeneous verbal protocols in terms of the types of processing function each verbal proposition represents" (p. 551). The PPSCS may be used to code six categories of strategies used in problem solving by integrating constant comparison
analysis (Glaser and Strauss, 1967) in the systematic classification of qualitative data, specifically that of transcribed responses (Ennis and Safrit, 1991). Thus, respondents' classification within the PPSCS framework represented five indicators of relative expertise in economic problem solving.

Based upon past studies in cognitive psychology (Voss, et al., 1984; Chi and Glaser, 1980), a second indicator of relative expertise was simply the absolute number of statements—economically correct and relevant—employed by the participant in responding to an economic problem. Similarly, a ratio of non-relevant statements—those that are neither economically accurate nor impact directly upon the problem in question—to relevant statements was calculated and compared across sub-groups.

Other examples of relevant indicators analyzed included an Expert Ratio Profile (ERP), which, along with the EEPSSM and the Pitt coding system, will be described in greater detail in subsequent sections of this chapter. The ERP was developed by dividing the number of respondent's statements classified as demonstrating one of the three categories of statements--problem representation, propositional, and causal--developed by Miller and VanFossen (1994), by the total number of statements made. Other indicators include the absolute number of economic concepts invoked during a response, the number of economic models used, the number of cross-referenced concept maps invoked (Chi and Glaser, 1980), and the level of problem representation, or planning, present in responses and the level of economic education of the respondents.

The final indicator of relative expertise employed in this study was the rating of participant responses by a panel of expert judges. This rating was used both in the analysis of the nature and construct of relative expertise and for
checking the reliability and validity of the other indicators, most notably, the EEPSSM.

Once such a scaling model has been developed, and other relevant indicators of the nature of relative expertise in economic problem solving have been identified, other key areas of study may proceed. For example, the use of these indicators in an *ex-post facto* design might result in the identification of the most salient attributes for the acquisition of expertise in economic problem solving. Knowledge of these attributes can assist in the design of curriculum and instruction that might better facilitate the acquisition of these attributes.

Future study of expert problem solving in economics depends upon a conceptualization of what the nature and constructs of the acquisition of expertise in economic problem solving resemble. Moreover, as Chi and Glaser (1980) concluded, if we knew more about "the stages and processes involved in the changes from novice to expert performance, it would then be possible to devise achievement measures more directly focused at efficient educational strategies--strategies that perhaps would take the novice through a different succession of stages, yield fewer failures of learning and bring about...higher levels of achievement" (p. 37-38).

**Research Questions**

Given the issues presented in the preceding sections, this study attempted to investigate the following research questions:

1. Based upon a sample of economic problem solvers and various relevant indicators, what are the nature and constructs of relative expertise in economic problem solving?

2. What is a viable method for developing Expertise in Economic Problem Solving Scaling Model (EEPSSM)?
(3.) Is EEPSSM an operational, parsimonious and theoretically valid scaling model?

(4.) Based on the investigation into the first three research questions, and upon the results of expert panel ratings of participant transcripts, what is the impact of various levels of economic education on relative expertise in economic problem solving?

**Methodology**

Drawing from relevant studies on differences in expert and novice problem solving and psychometric analysis (Thorndike, 1982; Reckase, 1980; Guttman, 1950), the researcher undertook the following procedures in the investigation of the research questions noted above.

**Sampling.** As outlined earlier, preliminary study in this area has focused on differentiating extreme examples of expert and novice economic problem solvers (Miller and VanFossen, 1994). In order to analyze relevant indicators of expertise and in order to create a meaningful scaling model able to provide more detailed discrimination, a wide range of levels of expected expertise in economic problem solving were sampled. Thus, data were collected from seven categories of expected expertise. These categories were: (1) university-level Ph.D. economists (PHD-OSU), (2) Ph.D. economists outside the university (PHD-FIELD), (3) graduate students in economics (GRAD), (4) undergraduate majors in economics (UND-ECON), (5) undergraduates majoring in fields other than economics (UND NOECON), (6) high school students who have taken high school economics (HSECON), and (7) high school students who have not taken high school economics (HS NOECON). Each of the seven sub-samples contained four members.

**Data Collection.** Members of each sub-sample group responded to three economic problems based on those used by Miller and VanFossen (1994). These
problems were each pointedly designed to address one of three broad areas in economic study: microeconomics, macroeconomics and international trade. The problems used in this study were:

1. Suppose Congress were to double the current minimum wage of $4.35 an hour to $8.70 an hour. Analyze the economic impact of this policy and discuss whether you believe such a policy would be a good idea or not and why. (microeconomic focus)

2. In 1929, the so-called Great Depression began. Discuss what you believe caused the Great Depression and what, if anything, the federal government should have done to keep economic conditions from deteriorating so badly. (macroeconomic focus)

3. Trade among nations is a perennial economic issue. Suppose that you are the recently appointed Secretary of Commerce, and assume that our trade deficit has been growing (the US has been buying more goods and services from foreign countries than they have been buying from the US). As the Secretary of Commerce, your problem is to design and defend the new administration's trade policy. How will you respond? (international trade focus)

These problems were developed under the assumption that individual differences in economic problem solving might be idiosyncratic to specific types of problems (Miller and VanFossen, 1994). Thus, one might reasonably expect that responses to the minimum wage question might elicit more application of the relevant microeconomic models than, for example, the question regarding the Great Depression. Further, the level of agreement among economists varies with respect to microeconomic, macroeconomic and international trade issues. Finally, it may be the case that different problems require varying levels of goal setting and identification. That is, it may be more important to establish specific economic policy goals regarding a certain type of economic problem before one may approach solutions to those problems.
Procedures for presentation of the problems were standardized (See Appendix B for Directions Sheet). Participants engaged in a 'talk-aloud' during their responses to respective problems. This methodology and its application has been well documented in much of the seminal research in this area of study (See, for example, Voss, et al., 1984, 1988; Chi, Glaser and Rees, 1982; Lesgold, et al., 1981). Essentially, this methodology asks participants to verbalize their thought processes during the problem solving activity. Thus, it was believed, participant ruminations regarding the economic problem closely paralleled the cognitive processes that occurred during the problem solving process.

Each participant's 'talk-aloud' was audio-taped. These responses were transcribed by the researcher. In addition, a protocol model, based on the Miller and VanFossen (1994) model was rendered for several members of the sample (See Appendix C for an example). Participants were also encouraged to create and apply any drawings, diagrams, graphs or charts they felt were necessary during the 'talk-aloud' procedure. These were also collected for later analysis.

*Data Analysis*. Due to the fact that a variety of relevant indicators of relative expertise in economic problem solving were employed in this study, the following section provides a brief treatment of the techniques of data analysis used with each of the indicators.

**Pitt Problem Solving Coding System.** The PPSCS uses six basic categories of problem solving to categorize participant's responses: general problem solving, feedback, pattern extraction, hypothetico-deductive, evaluation and heuristics. These six strategies contained a total of twenty-four subroutines (See Figure 2, Chapter III). Transcribed responses were classified using the PPSCS sub-routine framework and the constant comparison analysis technique (Glaser
and Strauss, 1967). The constant comparison technique is an inductive process that provides a systematic procedure for classifying qualitative data by comparing statements to discover embedded commonalties (Ennis and Safrit, 1991). After categorization of responses, sub-groups were compared using chi-square tests, two-way analysis of variance and t-test statistics where appropriate.1

**Absolute Number of Statements and Relevant Statement Ratio.** A second strategy for developing a more detailed picture of relative expertise was simply to count the number of total statements made by a respondent. This total reflected the number of relevant and economically correct statements and therefore served as an indicator of the respondent's subject-related, declarative knowledge. One may infer that the more statements made by a respondent, the greater the economic content knowledge being displayed (VanSickle, 1992). Indeed, Chi and Glaser (1980) noted that the "expert has more nodes in memory about subject-related knowledge" (p. 40) and that because experts have more subject-related declarative knowledge, they are able to offer more absolute statements in response to problems.

Once the number of statements were recorded, a range of the number of statements made could be reported for each sub-sample group. In addition, the mean number of statements made was calculated for each sub-sample group and compared across sub-samples using one-way analysis of variance

1 The researcher is fully aware that the use of nonrandom, purposive sampling creates problems with respect to the use of inferential statistics. However, the t- and f-tests have been shown to be robust with respect to assumptions concerning sampling. Indeed, as the sampling procedure was designed to provide representative sub-sample groups, there is no reason to believe that the samples are not representative of the populations from which they were sampled.
techniques. Thus, an elementary scale was constructed representing the results of this data analysis across the range of respondents.

Ennis and Safrit (1991) examined respondent's ratio of non-correct statements to correct statements. However, the Ennis and Safrit study involved a more concrete domain--exercise science--than that of economics. Indeed, given the relative debate over various schools of economic theory, the evaluation of responses as correct or incorrect proved problematic. Therefore, in place of 'incorrect statements' this study calculated a ratio of non-relevant statements to relevant statements. For this study, non-relevant statements were defined as those being neither economically accurate nor having direct impact upon the problem in question. One-way analysis of variance (ANOVA) techniques were used to compare sub-samples.

**Expert Ratio Profile (ERP)** The model created by Miller and VanFossen (1994) for rendering economic problem solving was an attempt to explicitly depict the demonstration, or lack thereof, of three specific types of respondent statements--problem representation statements, causal statements, and propositional statements. Problem representation may be thought of as an attempt to re-order or re-construct a problem in an effort to discover connections, or sort the problem into a more accessible algorithm (Glaser and Chi, 1988). Miller and VanFossen (1994) defined statements with "links...which often resembled the 'if' part of an 'if...then' statement, as propositional" (p. 17). Miller and VanFossen went on to note that "in the chain of reasoning begun with the "then" part of such statements (and in other instances as well), the expert clearly established links of causality, which the researchers designated causal links, usually of the 'A causes B' type" (p. 17).
One alternative for analyzing the data generated by the samples in this study was to record the number of total statements made by each respondent and then compare this total to the number of statements made that could be classified as demonstrating one of the three statement categories outlined above. This ratio became the Expert Ratio Profile (ERP) and was calculated for each sub-sample. Comparing the ERP across sub-samples provided insight as to the demonstration of the identified attributes of expertise across the various level of expected expertise.

For example, a high school student who has not taken an economics course produces fourteen total statements in response to problem 1. Two of these statements demonstrate problem representation. The subject would thus be assigned a problem representation ratio of .015. Once each of the participants from this sub-sample have been assigned an ERP, a mean ERP was calculated and compared with the mean problem representation ERP for the other sub-sample groups. An ERP was then be generated for each sub-sample, across the three economic problems. These ERP’s were used to provide a range for each of the sub-samples. By comparing these across samples, a relative ERP—a profile of the level of demonstration of each of the three statement categories—of each sub-sample group was developed. One-way ANOVA techniques were applied to analyze differences among the sub-samples.

Number of Economic Concepts, Concept Maps and Models Used. Another relevant indicator of relative expertise in economic problem solving included the use of economic concepts and models. Chi and Glaser (1980) noted that "for a given subject domain...there are more concepts that an expert can define and recognize as compared to a novice" (p. 40). Thus, recording the frequency at which respondents invoked economic concepts provided insight
into the density of conceptual mapping for a particular respondent, and across sub-samples.

Additionally, Chi and Glaser noted, for experts "each concept is connected to a greater number of other concepts" (p. 40). That is, if an expert invoked an economic concept during the problem solving process, this implied that other conceptual connections will be made. This further implies "that there are multiple routes relating one concept to another" and that "one way to quantify these multiple relations is to look at the amount of (conceptual) cross referencing" (Chi and Glaser, 1980, p. 40).

Gobbo and Chi (1986) engaged in such a process with expert and novice dinosaur classifications. In this study, Gobbo and Chi analyzed the frequency with which the invocation of one of the salient dinosaur classification attributes (Defense) was followed by a connection to another of the attributes. The end result of this analysis was a model that represented the level of concept integration for both the expert and novice children. Developing such a model for the respondents in this study added further detail to the picture of relative expertise in economic problem solving.

For similar reasons, knowledge about the use of economic models used by respondents in solving economic problems was an important indicator of relative expertise. Indeed, if we think of economic models as a network of concepts (or schema), then the use of models might serve as proxy for the number and types of economic schema invoked by a respondent. VanSickle (1992) noted that such economic schema can be "represented graphically; common economic examples include supply and demand graphs and diagrams of circular flow of economic activity" (p. 58).
Thus, the absolute number of economic models used by each respondent was recorded. These data were used to construct a range and mean for each sub-sample on this attribute. One-way analysis of variance techniques were used to analyze differences among groups.

The various indicators of relative expertise in economic problem solving were examined using factor analysis. This statistical technique has been described as a method "to discover or construct from a larger group of observed characteristics, or items, a small set of general characteristics, or factors, various combinations of which will produce each of the observed patterns of items" (Selvin, 1972, p 255; italics original). Thus, for this study, the relevant indicators of relative expertise in economic problem solving corresponded to the items in the analysis and the factors identified represented some measure of relative expertise. This powerful technique was used, as Thorndike (1982) noted, "to find an underlying structure" and to "identify a small number of fundamental trait dimensions" (p. 277).

**Expert Panel Ratings.** As noted earlier, the participants responses were examined by a panel of experts. These expert jurors were defined as either (1) an economic expert who had been 'trained' by the researcher on the important criteria related to expertise in economic problem solving, or (2) someone who had a significant background in both economics and expert novice problem solving. At least two expert jurors read each transcript and assigned an 'expertise rating' from 1-100. In addition, a Likert-type rating was given by the expert jurors on such attributes as overall knowledge, the use of economic concepts and models, and the number of problem representation statements made. Group differences in these scores were then analyzed. Finally, the expert panel scores were used to test the construct validity of the EEPSSM by using a
Pearson product moment correlation analysis to compare EEPSSM ratings with the expert panel rating.

The Expertise in Economic Problem Solving Scaling Model (EEPSSM) As noted earlier, one technique for analyzing the data in this study that held significant potential for providing a more detailed picture of relative expertise was the creation of a scaling model. As a strong case has been made within this introduction for the multi-dimensional nature of expertise--and thus, by association, the acquisition of expertise--any scaling model must therefore also be multi-dimensional in nature. The creation of such a model might therefore have to integrate many of the indicators outlined above. That is, in order to properly represent the relative contribution of such aspects as content knowledge, the use of economic concepts and models, procedural knowledge and problem representation, the EEPSSM should be a function of these indicators.

An ordered Probit technique was employed in the construction of the EEPSSM. The researcher selected this technique on the basis of the nature of the output of the ordered Probit analysis. The ordered Probit is essentially a technique for providing estimates of the maximum likelihood of a series of events--or more precisely, a combination of independent variables--resulting in one of several levels of a limited, dependent variable.

Thus, it seemed theoretically plausible, using the ordered Probit technique, to create a model based on the ordered category probability estimates associated with various combinations of the independent variables. In essence, such a model would shed light on the relative impact of changes in various relevant indicators of expertise in economic problem solving on the probability estimates associated with membership in one of the seven categorical sub-
sample groups. Indeed, for the purposes of the current study, the previously identified relevant indicators of relative expertise were used as independent variables in the analysis, and the formal level of economic education was used as a single dependent variable with seven levels (HS NON-ECON through PHD-OSU). The model produced by this analysis was further parsed, based on previous data and analysis, to highlight two of the relevant indicators of expertise: percentage of relevant statements used and number of economic concepts used. This parsimonious model proved just as capable of rendering the distribution of expertise across the participants.

**Relationship of Economic Education and Expertise.** The level of formal economic education possessed by participants in this study varied from essentially none (high school students who have not taken economics) to extremely high (Ph.D. economists). Based on the results of the previously described analysis, it was possible to determine, to a significant degree, the relationship between level of formal economic education and associated level of relative expertise in economic problem solving. This final research question was discussed within the context of the findings associated with the first three research questions.

**Definition of Terms**

This section provides an operational definition for the high-inference terms used within the context of the current study.

**Indicators of relative expertise in economic problem solving:** The salient attributes that, by their application and demonstration, indicated expertise on the part of the problem solver.

**Schema:** Cognitive structures or mental representations of a set of related categories which are used in perception, comprehension, memory and
learning built up by individuals using discrete, and idiosyncratic, bits of experience and information.

**Economic education:** The level of formalized economic training attained by the particular participant.

**Expert problem solver:** Problem solvers who, through demonstrated ability, knowledge, and cognitive structures, are able to easily address and solve domain-specific problems.

**Novice problem solvers:** Problem solvers who, through notable lack of ability, knowledge and cognitive structures, are unable to easily address and solve domain-specific problems.

**Relative expert problem solvers:** Problem solvers who are neither experts nor novices, but whose abilities, knowledge and cognitive structures place them somewhere between expert and novice problem solving abilities.

**Protocol:** The open-ended, talk-aloud responses to structured problem sets. In the current study, these were the responses to the three economic problems identified.

**Economic model:** A complex series of conceptual connections, assumptions and rules for rendering economic interaction within a specific area of the domain of economics.

**Relevant statement:** One complete sentence in a respondent's protocol that contained relevant economic information or that specifically addressed the problem under consideration.

**Non-relevant statement:** One complete sentence in a respondent's protocol that neither contained relevant economic information nor specifically addressed the problem under consideration.

**Expert juror:** A member of the expert panel. Jurors had either significant economic expertise, significant knowledge of the key issues in expert novice problem solving research, or both. Jurors were instructed on key criteria prior to rating respondents' protocols.

**Economic concept:** A term used to note a class of economic phenomenon possessing common characteristics and/or attributes and to also note the linkages to other, broader more inclusive economic concepts. For the purposes of this study, economic concepts were those concepts whose
relation to economic theory were commonly accepted. An expert economist was consulted when terms are in dispute.

**Economic concept map:** An interrelation among economic concepts such that the invoking of one economic concept leads to the invoking of one or more other economic concepts. For example, a discussion of the concept of supply and demand requires a discussion of price and therefore equilibrium price, and so forth.

**Scaling Model:** An analytical model designed to order respondents along a series of attributes such that those with higher scaling possess more of--or demonstrate more of--the attributes in question. The scaling model, as defined for this study, differs from an explicit scaling instrument. Primarily, the scaling model is more theoretical, and therefore less pragmatic, than a scaling instrument.

**Nature of relative expertise in economic problem solving:** The cognitive and experiential make-up of a problem solver who is neither expert nor novice. This study assumes that the nature of relative expertise manifests itself in different forms across the gap from expert to novice. That is, part of the nature of relative expertise is that different cognitive and experiential levels exist between expert and novice.

**Constructs of relative expertise in economic problem solving:** An outline of the process of transformation, not only from expert to novice, but from relative levels of expertise to other, higher, levels of expertise.

**Assumptions of the Study**

For the purposes of the current study, the following assumptions were made:

1. Respondent's talk-aloud protocols closely paralleled the cognitive structures and cognitive processes present in each participant.

2. Participants responded to the economic problems used in this study to the best of their abilities--both economically and cognitively.

3. Formal economic education and experience served as a reasonable initial estimate for expected expertise in economic problem solving.
4. Some category of problem solving ability existed between the extreme categories of "expert" and "novice."

5. Expert panel members adhered to the operational criteria provided in the rating of respondent's protocols.

6. Expertise in economic problem solving was a scalable variable, and therefore indicators of expertise exist.

7. Due to the purposive sampling employed in this study, there was no reason to believe that the sub-sample groups were not representative of the populations from which they were sampled.

8. The use of inferential statistics in this study was done solely for the purposes of describing the nature and constructs of relative expertise in economic problem solving for this sample of participants and no attempts should be made to generalize to larger groups.

Limitations of the Study

The following limitations must be considered before interpreting the current study's results:

1. The study used purposive sampling techniques and therefore studied a necessarily small sample. Further, as purposive sampling implies, no attempts at random sampling were undertaken.

2. Due to the nature of the data collection, the sample population was limited to the area in and around The Ohio State University and Columbus, Ohio.

3. The problems presented within the context of this study have only been used in a very limited pilot test. Other problems might generate different responses.

4. Expert panel ratings were standardized only across very broad criteria.

5. The operational definition of the variable economic education only addressed formalized economic education.

6. The relevant indicators in this study have been identified via a thorough review of related theoretical and applied studies. It is possible that these indicators were not the best, nor the most accurate,
for the domain of economics. It was also possible that more, and better, indicators exist.

7. Given these limitations, broad generalization to populations other than that of the research sample may be in error.

Overview of the Study

In Chapter I, the researcher presented an introduction to the current study, provided the relevant context for the study, stated the problem, outlined the four research questions to be investigated and discussed the assumptions and limitations of the study. Chapter II examines in detail the research literature as it relates to the study. Chapter III outlines the research procedures and methodology of the study. Chapter IV presents a summary and analysis of the data collected. Finally, Chapter V begins with a summary of the study's findings, goes on to provide conclusions and then highlights potential implications for the study and recommends further research to be undertaken.
Chapter II
Review of the Literature

This chapter presents a review of the relevant research literature in order to place this study within the larger context of research on expert novice differences in problem solving in general and economic problem solving specifically. Further, this chapter reviews previous research about the strategies employed within this study. The review presents the previous research in four sections: (1) a rationale for economic education and the importance of problem solving within economic education, (2) research in cognitive psychology examining differences in the problem solving of experts and novices within a domain, (3) the variables examined in this study and models used in that examination and (4) a rationale for the methods employed in this study, particularly scaling theory, factor analysis and ordered Probit techniques.

Economic Education and Economic Problem Solving

Researchers have argued that the ability to engage in economic problem solving is central to any form of economic education. In 1961 the National Task Force on Economic Education concluded that "everyone must, to some extent act as his own economist...and both he and the community will be better served if he is well informed and can think clearly and objectively about economic questions" (p. 13). Calderwood, et al. (1975) echoed this sentiment when they stressed that "a knowledge of economics is important if we are to meet our responsibilities as citizens..." (p. 3).
Moreover, noted Miller (1988), many, if not most, of the key issues that confront our citizenry on a daily basis are fundamentally economic in nature. Calderwood, et al. (1975) concurred on this point and noted that "citizens should understand the economic consequences of their actions" and that "some knowledge of economics is essential if these decisions are to be made intelligently" (p. 3). Therefore, Calderwood, et al., argued "economic understanding is part of the basic fabric of a democratic society" (p. 3). Indeed, as Nobel Laureate James Tobin (1986) wrote:

High school graduates will be making economic choices all their lives...as citizens and as voters. A wide range of people will bombarded them with economic information and misinformation for their entire lives. They will need some capacity for critical judgment. They will need it whether or not they go on to college (p. 8).

Buckles (1991) extended this discussion when he implied that the "most important justification for economic education is that it is training in rational and logical thinking" and thus it can "enhance our students' abilities to analyze situations and problems in a rational manner" (p. 25). This process, Buckles intimated, not only contributes to the major goals of elementary and secondary education, but also augments student's abilities to solve personal and societal problems.

Perhaps the most striking argument for the necessity of economic education comes from another Nobel laureate, the late Kenneth Boulding:

[A]n accurate and workable image...of the economic system in particular is...increasingly essential to human survival. If the prevailing images of the social system are unrealistic and inaccurate, decisions which are based on them are likely to lead to disaster....Economic education, therefore, along with education in other aspects of the social system may well be one of the keys for man's survival....In a complex world, unfortunately, ignorance is not likely to be bliss, and a society in which
important decisions are based on folk tales may well be doomed to extinction (1969, pp. 10-11).

If economic education may be one of the "keys to man's survival," how much economic education is enough? Stated alternatively, what is economic literacy? Miller (1988) stressed the importance of being able to "analyze new and unique (economic) problems and not merely interpret or understand the analysis of others" (p. 4). Buckles (1991) addressed this question of economic literacy by noting that "economic literacy is also required for finding answers to the multitude of questions that face the public" (p. 26). Thus, it would seem, an essential component of economic literacy--the sine qua non of necessary economic knowledge and experience--turns on the issue of economic problem solving. That is, the economically literate citizen is one who can recognize, analyze and act upon relevant economic problems.

Symmes and Gilliard (1981) recognized the fundamental role of economic problem solving in the acquisition of economic literacy. Indeed, Symmes and Gilliard defined economic literacy as:

[A] capacity to apply reasoning processes when making decisions about using scarce resources. Economic reasoning implies having the capacity to: define the choice-related problems which confront us;...use knowledge (facts and concepts) to analyze the probable consequences of choosing each alternative; and take action based upon the evaluation of the costs and benefits of various alternative choices (p. 5).

Indeed, the National Survey of Economic Education reported that ninety percent of the economics teachers surveyed stated that preparing students to make intelligent economic decisions was an "important goal of economics as it is taught in my school" (Yankelovitch, et al., 1981, p. 56). Fully two-thirds of the teachers surveyed in this study noted that helping students deal with "the
current problems facing the country" was also an important goal of economic education (Yankelovich, et al., p. 56).

It seems safe to conclude, therefore, that as citizens of a democratic society grounded in free market economics, all persons should ideally possess the ability to make reasoned economic judgments on a wide variety of important economic issues. As Calderwood, et al., (1975) highlighted, the ability to engage successfully in economic problem solving is one overarching tenet of citizen participation within a democratic society.

Finally, Miller (1991) provided a concisely argued conclusion for this section. He proposed that the goal of economic education is "more responsible and effective citizenship through helping students acquire the ability to use economics as independent decision makers confronting problems...rather than merely helping them gain the knowledge...that comprises part of the discipline" (p. 37). Economic education, Miller believed, "empowers students to understand their world, make reasoned decisions and act appropriately on personal and social issues of significance" (p. 37).

Research on Expert Novice Differences in Problem Solving

As a first step toward the examination of questions surrounding the nature of economic literacy, economic reasoning and economic problem solving, one may turn to the significant body of research in cognitive psychology that has attempted to investigate differences between so-called expert and novice problem solvers. Van Sickle (1992) noted that "cognitive psychological research on problem solving has provided the basis for re-conceptualizing the problem of teaching students to reason" (p. 56). Further, studies in this area that highlighted the interaction of content knowledge and the utilization of such knowledge in the solving of problems "provide useful insights for economics
teachers" (VanSickle, 1992, p. 57). Indeed, while cognitive psychologists have studied both naturally developing abilities and the acquisition of expertise, as Bereiter and Scaramalia (1986) have stressed "it should be...obvious that expertise is the more educationally relevant, since it presents the more serious challenge to education" (p. 10).

The nature of expertise and techniques for its acquisition became topics for investigation as a result of studies on human problem solving. Newell and Simon's (1972) seminal work on the information processing model of problem solving incorporated early research on the cognitive processing of master chess players as compared to those of less experienced players (deGroot, 1966). In reporting this research, however, Newell and Simon focused almost exclusively on the knowledge competence dimension of expertise. Thus, early work in expert-novice problem solving identified superior domain-specific knowledge as the primary attribute in acquiring expertise.

While such knowledge competence is obviously a prerequisite for acquiring expertise (Chase and Simon, 1973), later studies indicated that more than superior content knowledge alone was present in expert problem solvers. Simon and Simon (1978) and Chi, et al., (1982) found that problem representation was a crucial component of expert problem solving in physics. In these studies, novice physicists tended to apply equations quickly and with little discrimination while experts concentrated primarily on understanding and categorizing a physics problem before applying relevant equations. Further, expert physicists employed a "work-forward" strategy using straightforward inferences that focused attention explicitly on a particular solution (Simon and Simon, 1978). Novices, on the other hand, employed a "work backward" strategy that forced them to follow a limiting set of criteria (a sort of 'checklist' of
equations), any of which might have been useful in solving the particular problem in question (Simon and Simon, 1978; see also Chi, Glaser and Rees, 1982).

Similarly, Lesgold, et al. (1981) demonstrated that content knowledge alone is insufficient for acquiring expertise. In a series of studies investigating how radiologists use x-rays to reach appropriate diagnoses, experienced practitioners were compared to recent interns. In these cases, the level of medical knowledge was approximately equal. However, the experienced radiologists were nearly always more successful with their diagnoses. Lesgold (1984) attributed this difference, at least in part, to the presence of a series of "specialized schema" for radiology (p. 43). These schema may be defined as "a set of assumptions and rules for interpreting new information that is triggered when certain conditions are satisfied" (Lesgold, 1984, p. 43). Thus, the presence and use of these specialized schema during the problem solving process further differentiates expert problem solvers from novices.

As Lesgold implied, the notion of schema, or cognitive structures, is closely tied to the research efforts in expert-novice research. Further, schema theory held significant potential for economic and social studies curriculum and instruction. Indeed, Torney-Purta (1991) noted that "the application of schema theory and cognitive psychology in social studies is part of a growing focus on making learning meaningful..." (p. 205).

Howard (1987) defined schema as "mental representations of a set of related categories which are used in perception, comprehension, memory and learning" (p. 30). Head and Sutton (1985) noted that cognitive structures, such as schema, are like mosaics built up by individuals using discrete, and idiosyncratic, bits of experience and information. Anderson (1984) suggested
that a *schema* is "an abstract structure of information...which summarizes information about many particular cases and represents relationships among components" (p. 5).

According to Rumelhart (1980), *schema* play a fundamental role in problem solving. *Schema* are used to store knowledge about certain types of problems. Further, *schema* may represent a set of procedures for solving a particular type of problem and an understanding or representation of what type a particular problem is. Miller and VanFossen (1994) recognized this nature of *schema* and concluded that "the notion of economic knowledge as highly developed *schemata* (interconnected cognitive structures) suggests a redefinition of economic knowledge as inextricably intertwined in a network that includes the linkages among bits of economic knowledge and the specialized procedures for using that knowledge" (p. 3).

VanSickle (1991) proposed that "domain specific *schemata* provide useful ways of conceptualizing problems, and they enable expert problem solvers to perceive what knowledge is needed to solve a problem and to access information already in their long term memory" (p. 156). As experts are likely to possess more domain specific *schema*, VanSickle noted, they are more likely to "cross reference" specific *schema* with other specific *schema*. (p. 156). This implied that expert problem solvers in economics not only have more total schema, but also more interconnections among schema. Thus, another key differentiation between experts and novices was the presence and use of more highly developed cognitive structures--*schemata*--for problem solving.

James Voss, et al. (1989, 1984) have investigated differences between expert and novice problem solvers in the social sciences. Voss posed a question regarding a specific problem in Soviet agriculture to experts in Soviet studies
and to novices who had some knowledge of the Soviet Union but whose expertise lay in other domains. Each participant was encouraged to "think aloud" during the problem solving exercise and the responses were audio-taped. Subsequent analysis revealed that experts generally divided the problem into several relevant sub-problems while searching for possible solutions. Novices tended to attack the problem as presented. The Soviet experts also engaged in more self-evaluation and analysis throughout the problem solving process. Further, Voss, et al. (1983) concluded that the Soviet experts provided deeper and more principled support for subsequent solutions. Finally, the Soviet experts displayed discipline-specific and domain-specific strategies for applying appropriate content knowledge during problem solving. In this, the conclusion of Voss, et al. was reminiscent of Lesgold's discussion of the importance of specialized schema for the acquisition of expertise.

While many of the previously noted studies have focused on the types of cognitive processing necessary for expert problem solving, the role of knowledge as a critical variable in the acquisition of expertise has also been well-documented and should not be overlooked (Voss, 1989; Glaser, 1987; Voss, Tyler and Yengo, 1983, Curtis and Glaser, 1983). Indeed, VanSickle (1992) noted that "research on problem solving...demonstrates the importance for education of understanding how experts' knowledge differs from that of novices" (p. 57). VanSickle identified various categories of knowledge that experts use in the problem solving process. Of these, three--declarative, procedural and schematic knowledge--warranted brief discussion.

Declarative knowledge, according to VanSickle (1992), referred to the discipline-related content knowledge of a particular field of study; that is, the body of facts, concepts and accepted generalizations associated with a particular
domain (e.g., economics). Voss (1989) concluded that expert economic problem solvers have more declarative knowledge—more knowledge about economics—than do novice economic problem solvers. VanSickle stressed that such declarative knowledge is "a valuable resource for solving economic problems" (p. 58).

*Procedural knowledge* may be described as the "knowledge of how to" (Voss, 1989). This category of knowledge involves correctly invoking appropriate domain-specific knowledge and "the ability to apply it (domain-specific knowledge) to questions for which answers are not immediately obvious" (VanSickle, 1992, p. 58). VanSickle concluded that "experts generally have extensive procedural knowledge in their areas of expertise; novices are likely to have little or none" (p. 58).

*Schematic knowledge* denoted the network of rules and assumptions surrounding particular examples of declarative knowledge. These networks of ideas may be thought of as interconnected cross-references between concepts and generalizations within a particular domain (Cornbleth, 1985). Such *schemata* "can be represented graphically; common economic examples are supply and demand graphs and diagrams of the circular flow of economic activity" (VanSickle, p. 58). Moreover, as noted earlier, VanSickle states that "experts

* It should be noted that while VanSickle's discussion of knowledge differentiation provides useful insight, the author has some concern over the categories of knowledge outlined above. In particular, VanSickle's use of the term "schematic knowledge" is potentially confusing and perhaps even misleading. VanSickle implies that *schematic knowledge* is one component of domain-specific knowledge and that as such is in some way separate from the declarative and procedural components. However, it is important to recognize, as Lesgold, et al. (1981) noted, that the development and use of *schema* involves both declarative and procedural components. That is, *schema* consist of both the specific declarative knowledge associated with a domain and the procedures associated with accessing and applying such knowledge. Indeed, *schema* are the declarative knowledge and the networks of interconnections between knowledge and process. This is an important distinction that might be confounded by VanSickle's use of "schematic knowledge."
have more *schemata* than novices, and experts' *schemata* are developed more fully in their areas of expertise" (p. 58).

Other studies on expert-novice problem solving have focused on the nature of expertise in cab drivers (Chase, 1983), baseball fans (Chisei, et al., 1979) and children identifying and classifying dinosaurs (Chi, 1978). While this research in expert-novice problem solving may appear quite disparate, Glaser and Chi (1988) characterized these studies' findings as "robust and generalizable across the various domains that have been studied" (p. xvii).

Given this, the following list represents attributes or characteristics that, according to the extensive research literature on expert novice problem solving, expert problem solvers are more likely to possess than novices:

1. Experts excel mainly in their domain.

2. Experts perceive relevant patterns in their domains. These meaningful patterns assist in the application of domain-specific knowledge.

3. Experts see and represent problems at a deeper, more principled level than do novices.

4. Experts spend more time on problem representation. Experts employ a 'work forward' strategy that requires greater time allocation for problem identification before the application of theory or knowledge.

5. Experts have strong self-monitoring and self-evaluation skills.

6. Experts demonstrate more flexibility in the process of problem solving.


8. Experts possess more domain-specific, declarative knowledge.

9. Experts have extensive procedural knowledge.
10. Experts have more highly developed specialized *schemata* than novices.

Miller and VanFossen (1994) conducted a pilot study that developed a model for differentiating expert and novice problem solvers in economics. This study reviewed models used to render expert and novice protocols in other domains (Gobbo and Chi, 1986; Voss, et al., 1984; Chi and Glaser, 1980). Miller and VanFossen concluded that these models were inadequate for rendering economic problem solving due, in part, to the researchers' belief that economic problem solving involved idiosyncrasies not present in other domains studied (e.g., physics, chemistry, radiology).

Miller and VanFossen posed three economic problems (identical to the problems employed in the current study) and audio-taped participant's "talk aloud" responses to these problems. The subjects were three Ph.D. economist and two undergraduate students; one who had taken an advanced placement high school economics course, the second who had no formal economic education. The researchers independently rendered the respondent's protocols and then resolved differences before developing the final model. Miller and VanFossen concluded that the "model developed appears to render the attributes of expert problem solving and successfully distinguishes expert from novice protocols" in economics (p. 22).

This preliminary study, and the broad literature reviewed previously, provided a strong theoretical basis for work examining differences in expert and novice problem solvers in any domain. However, nearly all of the studies in this area, including that of Miller and VanFossen, have focused on the extreme categories of expert and novice. This is insufficient to inform the application of such research to improving curriculum and instruction in pre-collegiate
economic education. If the goal of pre-collegiate economic education is to improve citizens' economic problem solving, then the simplistic expert-novice distinction provides little guidance for restructuring economic education, for it is highly unlikely that pre-collegiate economic education will produce experts, in any sense, in economic problem solving.

Therefore, it became necessary to focus on the process of acquisition and the nature of relative expertise, and the process of its acquisition, a focus that most studies in this field, according to Chi and Glaser (1980), have failed to pursue. Chi and Glaser noted the importance of knowing more "about the changes from novice to expert performance" in order to focus on "more efficient educational strategies that will perhaps take the novice through a different succession of stages...and bring about the higher levels of achievement" (p. 38). Toward this end, Chi and Glaser called for studies to be undertaken "of the changes that take place as individuals attain increasing competence" (p. 38).

As noted earlier, few studies have identified the importance of concentrating on the nature of relative expertise. However work by Bereiter and Scaramalia (1986, 1984) and Case (1978) has attempted to address the issue of relative expertise. For example, Case (1978) developed a theory of the technology of instruction based upon the notion of transforming novice performance into more expert-like performance and then modified this approach to specifically address relative expertise, specifically identifying the procedures of students who are only one stage more advanced than those who received instruction.

Bereiter and Scaramalia (1986) drew several conclusions pertaining to relative experts. "One idea is that the relative experts are not merely better at doing the same things that others do; they do things differently and the same
differences appear in various domains" (p. 16). Thus, Bereiter and Scaramalia concluded, relative expertise was recognizable and relative experts performed differently enough to be measured. Further, this difference, Bereiter and Scaramalia imply, was qualitative in nature.

It is unfortunate that little work had been undertaken regarding the nature of relative expertise. For as Chi and Glaser (1980) noted: "[l]ack of knowledge of the phases of development of complex performance can result in educational conditions that place artificial limits on performance that serve as detriments to the learning of advanced competence" (p. 46). Chi and Glaser concluded that research in this area must attempt to "theoretically and experimentally determine how performance of these skills (expertise) can be best achieved and maintained for the greatest number of individuals" (p. 46).

At least one study has been conducted that attempted to measure student's economic knowledge structures after instruction in economic problem solving (Son and VanSickle, 1993). However, this study highlighted the difficulty associated with analyzing data on knowledge structures, knowledge integration and problem solving. Although Son and VanSickle reported significant effect sizes in the experimental group, they also cautioned against passing judgment based upon this study alone. Indeed, Son and VanSickle used the Naveh-Benjamin, et al. (1986) 'order-tree' technique for which the authors concluded that "no information about its reliability could be obtained due to the immaturity of this measurement field" (p. 14). Thus the issue of economic problem solving measurement, so necessary for comparison studies in this area, remains relatively unaddressed.
**Variables Studied**

This section reports on relevant literature in order to provide theoretical background for each of the variables examined within the context of this study.

*Absolute Number of Relevant Statements.* There is broad agreement in the research literature that experts in a domain possess more domain-specific content knowledge. Chi and Glaser (1980) noted that "to be an expert in a subject domain means that one knows more..." (p. 39). VanSickle (1992) posited that expert economic problem solvers "possess large stores of declarative knowledge, that is, 'knowledge about' economic and social phenomenon, in their long term memories" (p. 58). Glaser and Chi (1982) believed that "one obvious reason for the excellence of experts is that they have a good deal of domain knowledge" (p. xvii).

Moreover, as VanSickle (1992) intimated, this extent knowledge, of which experts possess more, included "definitions of concepts...specific factual information" and economic "generalizations" (p. 58). What VanSickle implied was that not only did experts "know" more, in any sense, but experts were able to demonstrate this knowledge explicitly.

Previous studies in cognitive psychology have employed a "talk-aloud" data collection strategy (this method will be discussed in detail in Chapter III) in which experts where asked to demonstrate, among other things, their domain specific knowledge by speaking to, and about, a domain-specific problem. The current study replicated this strategy.

The current study used the total number of statements--either economically relevant or relevant to the problem being addressed--made by a respondent, as one indicator of the level of domain-specific knowledge possessed by a respondent. Data collected on this variable were analyzed using
one-way analysis of variance in order to determine whether significant differences existed in this variable across each of the seven sub-samples in this study.

_Relevant Statement Ratio._ Ennis and Safrit (1991), during a study of expert problem solving in exercise science, examined the ratio of correctly reasoned response statements to incorrectly reasoned statements. The Ennis and Safrit study, however, used a tightly constrained problem set for which broadly accepted agreement--across the domain of exercise science--on the nature of "correctness" could be gauged. Economics, as a domain, however, does not necessarily possess such broad, across-domain agreement in all areas. Thus, as Miller and VanFossen (1994) noted, "the level of theoretical agreement among economists varies among micro, macro, and international economics" and therefore "it is possible that experts might distinguish among different theoretical approaches in some problems" (p. 15).

Given this nature of the domain of economic theory, the current study attempted to purchase similar analytic ground by replacing Ennis and Safrit's notion of "incorrectness" with that of "non relevance." While it was true that it was difficult to report the level of economic "correctness" found in respondent's statements, it was possible to analyze the level of relevance found in respondent's statements. As noted previously, relevance in this case refers to whether a respondent's statement was either economically relevant or relevant to the process of solving the particular problem being addressed.

After the number of non-relevant statements have been recorded, a ratio of relevant-to-non-relevant statements was calculated. One-way analysis of variance techniques were used to determine whether significant differences in non-relevant statement ratio exist across the sub-sample groups.
Number of Economic Concepts. For Chi and Glaser (1980), being an expert, in part, implied "having more central concepts or conceptual nodes in memory" (p. 39). As an essential part of domain specific knowledge, knowledge of key concepts "acts as a valuable resource for solving economic problems" (VanSickle, 1992, p. 58).

Chi, Hutchison and Robbins (1989) found that experts not only possess more conceptual knowledge, but that when experts activated a concept node "they feel compelled to state them (concepts)" (p. 38). Therefore, the current study recorded the number of economic concepts invoked by respondents during the talk-aloud protocol. This accounting served to represent, at least in part, the number of concept nodes available to a participant during the problem solving exercise. Once recorded, the number of concepts invoked was analyzed across the sub-sample groups to determine if significant differences exist in the number of economic concepts used. One-way analysis of variance techniques were employed in this analysis.

Concept Maps. Gobbo and Chi (1986) found that when expert children invoked domain specific concepts, connections among various other, related concepts were also likely to be invoked. That is, the researchers concluded, "when experts activate a (concept) node, several...other concepts also get activated with high strength..." (p. 228). Indeed, in Gobbo and Chi's study, children who were experts in dinosaur classification often invoked several connections to salient classification attributes during the problem solving process. VanSickle (1992) stressed the importance of this cross-referencing of concepts for expert economic problem solvers. For example, VanSickle noted that "even more important for problem solving, an economic expert's knowledge of investment in capital goods would be cross-referenced with other
knowledge...[a]n expert would probably think of investment in research and development and its relationship to capital investment" (p. 59).

Chi and Glaser (1980) also noted that one key difference between experts and novices was the greater level of interrelating concept nodes on the part of experts. This means, according to Chi and Glaser "each concept is connected with a greater number of other concepts (for the expert) than for the novice" (p. 40). Further, the authors posited, "more robust relations between concepts means that the probability is higher of a concept evoking other concepts as well as its defining features" (p. 40). Moreover, the authors concluded, "[O]ne way to quantify these multiple relations is to look at the amount of cross-referencing" present in respondent's protocols (p. 40).

Based upon the conclusions of Chi and Gobbo (1986), the current study identified and recorded the number of economic concept maps present in the responses of the participants. In order to identify the use of an economic concept map the researcher employed a modification of the frequency of transition model developed by Chi and Gobbo (1986) and described in detail in Miller and VanFossen (1994). Once this identification occurred, the resulting data were analyzed using one-way analysis of variance techniques to determine if significant differences exist among sub-sample groups.

**Number of Economic Models.** According to Glaser and Chi (1982) "experts perceive large meaningful patterns in their domain" (p. xvii). This implies that experts employ more principled responses, based upon some larger framework, during the process of problem solving. Newell (1973) categorized this larger framework as a production system. This production system, as related by Chi and Glaser (1980) was:
[A] set of rules, each rule containing some conditions, which if satisfied, result in the execution of some action rule. For example, one's knowledge about how to solve a physics problem can be captured by a set of rules, where each rule specifies the conditions under which a given physics problem equation applies to the problem....We would hypothesize that an expert's knowledge base (a) contains more productions than a novice, (b) discriminates more finely among productions and (c) order productions within a production systems in different ways from the novice....Hence, solving a standard physics problem requires no direct problem solving skill, but merely matching and retrieving the 'right' production system (p. 41).

VanSickle (1992) implied that the use of economic models in problem solving was closely related to the cognitive structure, specifically the schemata, of the problem solver. These economic schemata can be combined into a "network of ideas" that may be "represented graphically" (p. 58). VanSickle noted that supply and demand graphs and circular flow diagrams are two such examples.

Thus, according to the previously outlined studies, the development and application of economic models seemed crucial for developing expertise in economic problem solving. Therefore, the current study recorded the total number of economic models employed by respondents, as well as the number of distinct models used, and analyzed these data across sub-samples to determine if significant differences existed in the number of economic models used.

The Expert Ratio Profile. Voss, et al., (1984) concluded that experts in a domain spend significantly more time representing problems than do novices. Glaser and Chi (1982) noted that "experts see and represent a problem in their domain at a deeper (more principled) level than novices" (p. xviii).

Several studies (Simon and Simon, 1978; Chi, et al., 1982; Chi, Glaser and Rees, 1982) have noted that novice physicists tended to apply equations quickly and with little discrimination while experts concentrated primarily on understanding and categorizing a physics problem before applying relevant
equations. This form of problem representation was generally referred to as "work forward" as opposed to the novice strategy of "work backward" (Simon and Simon, 1978).

In addition to the differentiation that existed in representation strategies, experts also tend to break problems down before solving them. For example, in the Voss, et al., (1984) seminal study on the "Soviet agriculture problem," experts in Soviet studies tended to develop relevant sub-problems before tackling the main issue of privatization of the Soviet agriculture system.

Ennis and Safrit (1991) found that novices "were more likely to use means-end analysis" and that experts were significantly more likely to use hypothesis testing and to apply propositional heuristic sub-routines during problem solving (p. 251-252). Further, Pitt (1983) concluded that experts were more likely "to generate adequate predictive hypotheses..." (p. 579). Pitt also discovered an "overall developmental trend toward increasing use of Hypothetico-deductive strategy and increasing and increasing logical adequacy..." (p. 579). What this implied, obviously, was that as expertise was acquired, more propositional and causal reasoning was demonstrated. Miller and VanFossen (1994), within the context of their model for rendering expert novice differences in economic problem solving, examined problem representation, causal and propositional statements in order to identify this type of reasoning.

Miller and VanFossen defined problem representation statements as "comments that defined, clarified, or classified the problems in some way" (p. 16). The authors also noted that these types of "statements were similar to some of the Voss G-structure operators (See Voss, et al., 1984)...for the sake of
simplicity in depicting the model, the researchers decided to denote all such statements as aspects of problem representation" (p. 16).

Miller and VanFossen classified statements which resembled the "if" part of an "if...then" statement, as propositional. Further, the authors reported that "in the chain of reasoning begun with the 'then' part of such statements (and in other instances as well), the expert clearly established links of causality, which the researchers designated causal links, usually of the 'A causes B' type" (Miller and VanFossen, 1994, p. 16).

The current study calculated, for each respondent, an Expert Ratio Profile (ERP) based on the three statement classifications outlined above: representational, propositional and causal. This ERP was calculated by dividing the number of statements classified as one of these three types by the absolute number of relevant statements. This ERP data were then analyzed using one-way analysis of variance techniques to determine if significant differences existed across sub-sample groups.

*The Pitt Problem Solving Coding System.* Pitt (1983) developed a model of problem solving that incorporated both information-processing and Piagetian paradigms. This model, and its subsequent analysis, became know as the Pitt Problem Solving Coding System (PPSCS). Essentially, the PPSCS represented "24 empirically discriminable sub-routines addressing such functions as listing given information, listing possible questions, deleting irrelevant information and so on" (Pitt, 1983, p. 548). Further, the PPSCS grouped these elementary sub-routines into five strategies that address the following functions: the use of empirical feedback, the use of a means-end algorithm to acquire data, the extraction of patterns, the generation and testing of hypotheses and systematic evaluation (Pitt, pp. 548-549). Finally, the twenty-four subroutines were
grouped into three heuristic sub-processes: definition of a problem, data acquisition and interpretation. This final grouping focused upon an analysis of "whether...subjects have available basic general framework for guiding problem solving" (Pitt, 1983, p. 549).

Thus, the PPSCS provided "a comprehensive, empirical instrument to code heterogeneous verbal protocols in terms of the type of processing function each verbal proposition represents" (Pitt, p. 551). Therefore, as the PPSCS seemed to offer a reasonable method for classifying verbal responses along a commonly accepted problem solving model, its employment in the current study was logical. Indeed, the empirical nature of the PPSCS, and its successful application in other research studies (See, for example, Ennis and Safrit, 1991), held great potential for adding analytic purchase to the study. Specifically, the use of the PPSCS provided a clearer picture of the general problem solving abilities and strategies of the respondents--as applicable to economic problem solving.

 эксперт panel ratings. The use of expert panels to rate, and in some sense, scale open-ended responses has become relatively commonplace (e.g., LSAT, National Council of Architect Registration Boards, State Bar Examinations, etc.). Moreover, expert panels, or juries, have also been used in conjunction with empirical work in problem solving analysis to provide baseline data about both respondent's performance and the validity of various instruments.

For example, Bejar (1991) in developing an expert system computer program capable of scoring open-ended architectural design problems, reported using an expert panel of architects to (1) develop the algorithms used in responses and (2) test the validity and reliability of the computer program in scoring responses. This expert panel rated responses on the site-design sub-test
of the National Council of Architect Registration Boards. Bejar noted that the 
use of expert panels was integral as "such judgments can be rendered only by professionals in the field" (p. 523).

Similarly, Sebrechts, et al. (1991) used expert judges ratings on the College Board's Advanced Placement Test in Computer Science as baseline data in developing an expert systems program for scoring responses (GIDE). Content experts, recruited by the College Board, rated respondents and also helped generate the algorithms that guided construction of GIDE. The ratings were also used to analyze GIDE's reliability and validity.

Thus, the use of expert panel rating in analyzing qualitative data has precedent. For the current study, twelve content experts (both economists and economic educators familiar with this line of research) examined random samples of the eighty-four responses (twenty-eight participants, three problems) and assigned each an expertise in economic problem rating. These ratings were analyzed using correlation analysis techniques to determine if a relationship existed across sub-sample ratings or across raters. Finally, the expert panel ratings were used in a preliminary examination of the validity of the EEPSSM.

Level of Economic Education. As noted previously, studies in cognitive psychology on expertise in problem solving indicated that experts possess more domain specific knowledge than novices. Obviously, one way to acquire such knowledge in economics was through formal economic education. While the author could find no studies that examined the relationship of economic education and economic problem solving directly, several studies have examined factors that influence economic understanding.

Thornton and Vredeveld (1977) regressed high school economics teacher's scores on a standardized economic understanding instrument on
variables measuring both undergraduate and graduate hours of economics and found a significant positive relationship. Walstad (1979) observed a similar relationship between economic education and understanding of economics. Thus, background knowledge, as measured by economic courses taken, appears to be a significant indicator of economic understanding.

Based upon these studies, the current study examined respondents' level of formal economic education and compared this to the expert panel ratings to determine the nature of the relationship between expertise and formal economic education.

Methods Employed

This section will provide a brief theoretical background and rationale for the methodology employed in the current study.

Sampling. As noted earlier, the current study drew participants from seven sub-sample groups, based entirely on expected levels of expertise in economic problem solving. That is, a purposive sample was developed to include levels of expected expertise ranging from none (high school students without formal economic training) to expert (Ph.D. economists).

Babbie (1975) noted that "occasionally, it may be appropriate for the researcher to select his sample on the basis of his own knowledge of the population, its elements, and the nature of his research aims" (p. 167-168). Babbie goes on to state that when employing purposive sampling, the researcher "selects a sample of observations that he believes will yield the most comprehensive understanding of his subject of study, based on the intuitive 'feel' for the subject that comes from extended observation and reflection" (p. 203). Obviously, as one goal of this study was to be able to describe the nature and constructs of relative expertise in economic problem solving, a sampling of
various levels of expected expertise was necessary. Further, based upon the researcher's experience and judgment, this range of expected expertise was sufficiently represented by the seven sub-sample groups.

However, this sampling was not done without a clear understanding of the potential drawbacks of such a technique. Primary among these was the fact that this technique was non-probabilistic. Non-probabilistic sampling, by its nature, implied a lack of randomness, and therefore naturally limited conclusions regarding the generalizability of findings. In the current study, this trade-off was been carefully considered and the researcher concluded that the analytical ground lost in this case--due to lack of randomization--was, given the nature of the study, impossible to avoid.

Data Collection. The data collection techniques employed in the current study had significant theoretical and practical support. Indeed, the 'talk-aloud' technique used for developing respondent's protocols was the overwhelming data collection technique employed in the most recognized studies in expert novice problem solving (see, for example, Voss, et al., 1984; Gobbo and Chi, 1986; Simon and Simon, 1978; Chi Glaser and Rees, 1982 and Chisei, et al., 1983).

The problems used in the current study to generate participant responses were developed on the premise that expertise in problem solving was domain specific. Amsel, et al., (1987) found that domain specific expertise was not transferable to other domains. In this study, the problem solving protocols of lawyers and psychologists were compared. Amsel, et al., found that the organization of problem solving inference rules and functions were organized differently for each group. What this suggested was that expertise may be related to domain specific differences in problem solving and problem representation.
Miller and VanFossen (1994) designed the economic problems used to generate responses in their study (and replicated in the current study) under a similar premise. That is, that problem solving in economics may involve idiosyncrasies only found in this domain. Further, Miller and VanFossen concluded, these idiosyncrasies may extend to specific areas within the domain of economics. Thus the problems used to generate responses in the Miller and VanFossen study:

...were crafted to allow the researchers to detect important differences in economic problem solving that might be specific to the individual problems. For example, two of the problems are hypothetical, while one is based on historical events. Hence, the Great Depression might reasonably be expected to elicit more specific factual information than the other two. The level of theoretical agreement among economists varies among micro, macro, and international economics. Thus, it is possible that experts might distinguish among different theoretical approaches in some problems. Also, the different problems might permit goals to be identified in varying degrees, since it might be more important to specifically establish policy goals in some problems than in others (p. 15).

Therefore, the current study employed the data collection techniques used in most previous expert novice research and the problems developed by Miller and VanFossen for gathering data.

Data Analysis. The data analysis techniques used in the current study were briefly outlined in previous sections of this report and will be discussed in greater detail in Chapter III. As noted earlier, the researcher was aware of the potential problems regarding the use of inferential statistics on the current sample. A more detailed defense of this use was also conducted in Chapter III. However, this section will attempt to expand the logic behind employing three of these techniques: (1) factor analysis, (2) multi-dimensional scaling and (3) ordered Probit analysis.
Factor analysis may be defined as "a variety of statistical techniques whose common objective is to represent a set of variables in terms of smaller number of hypothetical variables" (Kim and Mueller, 1978, p. 9). However, the fundamental assumption in factor analysis is that the first, larger set of variables possess some level of association, as measured by a correlation analysis. Factor analysis is therefore, in short, "a way to discover or construct from a larger group of observed characteristics, or items, a small set of more general characteristics, or factors" (Selvin, 1972, p. 254-255).

For example, in the current study, the various indicators of expertise investigated (e.g., number of relevant statements, number of economic concepts, etc.) represented a set of variables (items) that may act to define a hypothetical variable known as "expertise in economic problem solving" (a factor). Indeed, according to Thorndike (1982), "a factor is a new variable generated by a linear combination of the original (items)" (p. 277-278). Moreover, Thorndike noted, "the hope is that judicious development of the factors can produce variables that imply clear and meaningful...constructs" (p. 279). Thus, in the current study, factor analysis was employed to determine which indicators can be used to define the factor (or construct) "expertise in economic problem solving."

Two types of factor analysis exist: exploratory and confirmatory. Specific issues concerning factor analysis will be treated in Chapter III of this report, but suffice to say the elementary difference between exploratory and confirmatory factor analysis concerns whether or not hypothesis are tested. Exploratory factor analysis "may be used as an expedient way of ascertaining the minimum number of hypothetical factors that can account for observed covariation, and as a means for exploring data for possible data reduction" (Kim and Mueller, 1978, p. 9). Confirmatory factor analysis, on the other hand, "is used as a means of
confirming a certain hypothesis" (Kim and Mueller, 1978, p. 9). This hypothesis is likely to regard the number of factors involved and which variables belong in which factor. The current study employed both exploratory and confirmatory factor analysis.

The development of scale construction and scale theory was due, in large part, to military studies conducted as a result of the second World War. Stouffer (1950) noted that the need for scaling models was a function of efforts designed to transform qualitative data and observations into quantitative analysis, and concluded that "this requires rigorous yet economical methods for handling data which are initially qualitative, not quantitative" (p. 3, italic in original). Most of these efforts, on the part of sociologists and psychologists associated with the War Departments Research Board, "represented an effort to apply quantitative methods to qualitative data" (Stouffer, 1950, p. 4). The goal of scale theory then was to determine whether an area is scalable along some series of attributes and, if it is, to order respondents along that dimension in a practical operation (Stouffer, 1950). Reckase (1980) stated that the "basic concept in the theory of scale formation is that of a property" (p. 39). Such properties are used to denote characteristics, traits or qualities, or various levels of each.

Guttman (1944) argued cogently that "certain interest lies in large classes of qualitative observations" and that "it is often desired in such items to summarize the data" by ordering the observations along some attribute (p. 139). Guttman (1944) further defined a scale for any given population as "the multivariate frequency distribution of a universe of attributes that can be derived from the distribution of a quantitative variable, such that each attribute is a simple function of that variable" (p. 140). These attributes are a class of qualitative variables that, taken together, define a universe of behaviors. For
example, in the current study "expertise in economic problem solving" was the qualitative variable under investigation, and thus the attributes that defined that variable should be the most relevant indicators of expertise, as determined by other analyses within the context of the study. Therefore, the creation of a scale designed to represent the "expertise" level of various respondents employed the attributes that defined the variable "expertise."

In an effort to create such a scaling model, the current study employed an ordered Probit technique. The ordered Probit analysis is a technique for providing estimates of the maximum likelihood of a series of events--or independent variables--resulting in one of several limited, dependent variables (Greene, 1986). The application of this technique allowed the researcher to identify the relative impact of particular combinations of independent variables (the various relevant attributes identified in the study) on the level of probability associated with being placed in one or another of the seven sub-group categories. Further, the use of such techniques allowed the researcher to pare down the relevant variables used in the scaling model to a parsimonious and plausible few.

In conclusion, then, the use of scaling models held significant potential for further understanding the nature and constructs of the acquisition of relative expertise in economic problem solving. Indeed, the creation of a scaling model for the variable "expertise" (the EEPSSM) provided important data on the relative positioning of various participants and their responses and how closely this relative ranking corresponded with preconceived notions regarding expected levels of economic expertise and the role of economic education in the acquisition of expertise in economic problem solving.
Chapter III
Methodology

This chapter provides a summary of the methods employed in conducting the current study. As such, it presents information on the research design of the study and provides details on the selection of participants, and strategies for data collection and data analysis.

Research Design

Due to the nature of the research goals of the current study, two general research designs were employed: causal-comparative and descriptive. According to Fraenkel and Wallen (1990), causal-comparative designs attempt "to determine the cause or consequences of differences that already exist between groups or among individuals" (p. 305). Fraenkel and Wallen went on to note that causal-comparative designs also "involve comparing known groups who have had different experiences to determine possible causes or consequences of group membership" (p. 15). Another term for causal-comparative research is ex post facto design, as the 'effects,' and any alleged 'causes' of those effects, have already occurred. Thus, such studies are retrospective in nature.

Causal-comparative research employs the static group comparison design (Campbell and Stanley, 1963). In this research design, two or more groups are studied and comparisons are made among groups which have had
different experiences (or treatments, as the case may be), or which represent different groupings. Subjects are not randomly assigned to the various groups under investigation. Figure 1 provides a schematic that represents the static group comparison research design used in the current study.

<table>
<thead>
<tr>
<th>Group</th>
<th>Independent Variables</th>
<th>Dependent Variable</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>relevant indicators of expertise, BESPSSM, expert panel ratings, etc.</td>
<td>relative expertise in economic problem solving</td>
</tr>
<tr>
<td></td>
<td>(group characteristics)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>relevant indicators of expertise, BESPSSM, expert panel ratings, etc.</td>
<td>relative expertise in economic problem solving</td>
</tr>
<tr>
<td></td>
<td>(group characteristics)</td>
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<tr>
<td>(Groups III-VI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>relevant indicators of expertise, BESPSSM, expert panel ratings, etc.</td>
<td>relative expertise in economic problem solving</td>
</tr>
<tr>
<td></td>
<td>(group characteristics)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Design of the Current Study

Fraenkel and Wallen (1990) stressed that the “group differences variable in a causal-comparative study is a variable that cannot be manipulated” at the time of the study (p. 305). For the current study, the group difference variable was defined as expected level of relative expertise in economic problem solving as indicated by the level of formal economic education attained by a participant. Thus, differences among participants along the relevant indicators of expertise in economic problem solving identified by the current study were analyzed across differences in the participants’ level of formal economic education.
The static group comparison design posed several significant problems with respect to questions of internal and external validity. Among these were: (1) lack of randomization, (2) inability to manipulate independent variables, (3) subject selection and (4) data collector bias (McCracken, 1991; Campbell and Stanley, 1963).

The current study addressed the lack of randomization and subject selection issues by creating homogenous sub-sample grouping and by employing purposive sampling techniques. Fraenkel and Wallen (1990) noted that one way to control extraneous variables, outside of random selection, was to "find, or restrict, one's comparison to groups that are homogenous on that variable" (p. 310). Therefore, the current study used an across group comparison based upon participants' expected level of expertise in economic problem solving as indicated by the level of formal economic education attained. Further, these groups were sampled purposively such that, on the variable expected expertise in economic problem solving, sub-sample groups were homogenous in broad terms. That is, each of the seven sub-sample group members were relatively equivalent with regard to level of formal economic education and economic experience attained. Moreover, as it was not a goal of this study to engage in an experimental design, the issue of manipulating an independent variable was unimportant.

Finally, the question of data collector bias in the analysis of transcribed responses was addressed by having a second rater examine and code a random sample of the respondents' protocols. This rater was extremely familiar with this line of study and was trained using the coding rubrics outlined in this chapter. An inter-rater reliability coefficient was then calculated to determine if questions of collector bias were valid.
As noted earlier, the current study was also an attempt to develop a description, along a series of variables, of the nature of relative expertise in economic problem solving. Fraenkel and Wallen (1990) noted that “descriptive studies describe a given state of affairs as fully and carefully as possible” (p. 11). Further, descriptive study designs are usually conducted in a natural setting with data collection involving interviews or survey instruments.

Thus, the current study employed a descriptive design in accumulating and reporting sub-sample group mean scores on each of the relevant indicators of relative expertise in economic problem solving, the expert panel ratings, the EEPSSM and on other data generated by respondents. The combination of these factors, it was believed, provided a more accurate rendering of the nature of relative expertise in this domain.

Selection of Participants

Members of the seven sub-sample groups were invited to participate, either directly, or indirectly, by the researcher. The university-based Ph.D. (PHD-OSU) economists were approached based on suggestions from a member of the economics faculty at The Ohio State University (OSU) and were all members of the OSU economics faculty. The researcher contacted each suggested faculty member and conducted a brief interview to assess interest. Based upon these interviews, four OSU faculty members agreed to participate in the study.

A similar process was undertaken to secure the participation of the non-university Ph.D.’s (PHD-FIELD). A membership list of the Columbus Association of Business Economists (CABE) was used to identify potential participants. A subsequent mailing describing the study and the expectations of
participants was sent to six CABE members who were not full-time members of a university faculty (one was, however, affiliated on a part-time basis with a small business college). Four of these agreed to participate. These economists were employed by: the State of Ohio (2), Nationwide Insurance (1) and Economic Perspectives, Incorporated (1).

A list of second- and third-year OSU graduate students in economics (GRAD) was used to generate a mailing similar to the one sent to potential PHD-FIELD participants, differing only in that a small stipend ($10.00) was offered to the OSU graduate students for participation in the study. The researcher believed that this small stipend was necessary for securing sufficient graduate student participation. Four OSU graduate students (three second-year and one third-year) responded to the mailings and subsequently participated in the study.

The same process was employed in securing the undergraduate economics majors' participation. A list of undergraduate economics majors at OSU was used to produce a mailing, out of which four participants were identified. Two of the participants were of junior standing, one was a sophomore, and one was of senior standing.

The undergraduate, non-economic major participants were recruited directly by the researcher. All were members of a social studies education methods course taught by the researcher. As education majors, three of the four participants had never taken a formal economics course (high school nor university). The fourth participant had taken, as part of a Masters' Degree program in social studies education, a course titled Curriculum and Instruction in Global Economics, but no other formal economics courses.
The four high school economics students were members of a senior-level economics class that the researcher observed during winter quarter, 1992. The four were selected by the researcher, in conjunction with the student's classroom teacher, on the basis of their relative performance throughout the one-semester course. The students had just completed the economics course when the data was collected. It should be noted that this course was taught by a veteran high school teacher who had attended several workshops on teaching high school economics and whose course was based upon the National Council on Economic Education's Framework for Teaching the Basic Concepts, considered by many to be the major economics curriculum in use today.

This high school economics teacher also selected the four student participants who had not taken high school economics. All four were also seniors and data on this sub-sample group was also collected at the end of the term. Thus, in a broad sense, the two high school student sub-groups were relatively equivalent except in formal economic education and economic experience.

Data Collection

Data collected and analyzed for the current study took the form of transcribed participant responses to three pre-determined economic problems. These responses, or protocols, were audio-taped and then literally transcribed by the researcher. This section will provide detail concerning the methods used in this data collection and in the development of the economic problems used.

The data collection strategy employed in the current study was well supported by much of the previous expert novice research in cognitive psychology (See, for example, Chi and Glaser, 1980; Glaser and Chi, 1982; and
Lesgold, et al., 1981 and Voss, et al., 1983, 1989). The so-called 'talk-aloud' strategy used in the current study asked participants, to the best of their ability, to verbally express their thought processes during the problem solving activity. That is, as participants dealt with various domain-specific problems, they were encouraged to put into words the processes they engaged in while addressing these problems.

Participants in the current study were given a set of standardized instructions (See Appendix B) that allowed one minute for the respondent to familiarize themselves with each problem. Each problem was type-written on the top two inches of a standard-sized sheet of paper. The instructions explicitly encouraged respondents to draw any diagrams or graphs that might help them in dealing with the problem in question.

No pre-set time limit was suggested by the instructions. Rather, the researcher stated to each participant that they should begin when ready and continue speaking until they had, to their satisfaction, dealt sufficiently with the problem. Participants were told to continue speaking about the problem until they felt certain they had exhausted their input and felt comfortable with their response. This process was repeated for each subsequent problem.

The responses were audio-taped using a small, rather unobtrusive tape recorder. Each participant was recorded using a single cassette in order to prevent accidental erasure or over-taping. The researcher then transcribed each tape and formatted the text in order to facilitate later data analysis.

As noted in both Chapter I and Chapter II of this report, three economic problems--based upon those constructed by Miller and VanFossen (1994)--were employed in the current study. Each of these represented one of three broad areas of economic theory: microeconomics, macroeconomics and international
trade. As Miller and VanFossen noted, these problems "were crafted to allow the researchers to detect important differences in economic problem solving that might be specific to the individual problems" (p. 15). Further, Miller and VanFossen believed, some issues of expertise in problem solving may be domain-specific. Thus, it was essential to develop a series of economic problems that would generate the broadest range of responses and therefore demonstrate the widest range of expertise with respect to economic problem solving.

Each respondent’s protocol, for each of the three problems, was analyzed by the researcher. The first phase of analysis involved the coding of protocols for eight of the relevant indicators described earlier: absolute number of relevant statements, percentage of relevant statements, number of economic concepts, number of economic models, number of concept maps and expert ratio profiles (ERP) for causal, propositional and problem representation statements.

The number of relevant statements made by a participant during a response was counted. For the current study, a relevant statement was defined as one complete sentence in a respondent's protocol that contained relevant economic information or that specifically addressed the problem under consideration. Similarly, the number of non-relevant statements were also counted. A ratio of relevant-to-non-relevant statements was then calculated.

The number of economic concepts used by a respondent within a protocol were counted. For the current study, an economic concept was defined as a class of economic phenomenon that possessed common characteristics and/or attributes and that also noted linkages to other, broader more inclusive economic concepts. Moreover, for the sake of the current study, economic concepts were deemed those concepts whose relation to economic theory was
commonly accepted, or were considered low-inference concepts. A list of the economic concepts employed by participants in the current study may be found at Appendix D.

Data were collected regarding the total number of economic models used in a participant's protocol. The researcher coded and counted the number of times a participant used any economic models during a response, therefore making no distinction between multiple uses of a single model. During this data collection, an economic model was considered to be a complex series of conceptual connections, assumptions and rules for rendering economic interaction within a specific area of the domain of economics. The researcher used the protocol of the expert economic problem solver from the Miller and VanFossen (1994) pilot study to generate an initial list of applicable economic models for each of the three economic problems. Additional models were added as the researcher examined more expert protocols. Examples of such models include: general supply and demand models, aggregate demand and aggregate supply models, exchange rate markets, public choice models and industrial organization (I-O) models. A complete list of the economic models employed by participants in response to the three economic problems is located at Appendix E.

The researcher collected data on the use of economic concept maps by first identifying the economic concepts used in a protocol by a respondent. Once these concepts were identified, tracing out a conceptual network became relatively simple. A conceptual network was defined as an interrelation among economic concepts such that the invoking of one economic concept led to the invoking of one or more other economic concepts. In addition, it was assumed that the use of a concept map by the respondent was analogous to the invoking...
of a specific cognitive structure—much like schemata. Therefore, the concept maps took on different levels of complexity, as they were associated with the explication of a particular economic model. For example, a discussion of the concept of supply and demand required a discussion of price and therefore equilibrium price, and so forth. However, this is a general market model. A second concept map might involve linking such a general model with a specific example—a labor market—and therefore price with real wage rates. This second concept map implied a deeper level of conceptual connection.

Given this, the researcher coded an economic concept map as the following: a low-inference connection between two or more economic concepts situated somewhat contiguously within the context of a protocol and used in the explication of an economic model. Stated another way, if the respondent connected (or invoked) one or more economic concepts shortly after invoking a prior concept, and within the framework of an economic model, and this connection was essentially correct economically, the conceptual string created by the respondent was coded as a concept map. The following excerpt from a respondent's protocol is an example of such a concept map:

"So this is short run, very short run, it is going to happen overnight. The there will a gap in quantity of labor demanded and quantity of labor supplied with unemployment resulting..."

For this respondent, the invoking of the concept short run was followed closely by the invoking of three other, related concepts. These concepts were related in the sense that, economically, the concept of short run implies no time for markets to adjust to changes in factor inputs or other shocks and therefore the issue of "gaps in quantity of labor demanded..." only occur in the short run. Moreover, this map is directly related to the application of a generalized market model. This case was a more sophisticated example, as the issue of time, and its
relationship to the market, is implied. Furthermore, this concept map is directly related to the first concept employed by the respondent: short run.

Data concerning respondent’s problem representation statement, causal statement and propositional statement ERP’s were coded using criteria previously employed by Miller and VanFossen (1994). Statements were classified as problem representation if they demonstrated an attempt to re-order or re-construct a problem in an effort to discover connections, or to sort the problem into more accessible algorithms. Further, problem representation statements demonstrated some level of planning on the part of a respondent with respect to the problem and processes used to address the problem. The following excerpt from a respondent's protocol illustrates a problem representation statement:

"...if you're living in a world of fixed exchange rates, that sets up one set of problems. If you're living in a world with flexible exchange rates that sets up a different set of problems."

Similarly, statements were coded as propositional if they contained "links...which...resembled the 'if' part of an 'if...then' statement" (Miller and VanFossen, 1994, p. 17). Thus, statements that represented some level of logical connection between an economic condition and an economic outcome were coded as propositional. The example used above to illustrate problem representation is also an example of a propositional statement. A second example of such a prepositional statement is "if you double the minimum wage, that means that more people will not be employed."

Finally, statements that clearly established links of causality were coded as causal statements. These causal links were defined as statements that made an 'A causes B' distinction. Although similar in nature to the propositional
statement, the causal statement involved the demonstration of a more direct economic connection rather than a hypothesis for examination. For example, a respondent stated that the income tax increase of 1932 led to a fall in disposable income and therefore a drop in aggregate demand. This is clearly a causal statement as one can classify such a statement as fitting the 'A causes B' model.

The data collected on the aforementioned variables were transformed into standardized data by employing the ranking function of the SPSS package. Raw data on each of the variables were rank ordered (range 1-84) across the participant's level of formal economic education. Thus, respondent's performance on each of the variables was ranked relative to the other participants.

Data regarding the expert panel rating of respondent's protocols were collected from twelve designated experts in economics or economic education. Among these experts were eight Ph.D. economists, three economic educators with significant experience in the discipline of economics, and a nationally-known economic educator very familiar with the key issues involved in expert novice studies.

Four (two Ph.D. economists and two economic educators) of the twelve experts were identified after a message describing the study and asking for volunteers for the expert panel was posted on the National Association of Economic Educators electronic mail network (NAEEnet). Following a brief response from the potential experts, the researcher sent out detailed information regarding the study and four individuals offered to participate.

Four of the participants held Ph.D.'s in economics or economic education and were members of the National Council on Economic Education network. The two remaining Ph.D. economists were members of the OSU economics
faculty and were approached by the researcher to participate in the study. The final expert was co-author, with the researcher, of the initial pilot study from which the current study has been drawn (Miller and VanFossen, 1994) and was the researcher's Ph.D. advisor.

All expert panel members received an extensive packet of materials (See Appendix F) that contained the following: (1) a detailed overview of the study and of the key issues in expert novice problem solving, (2) an explication of the salient criteria on which responses would be judged, including relevant examples, (3) copies of from five to seven respondent protocols, (4) an expert juror rating sheet and, when applicable, (5) a self-addressed stamped envelope for returning the rating sheets.

The expert jurors rated respondent's protocols on eight criteria. These included: (1) use of economic concepts, (2) use of concept networks, (3) use of problem representation statements, (4) use of propositional statements (5) use of causal statements, (6) use of economic models and, (7) overall economic knowledge. Each of these criteria, and the detailed explications and examples used to inform the jurors, was based directly upon either the relevant indicators used as variables in the current study (e.g., number of economic models, number of problem representation statements), or key literature in cognitive psychology.

The jurors responded using a Likert-type scoring sheet that ranged from 1 (NOVICE) to 10 (EXPERT). Jurors rated each respondent protocol on each of the criteria according to how the jurors felt respondents fell between the two extreme categories of "novice" and "expert." For example, if a juror assigned a protocol a rating of '3' under the criteria 'use of economic concepts,' this would imply that, in the juror's judgment, the respondent used significantly fewer
economic concepts than an expert, in responding to the same problem, would have.

Finally, jurors were instructed to assign an overall expertise in economic problem solving rating. This expertise rating was a function of both the respondent's score on the seven criteria noted above, and the juror's overall reaction to the respondent's protocol. Thus, the economic expertise of the panel was brought to bear in assessing the problem solving abilities of a respondent on each protocol.

The second phase of analysis undertaken by the researcher involved coding the transcribed protocols in terms of the Pitt Problem Solving Coding System (PPSCS). First developed by Pitt (1983), the PPSCS coded qualitative data, such as the current study's transcripts, into one of six categories of strate-

<table>
<thead>
<tr>
<th>General Problem Solving</th>
<th>Evaluation</th>
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<tr>
<td>SR10. Define initial state</td>
<td>SR1. List given information</td>
</tr>
<tr>
<td>SR11. Define goal state</td>
<td>SR2. List assumptions</td>
</tr>
<tr>
<td>SR12. Identify data needed</td>
<td>SR4. Select evaluative criteria</td>
</tr>
<tr>
<td><strong>Feedback</strong></td>
<td>SR5. Assign priorities</td>
</tr>
<tr>
<td>SR17. Identify feedback</td>
<td>SR6. List relevant information</td>
</tr>
<tr>
<td>SR18 Tag new information</td>
<td>SR15. Edit algorithm</td>
</tr>
<tr>
<td>SR19 Organize new information</td>
<td><strong>Basic Heuristics</strong></td>
</tr>
<tr>
<td><strong>Pattern Extraction</strong></td>
<td></td>
</tr>
<tr>
<td>SR22. Extract patterns from data</td>
<td>SR 1. List given information</td>
</tr>
<tr>
<td>SR23. Summarize relevant patterns</td>
<td>SR 3. List questions</td>
</tr>
<tr>
<td><strong>Hypothetico-deductive</strong></td>
<td>SR 9. Select questions</td>
</tr>
<tr>
<td>SR 7. Formulate hypothesis</td>
<td>SR13. Identify set of available algorithms</td>
</tr>
<tr>
<td></td>
<td>SR24. Output conclusions</td>
</tr>
</tbody>
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Figure 2. Components of the PPSCS Model: Problem Solving Strategies and Subroutines (SR)(Pitt, 1983)
gies used in problem solving (general problem solving, feedback, pattern extraction, hypothetico-deductive, evaluation and heuristics; Figure 2 presents the components of the PPSCS model) by integrating constant comparison analysis (Glaser and Strauss, 1967). Pitt (1983) argued that the coding system developed in her study provided a "comprehensive, empirical instrument to code heterogeneous verbal protocols in terms of the types of processing function each verbal proposition represents" (p. 551).

For the current study, the researcher used the constant comparison technique to code statements from respondent's protocol into one of the six problem solving strategies in the PPSCS. Constant comparison analysis is a dynamic technique that involved two over-lapping stages. The first stage consisted of pre-coding data based on the researcher's first reaction to the data. That is, the researcher made coding decisions based entirely upon a first reading of the data.

The second stage involved a comparison within categories of the pre-coded data. According to Glaser and Strauss (1967) this is the basic, defining rule of constant comparison analysis: "a comparison of previously (coded data) in the same and different groups coded in the same category" (p. 106). Thus, the second stage involved a re-examination, in a systematic way, of the pre-coding to determine if the later data were indeed accurately coded. The researcher conducted this second stage twice. Thus, the data were pre-coded, compared across groups, and then re-coded, as necessary, on two separate occasions.

Pitt (1983) provided operational definitions for each of the six coding classifications in the PPSCS. For the purposes of the current study, general problem solving strategies included defining an initial state of the problem, defining the goals involved, and being able to identify necessary data needed in
solving a problem. *Feedback* strategies identified and incorporated new information as it becomes available during the problem solving process. *Pattern extraction* strategies referred to the identification of relevant patterns, symmetries or regularities in the assembled data. *Hypothetico-deductive* strategies involved the formulation of hypotheses, engaging in predictions and analyzing the validity of these predictions. *Evaluation* strategies suggested that problem solvers select evaluative criteria, assign priorities, and revise the problem solving strategy based upon the evaluation. Finally, Pitt identified a sixth category: *basic heuristics*. Basic heuristic strategies represented an abbreviated heuristic that can suffice for simple, familiar problems. This classification of strategies is more complex than simple trial-and error, yet is too simplistic for more complex problems. For purposes of the current study, however, data were coded on only the first five categories as the researcher believed that the *basic heuristics* category generated data similar to the ERP data already calculated for each participant.

Using the coding classifications outlined briefly above, and the constant comparison analysis technique, the researcher coded each protocol using the PPSCS. Mean scores where then calculated across each of the five problem solving strategies for each of the seven sub-sample groups that participated in the study.

**Data Analysis**

This section will provide a brief treatment of the analytical procedures used in the current study. Before this explication, however, this section begins with a defense of the use of inferential statistical analysis given the nature of the small sample used in the current study. Finally, it should be noted that all data
package SPSS for the Macintosh personal computer or the LIMDEP ordered Probit package.

Within the context of behavioral research, most sampling procedures are designed for the purposes of making inferences--from the statistics of the sample--about the population from which the sampling has occurred, the parameters. These parametric techniques have three basic assumptions: normality, homogeneity and continuity. Normality refers to the assumption that the sample that one studies is drawn from a population that is normally distributed. Homogeneity implies that the variance within groups in the population is homogenous from group to group within some bounds of random variation. Continuity assumes that the measures to be analyzed are continuous measures with equal intervals.

The current study employed sampling techniques that would appear to violate the first two assumptions necessary for employing inferential statistical techniques in data analysis. However, Kerlinger (1973) concluded that "the evidence...is that the importance of normality and homogeneity is overrated" (p. 287). Kerlinger went on to state that

"[U]nless there is good evidence to believe that the populations are rather seriously non-normal, and that variances are heterogeneous, it is usually unwise to use a non-parametric statistical test in place of a parametric one. The reason for this is that parametric tests are almost always more powerful that non-parametric tests" (p. 287).

Further, Kerlinger stressed, the $F$ distribution is relatively insensitive to the shape of the distribution in the parent population and that unless the evidence is obvious that the variances are so heterogeneous as to be easily seen, the impact on the $F$ test will probably be negligible (p. 287-88). Kerlinger
concluded that, even if the first two assumptions are violated, the $t$- and $F$-tests will be highly accurate.

Indeed, Harnett (1971) noted that the "assumption of normality can be relaxed without significantly changing the sampling distribution of $t$, the chi-square and the $F$ distributions" (p. 173). Harnett also concluded that the "robust" nature of these distributions implied that their usefulness extended to conditions that do not exactly conform to the assumptions outlined above (p. 173).

In addition to this evidence, the current study's use of a purposive sampling technique added further support for the use of inferential statistical analysis despite the lack of random selection and the relatively small sample size. The researcher deliberately sought to identify members of the seven sub-sample groups for whom claims of representativeness might be easily defended. Indeed, close examine of two of these groups (university Ph.D.'s and high school economics students) should provide the necessary insight in this case.

The university Ph.D.'s represented a wide range of research backgrounds from economic history to labor market theory. Further, each of the four received their terminal degrees from different institutions, including one from Ohio State. Each of the members of this sub-sample group taught a relatively distinct set of courses. Finally, the university Ph.D.'s assigned themselves a wide range of scores with respect to beliefs about personal levels of expertise regarding each problem area (See examples of this in Appendix H). Thus, it seems implausible that these Ph.D.'s were somehow grossly unrepresentative of Ph.D. economists in general.

The high school economics students had, as noted earlier, an above average economics instructor in economics. This, coupled with the fact that the
curriculum for the course was derived from the National Council on Economic
Education curriculum, implied that the students' experience was certainly no
worse than any other high school economics course, and perhaps even better
than most. Indeed, it can be argued, that these students experience was not
easily recognizable as out of the ordinary in any sense.

Therefore, in the current study, the researcher employed inferential,
parametric techniques in an effort to more completely describe the nature and
constructs of relative expertise in economic problem solving. However, the
researcher wishes to acknowledge the assumptions that have not been met and
to state explicitly that the use of these techniques should not be construed as an
a attempt to broadly generalize to any population or group other than that
described at length within the context of the current study.

In an attempt to provide a more detailed understanding of relative
expertise in economic problem solving, this study examined thirteen variables
thought to be indicators of expertise in economic problem solving. These were:
(1) number of relevant statements made by a respondent to one of the three
economic problems, (2) number of economic concepts used by a respondent, (3)
number of economic models used by a respondent, (4) number of concept maps
used by a respondent, (5) ratio of relevant statements to absolute number of
statements made by a respondent, (6) the problem representation statement
expert ratio profile (ERP), (7) the propositional statement ERP, (8) the causal
statement ERP, (9-13) the Pitt Problem Solving Coding Scores of the respondent.
The expert jury rating score assigned each respondent's protocol was also used
in data analysis. The following section provides a discussion of the data
analysis techniques employed on these variables in order to address each of the
four research questions investigated by the current study.
The Nature and Constructs of Relative Expertise. The first research question investigated by the current study examined the nature and construct of relative expertise in economic problem solving. The first level of analysis conducted with respect to this question involved the calculation of sub-sample group means and standard deviations for each of the variables under investigation. Further, these means were compared using one-way analysis of variance to determine if the means for each of the sub-sample groups differed significantly from the means of the other six sub-sample groups. In addition, the data on each of these variables were standardized for the sample by re-configuring the variable into absolute rankings (1-84). These rankings were used to calculate a mean ranking for each group across all variables. These means were then compared using one-way analysis of variance (ANOVA). A correlation analysis was conducted to determine if a relationship existed among any of the variables in question—including the rank order and mean ranking transformations—and the level of formal economic education of the participants.

For the second level of analysis, exploratory and confirmatory factor analysis were conducted in order to determine if it was possible to represent the variables in question in terms of any underlying factors. In addition, the confirmatory factor analysis employed an oblique rotation technique using a Kaiser normalization as the researcher believed that the factors involved might be closely correlated.

Finally, data collected from the Pitt Problem Solving Coding System (PPSCS) were analyzed. Sub-sample group means and standard deviations were calculated for five of the six categories of the PPSCS. One-way ANOVA was conducted to determine if statistically significant differences existed among group means on each of the five categories.
The Relationship of Economic Education and Expertise. In order to determine if a relationship existed between the level of participant's formal economic education and the expert panel ratings, the results of the first three research questions were considered. That is, within the context of the first three questions, the variable PARTLEV (participant's level of economic education) was used as an indication of expected expertise in problem solving. Subsequent analysis confirmed this supposition. Further, a correlation analysis was conducted to determine the relationship between PARTLEV and the expert panel ratings. This analysis was used to determine whether the expert ratings were at least as accurate as the participant's level of economic education in serving as a proxy for expertise in economic problem solving. This approach seemed most appropriate because coefficient estimates for independent variables under ordinary least squares regression have been shown to be biased when applied to dependent variables and thus the use of regression analysis was deemed inappropriate (Becker and Waldman, 1986).

The Expertise in Economic Problem Solving Scaling Model (EEPSSM). In an effort to develop an informative and parsimonious scaling model for describing relative expertise in economic problem solving, an order Probit technique was employed in the construction of the EEPSSM. The researcher selected this technique on the basis of the nature of the output of the ordered Probit analysis. As noted earlier, the ordered Probit is essentially a technique for providing estimates of the maximum likelihood of a series of events—or more precisely, a combination of independent variables—resulting in one of several levels of a limited, dependent variable (Greene, 1986).

Thus, it seemed theoretically plausible to, using the ordered Probit technique, create a model based on the ordered category probability estimates
associated with various combinations of the independent variables. In essence, such a model would shed light on the relative impact of changes in various relevant indicators of expertise in economic problem solving on the probability estimates associated with membership in one of the seven categorical subgroups. Indeed, for the purposes of the current study, the previously identified relevant indicators of relative expertise were used as independent variables in the analysis, and the formal level of economic education was used as a single dependent variable with seven levels (HS NON-ECON through PHD-OSU).

The results of this first ordered Probit analysis were used to parse down the EEPSSM to just two variables: percentage of relevant statements made and number of concepts used. Subsequent analyses were conducted to determine if this parsimonious EEPSSM was at least as accurate as the full model in predicting categories of expertise.
Chapter IV

Data Analysis

Introduction

This chapter presents an analysis of the data collected during the current study and addresses each of the four research questions presented in Chapter I. Chapter IV begins with a discussion of the relevant descriptive statistics concerning participant's responses. A discussion of the relationship between and among the previously noted relevant indicators of expertise and relative expertise in economic education follows. The data were transformed into standardized rankings by the program SPSS. Chapter IV reports the results of the analysis conducted to determine the relationship between these rankings and the other relevant indicators. Results of an analysis of the percentage change in the level of each variable across level of participant is discussed. Chapter IV also provides the results of exploratory and confirmatory factor analyses that investigated the presence of several underlying variables strongly associated with the relevant indicators of expertise. Further, Chapter IV reports the results of an ordered Probit analysis designed to determine the probability distributions for an underlying limited dependent variable: expertise in economic problem solving. This chapter also reports the results of a second ordered Probit analysis used in the design and development of the Expertise in Economic Problem Solving Scaling Model (EEPSSM). Finally, the transcripts
were reviewed and rated by an expert panel and these ratings were analyzed in order to determine their level of correspondence with the categorical variable level of expected expertise (PARTLEV).

**Statistical Significance and the Current Study**

There is some debate concerning the issue of statistical significance versus practical significance in research in the social sciences and especially within education. McCloskey (1993) argued that "'statistically significant' does not mean 'substantively significant'" and that these two types of significance may have "nothing to do with each other" (p. 360). What McCloskey suggested the researcher concentrate upon, rather than simply statistical significance, was whether the variable in question had "oomph" (p. 360). McCloskey concluded that a variable had 'oomph' if "its coefficient is large, its variance is high...all decided by quantitative standard in the scientific conversation" or if "the variable could vary enough to produce effects you deem important" (p. 360-61).

In this, McCloskey echoed Kruskal's (1968) line of argument that "it is easy to be over conservative and throw out an interesting baby with the nonsignificant bathwater...lack of statistical significance at a conventional level does not mean that no real effect is present" (p. 240). Indeed, Kruskal went on to note the "statistical significance of a sample bears no relationship to the possible subject matter significance" (p. 240).

Further, Kruskal (1968) noted that to speak of statistical significance without addressing the more important issue of the power (the probability of correctly rejecting the null hypothesis when it is false) of a test is misleading. Kruskal elaborated on this point when he stated that:
[A] common error in using significance tests is to neglect power considerations and to conclude from a sample leading to 'acceptance' of the null hypothesis that the hypothesis holds. If the power of the test is low for relevant alternative hypothesis, then a sample leading to acceptance of $H_0$ is very unlikely if those alternatives hold, and the conclusion is therefore unwarranted. Conversely, if the sample is very large, power may be high for alternatives close to the null (p. 244).

Finally, the researcher was fully aware that significance tests are attempts to determine whether a sample is large enough to ensure approximately equivalent results from subsequent samples. As such, these tests are, in effect, direct functions of sample size (take, for example, the $t$-statistic, where $t$ is determined using the standard error of the mean which is a direct function of $N$). Therefore, given the small sample size of the current study, results that have not proven to be statistically significant for the following analysis might plausibly result in significant results given a larger sample.

Based upon the issues outlined above, the researcher believed that the study generated some intriguing results that did not meet the stringent requirements for statistical significance, but were nonetheless essential for developing a deeper understanding of the nature and constructs of relative expertise in economic problem solving. Therefore, the current study reported results that were, in the judgment of the researcher, either statistically significant, practically significant, or both.

**The Nature and Constructs of Relative Expertise in Economic Problem Solving**

The first research question investigated by the current study was: based on a sample of economic problem solvers, what is the nature and construct of relative expertise in economic problem solving? The first level of analysis with respect to this question involved the calculation of sub-sample group means and
standard deviations for each of the thirteen variables under investigation. Further, these means were compared using one-way analysis of variance (ANOVA) to determine if the means for each of the sub-sample groups differed significantly from the means of the other six sub-sample groups. The one-way application was selected because the respondent's differed along only one factor of interest; namely, their level of expected expertise (the variable PARTLEV). In addition, data collected on each of the variables were standardized by transforming participant's performance into absolute rankings. Mean standardized rankings were calculated for each sub-sample group and analyzed for differences. Further, the percent changes in levels of relevant indicators were compared across sub-sample groups. Finally, a correlation coefficient was calculated to determine if a relationship existed between the variable in question and the level of formal economic education of the participants.

The aforementioned analyses were conducted in order to gain a more accurate depiction of the nature and constructs of relative expertise in economic problem solving. By comparing the sub-sample group means, standardized rankings and percent changes across each of the variables under analysis, it was possible to state explicitly what one sub-sample group looked like relative to the other groups. Therefore, the purpose of this first level of analysis was to provide a description of how sub-sample groups differed across the thirteen variables, identified as relevant indicators of expertise, relative to other sub-sample groups.

For purposes of discussion in this chapter, high school students with no formal economic education were Group 1 (or HS NONECON), high school economics students Group 2 (or HS ECON), undergraduate students Group 3 (or UND NOECON), undergraduate economics majors Group 4 (or UND
ECON), graduate students in economics Group 5 (or GRAD), Ph.D.'s not affiliated with OSU Group 6 (or PHD-FIELD) and OSU Ph.D. economists were Group 7 (or PHD-OSU).

*Interrater Reliability.* In an effort to address questions of researcher bias with respect to the coding of the transcripts used in the current study, a second rater coded a series of randomly selected transcripts. This rater was extremely familiar with the expert-novice paradigm and had engaged in the coding of transcribed responses for an earlier study (Miller and VanFossen, 1994). The rater was given detailed instruction on the methods used by the researcher to code the relevant variables in the current study. In addition, the second rater used the data coding rubrics found in Chapter III of this report as a final guideline for the coding process. The results of the second rater's coding indicated a very high degree of correlation between the researcher's coding and that of the second rater (correlation coefficient = .8341; p < .01). These results may be interpreted as partial validation of the coding process employed by the researcher for the current study.

*Relevant Indicators of Expertise in Economic Problem Solving*

The following section represents a report of the results of the aforementioned data analysis techniques for each of the thirteen variables— the relevant indicators of expertise in economic problem solving--investigated in the current study.

*Number of Relevant Statements.* The mean number and standard deviations of relevant statements used by respondents, according to level of formal economic education and experience, is presented in Table 1. The data presented here, and for all subsequent variables, reflect the sub-sample group
means across the three economic problems. The means reported here were simply calculated for each of the seven sub-sample groups and not for each of the three economic problems within each sub-sample group. A decision was made to collapse the data in this manner after a one-way analysis of variance showed no significant difference in the means of sub-sample groups when compared across problems. That is, there was no significant difference among the means for each of the variables considered, and across each of the sub-sample groups, for the three problems used. Therefore, unless otherwise noted, discussion of the data analysis in this section refers to combined means from each of the three economic problems.

The data indicated a difference in number of relevant statements made for each of the seven sub-samples groups. A one-way analysis of variance (Table 2) indicated that the number of economically relevant statements made during a transcribed response by Groups 1-4 did not differ significantly \([F(6,77) = 13.6, p=.05]\). The number of relevant statements made among Groups 2-5 did not differ significantly from each other. Further, there was no significant difference between the number of responses used by Groups 5 and 7 and Groups 7 and Group 6.

However, the analysis of variance indicated that the number of statements made by Group 6 differed significantly from all groups except Group 7 and Group 7 differed significantly from all other groups except Group 6 \((p=.05)\). Finally, Group 5 differed significantly only from Group 1 \((p=.05)\).

Thus, the Ph.D.. economists (PHD-OSU, PHD-FIELD) made significantly more statements than the first four groups (HS-NO ECON, HS-ECON, UND-NO ECON, UND-ECON), and non-university Ph.D.'s made significantly more statements than the first five groups (including GRAD). For this sample, no
Table 1

Summaries of Number of Relevant Statements by Level of Participant

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<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV 1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>3.4167</td>
<td>1.6214</td>
<td>12</td>
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</tr>
<tr>
<td>PARTLEV 2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>5.6667</td>
<td>3.6763</td>
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</tr>
<tr>
<td>PARTLEV 3.00</td>
<td>UNDERGRADUATE-NON EC</td>
<td>8.8333</td>
<td>3.8337</td>
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</tr>
<tr>
<td>PARTLEV 4.00</td>
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<td>9.3333</td>
<td>2.1034</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 5.00</td>
<td>GRAD STUDENTS</td>
<td>15.5833</td>
<td>4.6015</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>27.0000</td>
<td>16.8871</td>
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<td></td>
</tr>
<tr>
<td>PARTLEV 7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>24.6667</td>
<td>13.7731</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Table 2

One-way ANOVA: Number of Relevant Statements by Level of Participant

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>6188.5714</td>
<td>1031.4206</td>
<td>13.5890</td>
<td>0.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>5644.4167</td>
<td>75.9015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>12033.9881</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4167</td>
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<tr>
<td>5.6667</td>
<td>Grp 2</td>
</tr>
<tr>
<td>8.8333</td>
<td>Grp 3</td>
</tr>
<tr>
<td>9.3333</td>
<td>Grp 4</td>
</tr>
<tr>
<td>15.5833</td>
<td>Grp 5</td>
</tr>
<tr>
<td>24.6667</td>
<td>Grp 6</td>
</tr>
<tr>
<td>27.0000</td>
<td>Grp 7</td>
</tr>
</tbody>
</table>

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
significant differences existed between the mean number of statements made by high school economics students and high school students who had not taken economics. Further, no significant differences existed in the number of statements made by high school economics students, undergraduate students, undergraduate majors in economics and graduate students in economics.

While these differences were not all statistically significant, it was nonetheless interesting to note that both groups of Ph.D. economists made nearly twice as many statements as the graduate students and three times the number made by the undergraduate majors. Moreover, the difference between the number of statements made between both high school groups was marginal. Similarly, little difference existed between the undergraduate economics majors and non-majors. These results implied that, for this sample of economic problem solvers, those who had graduate training in economic education made a significantly greater number of relevant statements than those who had not.

Table 3
Correlation Coefficients: All Variables by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation with PARTLEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE</td>
<td>.6764**</td>
</tr>
<tr>
<td>HELPER</td>
<td>.7121**</td>
</tr>
<tr>
<td>CONCEPTS</td>
<td>.6701**</td>
</tr>
<tr>
<td>CONMAPS</td>
<td>.7390**</td>
</tr>
<tr>
<td>MODELS</td>
<td>.7588**</td>
</tr>
<tr>
<td>PROPERP</td>
<td>.3863**</td>
</tr>
<tr>
<td>PROBERP</td>
<td>.6900**</td>
</tr>
<tr>
<td>CAUSERP</td>
<td>.6819**</td>
</tr>
<tr>
<td>PITTOPS</td>
<td>.7968**</td>
</tr>
<tr>
<td>PITTEVAL</td>
<td>.8087**</td>
</tr>
<tr>
<td>PITTFeed</td>
<td>.8020**</td>
</tr>
<tr>
<td>PITTSD</td>
<td>.7466**</td>
</tr>
<tr>
<td>PITTpat</td>
<td>.7945**</td>
</tr>
</tbody>
</table>

* - Signif. LE .05  ** - Signif. LE .01  (2-tailed)
and that the number of statements made by the high school and undergraduate economics students were only marginally greater than counterpart groups.

The data indicated a substantial positive relationship (correlation coefficient = .68; p<.01, See Table 3) between a participant's level of formal economic education and the number of relevant statements used to respond to one of the three economic problems. Thus, for this sample of economic problem solvers, participants with greater levels of expected expertise, as indicated by formal economic education, were more likely to use a greater number of relevant economic statements in their responses.

Percentage of Relevant Statements Used. The mean percentages, out of the absolute number of statements used, of relevant statements employed by respondents according to level of formal economic education and experience is presented in Table 4. The data indicated a difference in the percentage of relevant statements used for each of the seven sub-samples groups. A one-way analysis of variance (See Table 5) indicated that the percentage of economically relevant statements used during a response was not significantly different among Groups 4-7 [F (6,77) = 18.6, p=.05]. Further, the mean percentages of relevant statements used among Groups 3-6 did not differ significantly. In addition, the mean percentages of Groups 2 and 3 did not differ significantly.

However, the analysis of variance did indicate that the number of statements made by Group 7 differed significantly from Groups 1-3. Groups 5 and 6 differed significantly from both Groups 1 and 2, and Groups 2 and 3 differed significantly from Group 1.

What these data suggested was that the Ph.D. economists (Groups 6 and 7), the graduate students (Group 5), the undergraduate majors in economics
Table 4

Summaries of Percentage of Relevant Statements by Participant Level

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.5483</td>
<td>.1741</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.7106</td>
<td>.1968</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON BC</td>
<td>.7900</td>
<td>.1327</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>.9025</td>
<td>.1052</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>.9406</td>
<td>.0682</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>.9300</td>
<td>.0459</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>.9642</td>
<td>.0363</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 5

One-way ANOVA: Percent Relevant Statements by Level of Participants

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>P Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>1.6472</td>
<td>.2812</td>
<td>18.6070</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>1.1637</td>
<td>.0151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>2.8509</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 2 3 4 5 6 7

| .5483  | Grp 1 |
| .7106  | Grp 2 |
| .7900  | Grp 3 |
| .9025  | Grp 4 |
| .9300  | Grp 5 |
| .9408  | Grp 6 |
| .9642  | Grp 7 |

(*) Denotes pairs of groups significantly different at the 0.050 level
(Group 4) and the undergraduate non-majors (Group 3) used a significantly greater percentage of relevant statements than both groups of high school students (Groups 1 and 2). In fact, while the results were not statistically significant, it was also interesting to note that for the undergraduate majors, graduate students and both groups of Ph.D.'s the percent of relevant statements used was greater than 90%. Moreover, there was a large difference--nearly seventeen percentage points--in the percentage of relevant statements used by high school economics students relative to high school students who had taken no economics. These results indicated that, for this sample of economic problem solvers, those who had taken high school economics demonstrated quite a large difference in the percentage of relevant statements used relative to those who had not, while those who had taken advanced graduate studies in economics (PHD-FIELD, PHD-OSU, GRAD) demonstrated only a marginal increase over their counterpart groups.

The data indicated a very strong positive relationship (correlation coefficient = .71; p < .01, See Table 3) between a participant's level of formal economic education and the percentage of relevant statements used to respond to the three economic problems. Thus, for this sample of economic problem solvers, the data indicated that participants with greater levels of expected expertise, as indicated by level of formal economic education, were more likely to use a greater percentage of relevant economic statements in their responses.

**Number of Economic Concepts Used.** The mean number of economic concepts used by respondents, according to level of formal economic education and experience, is presented in Table 6. The data indicated a difference in number of economic concepts used for each of the seven sub-samples groups. A one-way analysis of variance (Table 7) indicated that the number of concepts
Table 6

Summaries of Number of Economic Concepts by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Level Description</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>2.0833</td>
<td>1.2401</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>3.1667</td>
<td>1.8505</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-MON EC</td>
<td>7.4667</td>
<td>5.3144</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>7.9167</td>
<td>2.2344</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>21.7500</td>
<td>7.6175</td>
<td>12</td>
</tr>
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<td>PARTLEV</td>
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<td>FIELD-BASED PH. D.</td>
<td>37.8333</td>
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</tr>
<tr>
<td>PARTLEV</td>
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<td>UNIVERSITY-BASED PH.</td>
<td>30.3333</td>
<td>17.8343</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 7

One-way ANOVA: Number of Economic Concepts by Level of Participant

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>Prob</th>
</tr>
</thead>
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<tr>
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<td>6</td>
<td>14497.5714</td>
<td>2416.2619</td>
<td>14.8920</td>
<td>.0000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>77</td>
<td>12492.7500</td>
<td>162.2435</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>26990.3214</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 2 3 4 5 6 7
2.0833 Grp 1
3.1667 Grp 2
7.4667 Grp 3
7.9167 Grp 4
21.7500 Grp 5
30.3333 Grp 7
37.8333 Grp 6

(*) Denotes pairs of groups significantly different at the 0.050 level
used during a response was not significantly different among Groups 1-4 \( F (6,77) = 14.9, p=.05 \). Further, the mean number of economic concepts used by Groups 3-5 did not differ significantly. There was no significant difference in the number of economic concepts used by Groups 5-7.

A one-way analysis of variance indicated that the number of concepts used by Groups 5-7 differed significantly from Groups 1 and 2. Moreover, Groups 6 and 7 differed significantly from Groups 1-4.

The data suggested that the Ph.D. economists (Groups 6 and 7) used a significantly greater number of economic concepts than both groups of high school students, and of both groups of undergraduate students. Additionally, the graduate students used a significantly greater number of economic concepts than both groups of high school students. However, while the number of concepts used by graduate students was significantly greater than both groups of high school students, no significant difference was found between the number of concepts used by graduate students and the number used by undergraduate majors and non-majors.

Again, while these results were not all statistically significant, it is important to note that the graduate students, university-Ph.D.'s and field based-Ph.D.'s used nearly three, four and five times the number of economic concepts respectively than did the two undergraduate groups. Further, there was extremely little difference between the number of concepts used by both undergraduate majors and non-majors and marginal differences between the two high school groups. These data suggested that those who had graduate training (GRAD), and advanced graduate training in economics (PHD-FIELD, PHD-OSU) demonstrated a much greater use of economic concepts relative to the other four groups, while those who had taken high school and
undergraduate economics demonstrated little or no difference in the number of concepts used over counterpart sub-sample groups.

The data indicated a substantial positive relationship (correlation coefficient = .67; p<.01, See Table 3) between a participant's level of expected expertise, as indicated by formal economic education and experience, and the number of economic concepts used in response to the three economic problems. Thus, for this sample of economic problem solvers, the data indicated that participants with greater levels of formal economic education were more likely, on average, to use a greater number of economic concepts in their responses.

*Number of Concept Maps Used.* The mean number of economic concept maps used by respondents, according to level of formal economic education and experience, is presented in Table 8. The data indicated a difference in number of economic concept maps used for each of the seven sub-sample groups. A one-way analysis of variance (Table 9) indicated that the number of concept maps used during a response did not differ significantly for Groups 1-4 [F (6,77) = 20.4, p=.05], or for the number of economic concept maps used among Groups 3-5. In addition, there was no significant difference in the number of economic concepts used between Groups 6 and 7. The analysis of variance indicated that the number of concepts used by Groups 6 and 7 differed significantly from Groups 1-5. Further, Group 5 differed significantly from Groups 1 and 2.

The data suggested that the Ph.D. economists (Groups 6 and 7) used a significantly greater number of economic concept maps than both groups of high school students, both groups of undergraduate students, and the graduate students in economics. In addition, the graduate students used a significantly greater number of economic concept maps than both groups of high school
students. However, while the number of concept maps used by graduate students was significantly greater than both groups of high school students, no significant difference was found between number of concepts maps used by graduate students and those used by undergraduate majors and non-majors.

In fact, while not all of these results were statistically significant, it was noteworthy that both Ph.D. groups used approximately twice the number of concept maps as the graduate students. Moreover, the high school economics students and the undergraduate majors in economics used only marginally greater numbers of concept maps than counterpart groups, while the graduate students used exactly three times the number of concept maps used by the undergraduate majors. These results suggested that, for this sample of economic problem solvers, those who had graduate, and advanced graduate, training in economics demonstrated greater usage of economic concept maps. Conversely, those who had high school or undergraduate economics demonstrated only a marginally greater use of economic concept maps over their respective counterpart groups.

The data indicated a very strong positive relationship (correlation coefficient = .73; p< .01, See Table 3) between a participant's level of formal

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV 1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.0000</td>
<td>.0000</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
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<td>.3992</td>
<td>12</td>
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</tr>
<tr>
<td>PARTLEV 3.00</td>
<td>UNDERGRADUATE-NON ECON</td>
<td>.9167</td>
<td>1.1645</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>1.2500</td>
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</tr>
<tr>
<td>PARTLEV 5.00</td>
<td>GRAD STUDENTS</td>
<td>3.7500</td>
<td>1.8647</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>6.9167</td>
<td>4.6799</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>PARTLEV 7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>7.5000</td>
<td>3.7050</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
economic education and experience and the number of economic concept maps used in response to the three economic problems. Thus, for this sample of economic problem solvers, the data indicated that participants with greater levels of formal economic education were more likely to use a greater number of economic concept maps in their responses.

**Number of Economic Models Used.** The mean number of economic models used by respondents, according to level of formal economic education and experience, is presented in Table 10. The data indicated a difference in number of economic models used for each of the seven sub-samples groups. A one-way analysis of variance (Table 11) indicated that the number of models used during
Table 10

Summaries of Number of Economic Models by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>0.4167</td>
<td>0.5149</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>0.6667</td>
<td>0.7785</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON BC</td>
<td>1.3333</td>
<td>1.4975</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>2.5000</td>
<td>0.6742</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>3.9167</td>
<td>1.2401</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>7.0833</td>
<td>3.9187</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>9.1667</td>
<td>4.7450</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 11

One-way ANOVA: Number of Economic Models by Level of Participant

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>819.6667</td>
<td>136.6111</td>
<td>22.2508</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>472.7500</td>
<td>6.1396</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>1292.4167</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
a response did not differ significantly among Groups 1-4 \(F (6,77) = 22.3, p<.05\), or for the number of economic models used among Groups 3-5. In addition, there was no significant difference between the number of economic models used between Groups 5 and 6 or between the number of models used by Group 6 and 7.

The one-way analysis of variance indicated that the number of concepts used by Groups 6 and 7 differed significantly from the number used among Groups 1-4 and that Group 7 differed significantly from Group 5. Finally, the number of economic models used by Group 5 differed significantly from the number used by Groups 1 and 2.

The data indicated that the Ph.D. economists (Groups 6 and 7) used a significantly greater number of economic models than both groups of high school students and both groups of undergraduate students, and that the university Ph.D.'s used significantly more economic models than the graduate students in economics. In addition, the graduate students used a significantly greater number of economic models than both groups of high school students. However, while the number of concept maps used by graduate students was significantly greater than both groups of high school students, no significant difference was found among number of concepts used by graduate students and those used by undergraduate majors and non-majors in economics.

Again, while not all statistically significant, these results are of some practical significance. In particular it interesting to note that the university-Ph.D.'s and field based-Ph.D.'s invoked nearly two and three times, respectively, more economic models during responses than did the graduate students in economics. Further, it is important to stress that, once again, those who had participated in high school economics demonstrated only very small differences
over the counterpart group. However, for this sample of economic problem solvers, undergraduate economics majors used nearly twice as many economics models as did undergraduate non-majors. These results suggested that those with undergraduate, graduate and advanced graduate training in economics employed a significantly greater number of economic models. Moreover, those with training in high school economics displayed very little difference in the number of models used relative to the counterpart sub-sample group.

The data indicated a very strong positive relationship (correlation coefficient = .76; p<.01, See Table 3) between a participant's level of expected expertise, as indicated by formal economic education and experience, and the number of economic models used in response to the three economic problems. Thus, for this sample of economic problem solvers, the data suggested that participants with greater levels of formal economic education were more likely to use a significantly greater number of economic models in their responses.

Problem Representation Expert Ratio Profile (ERP). The problem representation ERP was calculated by dividing the number of statements used by the respondent to reorder, reclassify or subdivide the problem by the total number of relevant statements used. Thus, this ERP was a ratio of problem representation statements used to total relevant statements used. The mean problem representation ERP of respondents, according to level of formal economic education and experience, is presented in Table 12.

The data indicated differences in each of the seven sub-sample groups' problem representation ERP. A one-way analysis of variance (Table 13) indicated that the problem representation ERP did not differ significantly among Groups 1-3 [F (6,77) = 16.2, p<.05], nor did the problem representation ERP's of
### Table 12

**Summaries of Problem Representation ERP by Level of Participant**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.0483</td>
<td>.1142</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.0067</td>
<td>.0231</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON ECON</td>
<td>.0833</td>
<td>.0968</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>.1483</td>
<td>.0354</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>.2275</td>
<td>.0689</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>.2050</td>
<td>.0700</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.D.</td>
<td>.2300</td>
<td>.0942</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 13

**One-way ANOVA: Problem Representation ERP by Level of Participant**

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>.5917</td>
<td>.0986</td>
<td>16.1629</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>.4698</td>
<td>.0061</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>1.0615</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:

- G G G G G G G
- r r r r r r r
- D D D D D D D

Mean Group 2 1 3 4 6 5 7

- .0067 Grp 2
- .0483 Grp 1
- .0833 Grp 3
- .1483 Grp 4
- .2050 Grp 6
- .2275 Grp 5
- .2300 Grp 7

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
Group 1, Group 3 and 4 differ significantly. In addition, there was no significant difference among the problem representation ERP's of Groups 4, 5, 6 or 7. The one-way analysis of variance indicated that the problem representation ERP's of Groups 5, 6 and 7 did differ significantly from the ERP's of Groups 1-3 and that Group 4 differed significantly from Group 2.

The data implied that the Ph.D. economists (Groups 6 and 7), the graduate students (Group 5) and the undergraduate majors in economics (Group 4) had significantly higher problem representation ERP's than both high school groups and the undergraduate non-majors. Similarly, the graduate students in economics had significantly higher problem representation ERP's than did the undergraduate non-majors and both high school groups.

While not all statistically significant, these results are nonetheless interesting. Indeed, it is informative to observe, for example, that the graduate students and both Ph.D. sub-groups used nearly the same percentage of problem representation statements. This level was twice the percentage used by undergraduate economics students and nearly three times the percentage used by the other undergraduate group. More curiously, the high school students without economic training used a greater percentage of problem representation statements than the high economics students. These findings suggested that the use of problem representation in problem solving, for this sample of economic problem solvers, is more closely associated with the experience of graduate and advanced graduate training in economics. However, the participants who experienced undergraduate training also demonstrated relatively frequent use of problem representation statements. The researcher was unable to develop a cogent argument for the relatively low levels of problem representation demonstrated by Group 2, although one supposition might involve a kind of
"fishing around" scenario. That is, as one achieves a certain level of expertise, it may be the case that attendant levels of problem representation decrease at the margin. Thus, experts may be able to narrow down the realm of possibility with respect to sub-problem identification, while those with less expertise cast and re-cast a problem while searching for the problem's significant elements.

The data indicated a substantial positive relationship (correlation coefficient = .68; p<.01, See Table 3) between a participant's level of expected expertise, as indicated by formal economic education and experience, and the ratio of problem representation statements to total statements used. Thus, for this sample of economic problem solvers, the data indicated that participants with greater levels of formal economic education, were more likely to use a significantly greater ratio of problem representation statements in their responses.

*Causal Statement ERP.* The causal statement ERP was calculated by dividing the number of causal statements--those that resembled an 'A causes B' model--used by the respondent by the total number of relevant statements used. Thus, this ERP was a ratio of causal statements to total relevant statements. The mean causal ERP of respondents, according to level of formal economic education and experience, is presented in Table 14. The data indicated differences in each of the seven sub-samples groups' causal ERP. A one-way analysis of variance (Table 15) indicated that the problem representation ERP did not differ significantly among Groups 1-4 \( F (6,77) = 12.2, p<.05 \), nor did the causal ERP's of Group 3, Group 4 and Group 5 differ significantly. In addition, there was no significant difference among the problem representation ERP's of Groups 5, 6 or 7.
Table 14

Summaries of Causal Statement ERP by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00 HIGH SCHOOL-NO ECONO</td>
<td>0.0167</td>
<td>0.0577</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00 HIGH SCHOOL ECONOMIC</td>
<td>0.0167</td>
<td>0.0577</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00 UNDERGRADUATE-NON ECONO</td>
<td>0.0575</td>
<td>0.0871</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00 UNDERGRAD ECON MAJOR</td>
<td>0.0750</td>
<td>0.0682</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00 GRAD STUDENTS</td>
<td>0.1283</td>
<td>0.0742</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00 FIELD-BASED PH.D.</td>
<td>0.1867</td>
<td>0.0954</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00 UNIVERSITY-BASED PH.D.</td>
<td>0.2108</td>
<td>0.0946</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 15

One-way ANOVA: Causal Statement ERP by Level of Participant

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>.4424</td>
<td>.0737</td>
<td>12.1588</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>.4670</td>
<td>.0061</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>.9094</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 2 3 4 5 6 7

.0167 Grp 1
.0167 Grp 2
.0575 Grp 3
.0750 Grp 4
.1283 Grp 5
.1867 Grp 6
.2108 Grp 7

(* ) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
The one-way analysis of variance indicated that the problem representation ERP's of Groups 6 and 7 differed significantly from the ERP's of Groups 1-4 and that Group 5 differed significantly from Groups 1 and 2.

The data suggested that the Ph.D. economists (Groups 6 and 7), had significantly higher causal ERP's than both high school groups and both undergraduate groups. The graduate students in economics had significantly higher causal ERP's than did both high school groups. In fact, in absolute terms, no difference existed in the percentage of causal statements used by both high school groups. Additionally, the undergraduate economics majors used only marginally greater percentages of causal statements. Conversely, the Ph.D. groups used tremendously greater percentages of casual statements than did both high school groups and both undergraduate groups, and nearly seventy-five percent more than the graduate students.

The data also suggested a substantial positive relationship (correlation coefficient = .69; p<.01, See Table 3) between a participant's level of formal economic education and experience and the ratio of causal statements to total statements used. Thus, for this sample of economic problem solvers, the data indicated that participants with greater levels of formal economic education were more likely to use a significantly higher ratio of causal statements in their responses.

Propositional Statement ERP. The propositional statement ERP was calculated by dividing the number of statements that resembled an 'if....then' model by the total number of relevant statements used. Thus, this ERP was a ratio of propositional statements to total relevant statements. The mean propositional statement ERP of respondents, according to level of formal differ-
Table 16
Summaries of Propositional Statement ERP by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>FARTLBV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.0167</td>
<td>.0577</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.0500</td>
<td>.0811</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON BC</td>
<td>.0167</td>
<td>.0577</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>.0300</td>
<td>.0459</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>.0850</td>
<td>.0838</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>.0833</td>
<td>.0528</td>
<td>12</td>
</tr>
<tr>
<td>FARTLBV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>.1017</td>
<td>.0779</td>
<td>12</td>
</tr>
</tbody>
</table>

ences in each of the seven sub-samples groups' problem representation ERP. However, a one-way analysis of variance (Table 17.) indicated that the differences were not significant \( F(6,77) = 3.3, p<.05 \).

Again, though the ANOVA found no significant differences in the percentage of propositional statements used, some commentary on these results was still warranted. For this variable, the high school economics students used nearly three times the percentage of propositional statements as did the counterpart group. Similarly, the undergraduate majors used nearly twice the

Table 17
One-way ANOVA: Propositional Statement ERP by Level of Participant

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>P PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>.0095</td>
<td>.0149</td>
<td>3.3447</td>
<td>.0056</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>.3436</td>
<td>.0045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>.4331</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
percentage of propositional statements as did the undergraduate non-majors. Finally, the graduate students and both Ph.D. groups used nearly three times the percentage of causal statements of the undergraduate majors.

The data indicated a moderate positive relationship (correlation coefficient = .39; p<.01, See Table 3) between a participant's level of formal economic education and experience and the ratio of propositional statements to total statements used.

Figure 3. Comparison of Summary Statistics: STATE, CONCEPTS, CONMAPS, MODELS
Figure 4. Comparison of Summary Statistics: RELPER, PROBERP, PROPERP, CAUSERP
Figure 3 represents a graphical comparison of the first four variables described above: number of relevant statements, number of economic concepts, number of economic concept maps and number of economic models used. Figure 4 represents a graphical comparison of the percentage of relevant statements used and of the three ERP's: problem representation, causal and propositional.

It was evident from both Figure 3 and Figure 4 that the level of most of these eight relevant indictors of expertise in economic problem solving increased across level of economic education. Indeed, this trend appeared to hold for each of these eight variables under consideration. However, in several cases (e.g., number of economic concepts used, number of relevant statements used) it was also evident that the pattern noted above did not always hold.

A second important point to be gleaned from Figures 3 and 4 involved the size of increase in the levels of the eight variables across level of economic education. Indeed, the increase in the level of the eight variables across level of economic education was neither uniform nor, in most cases, linear. These results will be discussed at length in Chapter V and in subsequent analysis in this chapter, but suffice to say, Figures 3 and 4 offer strong evidence that, for this group of problem solvers and for this set of variables, the acquisition of expertise was not a continuum with equi-distant categories along it.

The Pitt Problem Solving Coding System (PPSCS)Variables

The PPSCS was described fully in Chapter III. The reader should recall, however, that the PPSCS provided "a comprehensive, empirical instrument to
code heterogeneous verbal protocols in terms of the type of processing function each verbal proposition represents" (Pitt, p. 551) and that the PPSCS provided a reasonable method for classifying verbal responses along a commonly accepted problem solving model. Specifically, use of the PPSCS provided a clearer picture of the general problem solving abilities and strategies of the respondents—as applicable to economic problem solving.

**PPSCS: General Problem Solving.** The general problem solving (GPS) measure was generated by counting the number of statements coded as meeting the Pitt GPS criteria. The mean GPS of respondents, according to level of formal economic education and experience, is presented in Table 18. The data indicated differences in each of the seven sub-samples groups' Pitt GPS. A one-way analysis of variance (Table 19) indicated that these differences were not significant \[ F (6,77) = 28.8, p<.05 \] among Groups 1-4. Additionally, the ANOVA indicated that Groups 5-7 did not differ significantly. However, Groups 5-7 did differ significantly from Groups 1-4.

The data indicated that the graduate students, and both Ph.D. groups, used significantly more Pitt GPS statements than both high school groups and both undergraduate groups. Further, while the high school economics students used a marginally greater number of Pitt GPS statements than the counterpart group, the graduate students used two and one-half times more Pitt GPS statements than undergraduate majors. The university-Ph.D. group used three and one-half times more GPS statements than the graduate students and a marginally greater number than the field-based Ph.D.'s. The data indicated a very strong, positive relationship between Pitt GPS statements used and formal level of economic education (correlation coefficient = .80, p < .01; See Table 3).
### Table 18

**Summaries of Pitt GPS by Level of Participant**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.2500</td>
<td>.4523</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.3333</td>
<td>.6513</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON EC</td>
<td>.5833</td>
<td>.5149</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>1.0000</td>
<td>.4264</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>2.5000</td>
<td>.5222</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>2.8333</td>
<td>1.1146</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>3.5000</td>
<td>1.6237</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 19

**One-way ANOVA: Pitt GPS Statements by Level of Participant**

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>129.0714</td>
<td>21.5119</td>
<td>29.8072</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>57.5000</td>
<td>.7460</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>186.5714</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 2 3 4 5 6 7

.2500 Grp 1
.3333 Grp 2
.5833 Grp 3
1.0000 Grp 4
2.5000 Grp 5
2.8333 Grp 6
3.5000 Grp 7

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
PPSCS: Hypothetico-deductive. The Pitt hypothetico-deductive (HD) measure was generated by counting the number of statements coded as meeting the Pitt HD criteria. The mean HD of respondents, according to level of formal economic education and experience, is presented in Table 20. The data indicated differences in each of the seven sub-samples groups' Pitt HD measures. A one-way analysis of variance (Table 21.) indicated that these differences were not significant \( F (6,77) = 28.8, p<.05 \) among Groups 1-4. Additionally, the ANOVA indicated that Groups 5-7 did not differ significantly in the number of Pitt HD statements used. However, Groups 5-7 did differ significantly from Groups 1-4.

Moreover, these data suggested that, although the differences were not all significant, those participants who had experienced high school economics used twice the number of Pitt hypothetico-deductive statements as the counter part group. Despite this, the absolute difference in the mean number of Pitt HD statements used by both high school groups, and the undergraduate non-economics majors, was so small as to be relatively insignificant. Indeed, even the undergraduate majors used an average of only slightly more than one Pitt HD statement per response. However, both groups of Ph.D.'s, and the graduate students, used approximately three times the number of Pitt HD statements as the undergraduate majors.
### Table 20

Summaries of Pitt H-D Statements by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV1</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.1667</td>
<td>.3092</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV3</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.3333</td>
<td>.4924</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV6</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON EC</td>
<td>.7500</td>
<td>.7530</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV4</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>1.2500</td>
<td>.7530</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV5</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>3.3333</td>
<td>1.0731</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV6</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>3.0333</td>
<td>1.0007</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV7</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>3.1667</td>
<td>1.5275</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 21

One-way ANOVA: Pitt H-D Statements by Level of Participant

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>174.8333</td>
<td>29.1399</td>
<td>24.7012</td>
<td>.000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>90.8333</td>
<td>1.1797</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>265.6667</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group

<table>
<thead>
<tr>
<th>Mean</th>
<th>Grp</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>.1667</td>
<td>Grp 1</td>
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<tr>
<td>.3333</td>
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<td>2</td>
</tr>
<tr>
<td>.7500</td>
<td>Grp 3</td>
<td>3</td>
</tr>
<tr>
<td>1.2500</td>
<td>Grp 4</td>
<td>4</td>
</tr>
<tr>
<td>3.1667</td>
<td>Grp 5</td>
<td>5</td>
</tr>
<tr>
<td>3.3333</td>
<td>Grp 6</td>
<td>6</td>
</tr>
<tr>
<td>3.8333</td>
<td>Grp 7</td>
<td>*</td>
</tr>
</tbody>
</table>

(*) denotes pairs of groups significantly different at the 0.050 level.
**PPSCS: Pattern Extraction.** The Pitt pattern extraction (PAT) measure was generated by counting the number of statements coded as meeting the Pitt PAT criteria. The mean PAT of respondents, according to level of formal economic education and experience, is presented in Table 22. The data indicated some difference in each of the seven sub-samples groups' Pitt PAT measures. A one-way analysis of variance (Table 23) indicated that these differences were not significant \[F (6,77) = 29.18, p<.05\] among Groups 1-3 or between Groups 4 and 5. Additionally, the ANOVA indicated that Groups 4 and Groups 6 and 7 did not differ significantly in the number of Pitt PAT statements used. However, Groups 4 and 5 did differ significantly from Groups 1-3, and Groups 6 and 7 differed significantly from Groups 1-3 and from Group 5.

More importantly, however, these data suggested that, although the differences were not all significant, those participants who had experienced high school economics used three times the number of Pitt extraction statements as participants who had not experienced high school economics. Interestingly, the mean number of Pitt pattern extraction statements used by high school economics students and the undergraduate non-economics majors was equivalent. Even more surprising was the fact that while the undergraduate majors used nearly five times the number of Pitt pattern extraction statements as the undergraduate non-majors, the graduate students used slightly fewer pattern extraction statements, on the average, than the undergraduate majors. Finally, both groups of Ph.D. economists used the same mean number of pattern extraction statements. This mean represented a fifty percent increase in pattern extraction statements over the undergraduate majors, and a seventy-five percent increase over the graduate students.
Table 22

Summaries of Pitt PAT Statements by Level of Participant

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NONECONOMO</td>
<td>.1667</td>
<td>.3892</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.5000</td>
<td>.6742</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NONECONOMO</td>
<td>.5000</td>
<td>.6742</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECONOMAJOR</td>
<td>2.2500</td>
<td>.8660</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>2.0833</td>
<td>.9962</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>3.2500</td>
<td>.7538</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.D.</td>
<td>3.2500</td>
<td>1.2581</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 23

One-way ANOVA: Pitt PAT Statements by Level of Participant

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>P RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>125.8095</td>
<td>20.9683</td>
<td>29.1787</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>55.3333</td>
<td>.7186</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>181.1429</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group: 1 2 3 5 6 6 7

.1667 Grp 1
.5000 Grp 2
.5000 Grp 3
2.0833 Grp 5 * * *
2.2500 Grp 4 * * *
3.2500 Grp 6 * * * *
3.2500 Grp 7 * * * *

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL.
PPSCS: Feedback. The Pitt feedback (FEED) measure was generated by counting the number of statements coded as meeting the Pitt FEED criteria. The mean number of feedback statements of respondents, according to level of formal economic education and experience, is presented in Table 24. The data indicated differences in each of the seven sub-sample groups' Pitt FEED measures. A one-way analysis of variance (Table 25.) indicated that these differences were not significant \( F (6,77) = 29.71, \ p<.05 \) among Groups 1-3. Additionally, the ANOVA indicated that Groups 4-7 did not differ significantly in the number of Pitt FEED statements used but Groups 4-7 did differ significantly from Groups 1-3.

Table 24

Summaries of Pitt FEED Statements by Level of Participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.2500</td>
<td>.4523</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.4167</td>
<td>.6666</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON EC</td>
<td>.8333</td>
<td>.5774</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>2.5833</td>
<td>.9003</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>2.8333</td>
<td>1.0299</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>3.4167</td>
<td>1.3114</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>3.5000</td>
<td>1.0071</td>
<td>12</td>
</tr>
</tbody>
</table>

As with previous variables, not all the differences in the number of PITTFEED statements used were statistically significant. However, these data indicated that while the expected pattern of increasingly greater usage of PITTFEED statements held for the sample groups, a substantial difference existed in the pattern of usage between Groups 1-3 and Groups 4-7. That is, the undergraduate economics majors (and groups above) used a much greater number of PITTFEED statements than any of the first three groups. The groups
above the undergraduates majors used more PITTFEED statements, but only marginally so. Thus, the data suggested that participants who had experienced undergraduate economic training—and those with economic training beyond—"leaped" ahead of the previous three groups with respect to PITTFEED usage.

Table 25

One-way ANOVA: Pitt FEED Statements by Level of Participants

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>146.6190</td>
<td>24.4365</td>
<td>29.7096</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>63.3333</td>
<td>.8225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>209.9524</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 3 4 5 6 7

.3500 Grp 1
.4167 Grp 2
.6333 Grp 3
2.5833 Grp 4 * * *
2.6333 Grp 5 * * *
3.4167 Grp 6 * * *
3.5000 Grp 7 * * *

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL

PPSCS: Evaluation. The Pitt evaluation (PITTEVAL) measure was generated by counting the number of statements coded as meeting the Pitt evaluation statement criteria. The mean number of evaluation statements of respondents, according to level of formal economic education and experience, is presented in Table 26. The data indicated differences in each of the seven subsamples groups' PITTEVAL measures. A one-way analysis of variance (Table 27) indicated that these differences were not significant \[F (6,77) = 31.39, p<.05\]
### Table 26

**Summaries of Pitt EVAL Statements by Level of Participants**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Label</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTLEV</td>
<td>1.00</td>
<td>HIGH SCHOOL-NO ECONO</td>
<td>.1667</td>
<td>.3092</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>2.00</td>
<td>HIGH SCHOOL ECONOMIC</td>
<td>.5000</td>
<td>.6742</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>3.00</td>
<td>UNDERGRADUATE-NON ECON</td>
<td>.5033</td>
<td>.6606</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>4.00</td>
<td>UNDERGRAD ECON MAJOR</td>
<td>2.4167</td>
<td>.9962</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>5.00</td>
<td>GRAD STUDENTS</td>
<td>2.5033</td>
<td>.9962</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>6.00</td>
<td>FIELD-BASED PH.D.</td>
<td>3.2500</td>
<td>.9653</td>
<td>12</td>
</tr>
<tr>
<td>PARTLEV</td>
<td>7.00</td>
<td>UNIVERSITY-BASED PH.</td>
<td>3.4167</td>
<td>1.0836</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 27

**One-way ANOVA: Pitt EVAL Statements by Level of Participants**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>D.F.</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>F RATIO</th>
<th>F PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>BETWEEN GROUPS</td>
<td>6</td>
<td>138.4048</td>
<td>23.0675</td>
<td>31.3908</td>
<td>.0000</td>
</tr>
<tr>
<td>WITHIN GROUPS</td>
<td>77</td>
<td>56.5833</td>
<td>.7348</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>194.9881</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Group 1 2 3 4 5 6 7

.1667 Grp 1
.5000 Grp 2
.5033 Grp 3
2.4167 Grp 4 * * *
2.5033 Grp 5 * * *
3.2500 Grp 6 * * *
3.4167 Grp 7 * * *

(*) DENOTES PAIRS OF GROUPS SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL
among Groups 1-3. Additionally, the ANOVA indicated that Groups 4-7 did not differ significantly in the number of PITTEVAL statements used. However, Groups 4-7 did differ significantly from Groups 1-3.

Again, while not all the differences among the mean number of evaluation statements made were statistically significant, some interesting patterns continued to emerge. As with each of the other Pitt Problem Solving variables, participant's usage of PITTEVAL statements followed the expected pattern of increasingly greater usage as the level of formal economic education and experience of participants increased. More importantly, however, the data regarding PITTEVAL statements used confirmed the presence of a second pattern. This pattern involved a "leap"--or a significant increase in usage of a Pitt variable over previous groups--of qualitatively different proportions. That is, at some level of economic education, participants demonstrated a substantially greater usage of the Pitt Problem Solving attributes than had groups with less economic education. For three of the Pitt variables (PITTEVAL, PITTFEED, and PITTPAT), this "leap" was manifest in the undergraduate economic majors. For the remaining Pitt variables (PITTHD and PITTGPS), this "leap" was evident from the graduate students. What these results imply is that, with respect to the aspects of problem solving measured by the Pitt Problem Solving Coding System (PPSCS), a clear pattern concerning the acquisition of expertise in economic problem solving emerged. Indeed, the data clearly indicated that, at least for this small sample of economic problem solvers, certain attributes of formal training in economics led to a substantial rise in the usage of PPSCS variables.
Figure 5 represents a graphical comparison of the sub-group means for each of the Pitt variables described above and provides evidence that the pattern noted for the first eight variables continued to hold. That is, the level of PPSCS variable demonstrated increased across level of economic education. What was even more interesting, for these PPSCS variables, was the significant change in the level of all PPSCS variables associated with either undergraduate or graduate training in economics. Further discussion on this issue will be provided in Chapter V, but it should be noted that these results also seemed to indicate the presence of a "leap" in level of expert-like problem solving--for this
sample of problem solvers—at some point along the path to expertise. In addition, Figure 5 also provided further evidence for the non-linearity of expertise acquisition and of relative expertise in general.

**Percent Change Across Levels of Economic Education**

In order to demonstrate the strength of the relative impact of increasing levels of formal economic education on expertise in economic problem solving, a percentage change term was calculated. This term was produced by converting changes in mean scores for each variable—across level of economic education—to percent changes. For example, the mean number of statements made by graduate students in economics represented a nearly sixty-seven percent change over the mean number of statements made by the undergraduate majors. These results indicated that, for this small sample, the move from undergraduate economics major to graduate student in economics resulted in a relatively large percentage gain in the number of economic statements used.

A second example may be seen in the percentage change in the number of economic concepts and the number of economic models employed when students who had taken high school economics were compared to those high school students who had not. The high school economics students used fifty-two percent more economics concepts than their counterparts. Similarly, the high school economics students used nearly sixty percent more economic models than students who had not taken high school economics.

Thus, by examining the percentage change across variables from level of expertise to level of expertise, the relative impact of movement from one level of expertise to another was determined. As a result, it seemed plausible to interpret these results as a type of marginal analysis. That is, by examining the
percentage change across variables, it was possible to draw inferences about the impact of category membership on demonstrated levels of one variable or another—at the margin. In this case, the term "margin" is used to indicate the move from one category of expertise to another.

One obvious implication of such inferences lay in identifying at what point the greatest percentage change in certain variables occurred and, therefore, in determining where the greatest potential for gains in expertise existed. Moreover, by determining at which margins the greatest percentage increase in certain variables was most likely to occur, valuable educational and training resources—designed to bring about expert-like economic behavior—may be more effectively allocated.

Indeed, other interesting results suggested by this analysis suggested that something akin to diminishing returns—as measured by falling percent change across categories of expertise—existed for certain variables. For example, the percentage change in number of economic concepts used fell from one hundred seventy-four to seventy-four to negative twenty (See Figure 6) across the categories of graduate student, field-based Ph.D., and OSU-Ph.D. respectively. In addition, the same pattern was evident—across these same three categories—in the number of causal statements used and the number of Pitt hypothetico-deductive statements used. As noted above, these results suggested that some manifestation of a diminishing returns phenomenon—with respect to the output level of expertise in economic problem solving relative to educational and experiential inputs—was present for this small sample.

Finally, these results seemed to refute the assumption that the path to expertise was some continuum, with equi-distant categories along it. Indeed, the data presented above indicated that the percentage change in the
Figure 6. Percentage Change for STATE, RELPER, CONCEPTS and MODELS

demonstrated level of all of the variables under investigation was not distributed across equal intervals. In fact, some evidence indicated that at various points some type of increasing returns associated with particular categorical memberships (e.g., graduate students) existed. Conversely, membership in other categories (e.g., both Ph.D. groups) indicated some type of decreasing returns with respect to demonstrated levels of particular variables.

Figure 6 presents a graphical comparison of the percent change along the four variables found to comprise the so-called Economic Knowledge factor variable (See "Factor Analysis" section of this chapter). Figure 7 presents a
similar graphical comparison of the eight so-called Economic Problem Solving Process factor variables (See "Factor Analysis" section of this chapter).

Figure 7. Percentage Change for PROPERP, CAUSERP, PITT GPS, PITT H-D, PITTPAT, PITT FEED and PITT EVAL Across Level of Participant

**Standardized Rank Data**

The last set of results for this first level of data analysis involved data concerning the absolute rankings of participant responses across each of the variables under investigation. By re-configuring the raw data set for each variable, the SPSS application generated a new series of variables: mean absolute ranking of respondents by participation level. By comparing the ranking of all participant responses relative to the position of other respondents
Figure 8. Comparison of Mean Standardized Rankings of CONCEPTS, CONMAPS, MODELS, STATE and PITTGPS

(and resolving all ties with the mean position of the tied responses), SPSS generated a new series of variables that provided further insight into the nature and constructs of relative expertise. The new data set allowed the calculation of a series of mean rankings for each variable across participant level (PARTLEV). With these mean rankings (calculated on the range 1-84), it was possible to examine the position of each sub-sample group—across each variable—relative to the other sub-sample groups. A comparison of these mean rankings may be
seen in Figure 8 and Figure 9. Figure 8 and Figure 9 also continued the
distinction between Economic Knowledge factor variables and Economic
Problem Solving Process factor variables described in the previous section. It
should be noted that, across most of the variables studied, the mean rankings
corresponded well with the participant's level of economic education.

Figure 9. Comparison of the Mean Standardized Rankings of CAUSERP,
PITTEVAL, PITTFEED, PITTHD and PITTPAT
In fact, a correlation analysis of the relationship between the mean rankings and participant's level of formal economic education ranged from moderate to very strong. Table 28 reports these correlation coefficients.

These results suggested that, at least for this sample of economic problem solvers, the initial supposition that the level of participant's formal economic education was related to expected levels of expertise was accurate. Indeed, the mean ranking data confirmed that, across each of the variables, respondents performance on each variable tended to rank according to their level of economic education.

However, it is also interesting to note the exceptions to these trends. For example, the mean rankings of the graduate student's problem representation ERP were above both Ph.D. groups. Similarly, the high school students with no economics ranked above the high economics students on the problem representation ERP (see Figure 9). It may very well be the case that, as noted

Table 28
Correlation Coefficients for Mean Standardized Rankings of All Variables with Level of Participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMODELS</td>
<td>.8570**</td>
</tr>
<tr>
<td>RCONCEPT</td>
<td>.8474**</td>
</tr>
<tr>
<td>RPITTSAPS</td>
<td>.8376**</td>
</tr>
<tr>
<td>RCOMMAPS</td>
<td>.8369**</td>
</tr>
<tr>
<td>RFITTFEE</td>
<td>.8217**</td>
</tr>
<tr>
<td>RFITTEVA</td>
<td>.8174**</td>
</tr>
<tr>
<td>RFITTPAT</td>
<td>.8082**</td>
</tr>
<tr>
<td>RFITTHD</td>
<td>.7998**</td>
</tr>
<tr>
<td>RSTATE</td>
<td>.7937**</td>
</tr>
<tr>
<td>RRELPERS</td>
<td>.7061**</td>
</tr>
<tr>
<td>RCAUSERP</td>
<td>.6984**</td>
</tr>
<tr>
<td>RFROSERP</td>
<td>.6780**</td>
</tr>
<tr>
<td>RFROPERF</td>
<td>.6803**</td>
</tr>
</tbody>
</table>

* - Signif. LE .05  ** - Signif. LE .01  (2-tailed)
earlier in this chapter, these results were due to some kind of "fishing around" on the part of respondents. That is, it may be the case that attendant levels of problem representation decrease at the margin. Thus, those with greater levels of expertise may be able to narrow down the realm of possibility with respect to sub-problem identification, while those with less expertise must cast and re-cast a problem while searching for the problem's significant elements.

These exceptions, in conjunction with the other data concerning the mean rankings, seemed to refute the supposition that the path to expertise was a continuum, with equi-distant categories along it. Indeed, although it was true that the order of the mean rankings for respondents was relatively consistent with intuitive expectations based upon participant's level of formal economic education, the intervals in these mean rankings were by no means equally distributed across each variable. These results suggested that the process of moving from one category of expertise to another was not the same for all respondents. Certainly this was evident in the fact that for several levels of participants, the calculated mean ranking on certain variables was above or below generally expected levels. The case of the problem representation statements noted above was one such example. Other examples included the mean rankings of number of relevant statements used, the mean rankings of propositional statements made and the mean rankings of the number of Pitt evaluation statements made (See Figure 9).

Moreover, if the path to expertise were continuous, the movement along such a continuum would involve equi-distant linear or linear combination intervals. The data suggested that, for the variables noted above, this was not the case.
Finally, as the data were standardized by rank, it was possible to calculate a mean of the mean rankings across all variables (Table 29). The results of this analysis suggested that the intervals between mean rankings were not equi-distant relative to each other. Indeed, it was apparent that the mean rankings fell into three groupings with respect to the standardized data: the two high school groups, the two undergraduate groups and the graduate students and both Ph.D. groups.

Table 29

Mean of the Mean Standardized Rankings (1-34) for All Variables

<table>
<thead>
<tr>
<th>Level of Participant</th>
<th>Mean of Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.53</td>
</tr>
<tr>
<td>2</td>
<td>22.71</td>
</tr>
<tr>
<td>3</td>
<td>31.11</td>
</tr>
<tr>
<td>4</td>
<td>40.91</td>
</tr>
<tr>
<td>5</td>
<td>57.61</td>
</tr>
<tr>
<td>6</td>
<td>62.09</td>
</tr>
<tr>
<td>7</td>
<td>64.43</td>
</tr>
</tbody>
</table>

For the current study, the ranked data was analyzed across all thirteen variables using hierarchical cluster analysis to determine if underlying groupings were present. The cluster analysis technique compared the similarity or distance associated with a group of cases and classified like variables into groups, or clusters, based on likeness. The results of this cluster analysis revealed that the mean cluster level (based on degree of association relative to all other groups) for both groups of high school students was 1.04. This implied that a cluster was created around the first twenty-four rankings. In other words, all but two of the first twenty-four cases were assigned to the first cluster—a very high degree of similarity.
The analysis clustered both undergraduate sub-groups into the second cluster and the mean cluster level for both groups was 1.74. This implied that a cluster—but perhaps not as tight a cluster as for the first twenty-four—was created around the second twenty-four rankings. Indeed, nineteen out of these twenty-four cases were assigned to the second cluster. For the graduate students and both Ph.D. groups, the mean cluster level was 2.94. This implied that a third cluster was created around the last thirty-six rankings. These results suggested that the three groupings apparent from the previous ranking analysis were plausible.

Figure 10. Comparison of the Means of Standardized Mean Rankings for All Variables Across Level of Participant
Figure 10 represents a graphical depiction of the mean rankings across participant levels and these results suggested two important conclusions. First, it was evident from Figure 10 that, to some extent, the "leap" introduced earlier in this analysis, was also present in this data. In fact, one should note the obvious change in slope associated with movement from undergraduate major to graduate student. Similarly, there was also a certain flattening in the mean rankings associated with movement from graduate student to both level of Ph.D.'s. These results seemed to confirm suppositions made earlier in this chapter concerning the nature of expertise and its acquisition. Namely, that the path to expertise is not a linear continuum and that, at the margin, certain levels of economic education exhibit diminishing returns with respect to increased acquisition of expertise in economic problem solving.

Summary of the First Level of Analysis

This section serves as a very brief summary of the first level of analysis done in an effort to describe the nature and constructs of relative expertise in economic problem solving. Obviously, a much more detailed discussion of these findings will be offered in Chapter V, but given the amount of analysis discussed to this point, it may be helpful to present several broad statements regarding preliminary findings.

The first important aspect of this level of analysis involved the findings of the analysis of the thirteen variables identified as relevant indicators of expertise in economic problem solving. This analysis consisted of examining summary statistics for each of the thirteen variables and then conducting a one way analysis of variance (ANOVA) to determine whether differences existed between observed means for each of the variables. Further, a correlation
analysis was done in order to determine if a relationship existed between the level of expertise of participants (PARTLEV) and the observed mean levels of the thirteen variables. An analysis of the percentage change of the thirteen variables across the participant categories was conducted. Finally, the data was re-configured into standardized rankings and the mean standardized rankings for participant categories were compared across variables. These findings were further analyzed using a hierarchical cluster analysis.

Very briefly, tentative conclusions regarding the outcome of these data analyses included:

1. Confirmation of the very strong, positive relationship between each of the thirteen variables and the level of expected expertise as indicated by participant level.

2. Identification of mostly marginal differences in the observed mean levels of most variables for the high school economics students over those who had not taken high school economics. Similarly, such a pattern was present when examining the observed mean levels of variables for both Ph.D. groups over the graduate students. Finally, the data indicated that some significant differences did exist between undergraduate economics students and their non-major counterparts.

3. Identification of a pattern in the observed level of Pitt Problem Solving variables across levels of expected expertise. This pattern involved a "leap"—or a significant increase in usage of Pitt variables over previous groups—of qualitatively different proportions. That is, at some level of expected economic expertise, participants demonstrated a substantially greater usage of the Pitt Problem Solving attributes than had groups with less expected economic expertise.

4. Support for the pattern noted above in the results of the mean standardized ranking analysis. Indeed, a hierarchical cluster analysis suggested that the rankings grouped into three clusters: (a) both high school groups; both undergraduate groups; (b) the graduate students and (c) both Ph.D. groups.
5. Support for the hypothesis that the path to expertise was not a continuum with equi-distant categories along it. This support lay in results from both the mean ranking analysis and the analysis of percentage change in observed levels of the variables across the categorical levels of participants.

Factor Analysis

The second level of analysis with respect to the nature and constructs of relative expertise in economic problem solving for the current study involved an attempt to assess whether the thirteen variables noted above might be described in terms of a smaller number of underlying hypothetical variables. In order to achieve these results, a factor analysis of thirteen independent variables was undertaken.

The first step in this analysis was to generate a correlation matrix for the variables under consideration. This matrix is presented at Appendix G. Next, an exploratory factor analysis using the Kaiser normalization and an unweighted least squares solution was conducted. The results (Table 30)

Table 30
Initial Exploratory Factor Analysis: Final Statistics

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COMMONALITY</th>
<th>FACTOR</th>
<th>EIGENVALUE</th>
<th>PCT OF VAR</th>
<th>CUM PCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PITPRED</td>
<td>.78605</td>
<td>1</td>
<td>0.39090</td>
<td>64.6</td>
<td>64.6</td>
</tr>
<tr>
<td>PITPSYCH</td>
<td>.73269</td>
<td>2</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>PITPPAT</td>
<td>.90777</td>
<td>3</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>COMCAPS</td>
<td>.84366</td>
<td>4</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>MODELS</td>
<td>.60725</td>
<td>5</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>PROBEP</td>
<td>.55475</td>
<td>6</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>RELPER</td>
<td>.51177</td>
<td>7</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>STATE</td>
<td>.92705</td>
<td>8</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>CONCEPTS</td>
<td>.92158</td>
<td>9</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>PITTHD</td>
<td>.77564</td>
<td>10</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>PITTCOPS</td>
<td>.60007</td>
<td>11</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
<tr>
<td>CAUSERP</td>
<td>.68514</td>
<td>12</td>
<td>1.1050</td>
<td>10.1</td>
<td>74.7</td>
</tr>
</tbody>
</table>

OBLIMIN ROTATION  KAISER NORMALIZATION  OBLIMIN CONVERGED IN 12 ITERATIONS.
indicated that two factors satisfied the minimum Eigenvalue requirement (Eigenvalue > 1.0).

Using the results of the exploratory factor analysis, a second, confirmatory factor analysis was conducted. Again, the analysis used an unweighted least squares solution. In addition, a factor rotation was conducted in order to present a simpler, more easily interpreted solution. The correlation matrix suggested that the two factors were correlated, and thus an oblique rotation technique, using an Oblimin, was employed.

The results of this second factor analysis confirmed that the two factors were indeed correlated (See Table 31). Further, the effect of the oblique rotation was to separate the factor loadings, or correlations among the identified factors and the variables in question, onto the two factors. The loadings on the first factor included number economic statements used (STATE), number of economic concepts used (CONCEPTS), number of economic models used (MODELS), number of concept maps used (CONMAPS) and Pitt general problem solving (PITTGPS). The second set of factor loadings represented the remaining variables: problem representation ERP (PROBERP), causal statement ERP (CAUSERP), propositional statement ERP (PROPERP), percentage of relevant statements used (RELPER), Pitt pattern extraction (PITTPAT), Pitt

Table 31

<table>
<thead>
<tr>
<th>FACTOR 1</th>
<th>FACTOR 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACTOR 1</td>
<td>----</td>
</tr>
<tr>
<td>FACTOR 2</td>
<td>.60527</td>
</tr>
</tbody>
</table>
hypothetico-deductive (PITTHD), Pitt feedback (PITTFEED) and Pitt evaluation (PITTEVAL). The factor loadings for the factor structure matrix are presented at Table 32.

Table 32

Factor Structure Matrix: Loadings for All Variables on Factor 1 and Factor 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>FACTOR 1</th>
<th>FACTOR 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCEPTS</td>
<td>.95984</td>
<td>.56731</td>
</tr>
<tr>
<td>STATE</td>
<td>.95534</td>
<td>.48284</td>
</tr>
<tr>
<td>CONMAPS</td>
<td>.94984</td>
<td>.63404</td>
</tr>
<tr>
<td>MODELS</td>
<td>.91815</td>
<td>.57618</td>
</tr>
<tr>
<td>PITTOPS</td>
<td>.88255</td>
<td>.71425</td>
</tr>
<tr>
<td>PITTPAT</td>
<td>.65860</td>
<td>.62903</td>
</tr>
<tr>
<td>CAUSERP</td>
<td>.41657</td>
<td>.82151</td>
</tr>
<tr>
<td>PITTHD</td>
<td>.76545</td>
<td>.61003</td>
</tr>
<tr>
<td>PITTFEED</td>
<td>.78762</td>
<td>.60075</td>
</tr>
<tr>
<td>PITTEVAL</td>
<td>.74105</td>
<td>.70955</td>
</tr>
<tr>
<td>RELPER</td>
<td>.50470</td>
<td>.70113</td>
</tr>
<tr>
<td>PROBERP</td>
<td>.48752</td>
<td>.77900</td>
</tr>
<tr>
<td>PROPERP</td>
<td>.32267</td>
<td>.59391</td>
</tr>
</tbody>
</table>

The results of this confirmatory factor analysis indicated the presence of two underlying factors. The first factor was defined as Economic Knowledge. Indeed, four of the five variables that loaded very heavily (> .90) onto the first factor (STATE, CONCEPTS, MODELS, CONMAPS) were treated as relevant indicators of economic knowledge in the current study. The extremely high factor loadings for these four variables may be interpreted as evidence of a very high level of inter-correlation between these four variables and this first factor—Economic Knowledge.

A strong case can be made for this conclusion, as economic knowledge is most certainly a function of economic concept knowledge, a knowledge of economic models and the linkages between such concepts and models. Further,
the number of relevant economic statements made was clearly an indicator of the strength of a respondent's economic knowledge. Thus, four of the five variables that loaded onto the Economic Knowledge factor were variables that corresponded to the relative level of economic knowledge demonstrated by participants.

The fifth variable (PITTGPS) was not used as an indicator of economic knowledge in the current study. Rather, PITTGPS was taken—as were all the Pitt Problem Solving variables—to be an indicator of problem solving processes. Indeed, the PITTGPS measure was determined by coding respondent's statement that involved general problem solving abilities.

At least one potential explanation existed for this seemingly anomelaic result. Indeed, it was plausible that general economic problem solving abilities—but not necessarily advanced problem solving abilities—were a direct function of economic knowledge. Due to this relationship, then, the PITTGPS might be interpreted as a secondary indicator of economic knowledge. These findings, however, will be discussed in more detail in Chapter V.

The results of the confirmatory factor analysis seemed to support this position. It is noteworthy that the PITTGPS variable loaded heavily upon both factors (factor 1 = .8825; factor 2 = .7143). These loadings might be interpreted as demonstrating a high degree of intercorrelation between the PITTGPS variable and both factor 1 and factor 2.

The second factor was defined as Economic Problem Solving Processes. Seven of the eight variables (PROBERP, PROPERP, CAUSERP, PITHD, PITTFEED, PITTPAT, PITTEVAL) that loaded appreciably (> .75) on this factor were identified specifically for the purpose of analyzing the cognitive processing (Miller and VanFossen, 1994) and/or problem solving abilities (Pitt,
1983) of respondents. These cognitive processes (problem representation and the use of propositional and causal statements) and problem solving skills (pattern extraction, feedback, hypothetico-deductive statements and evaluation) have been well documented as essential attributes of expertise in problem solving (See Pitt, 1983; Chi and Glaser, 1983; Lesgold, et al., 1981). Thus, seven of the variables that loaded on the Economic Problem Solving Processes factor corresponded to the key problem solving processes as demonstrated by participants and as measured by other methods in the current study.

The eighth variable that loaded appreciably on the Economic Problem Solving Processes factor was the percentage of relevant statements used by respondents (RELPER). This result seemed out of place given the strong correlations between the factors and the high level of correspondence among variable loadings and expectations regarding such loadings. Indeed, it would seem that the RELPER, as a direct function of STATE, should have corresponded with the loadings associated with STATE. This, however, was clearly not the case.

However, these counter-intuitive results could have been a function of the fact that a lower percentage of relevant statements used reflected both a low level of economic knowledge and an inability to reason effectively about a problem due to this lack of knowledge. In this case, the loadings may not have been as expected. It may also be the case that this variable--RELPER--is a less than satisfactory variable in terms of what has been measured. Thus, this "crossing over" may be a function of a variable measuring something altogether different than what was proposed by the researcher.

**Relationship Between Acquisition of Knowledge and Problem Solving.** The researcher believed that while high degree of correlation existed between Factor
1 (Economic Knowledge) variables and Factor 2 (Economic Problem Solving Processes) variables, this level of correspondence might not have been extended to a correspondence of mean rankings for each of the factors across each of the seven groups. Stated another way, it was conceivable that membership in certain sub-groups implied a higher mean ranking on Factor 1 variables (Economic Knowledge) than on Factor 2 variables (Economic Problem Solving Process). Similarly, for other groups, membership might have implied a higher mean ranking on Factor 2 variables than on Factor 1 variables. Thus, it could have been the case that relative experts ranked higher, on average, on knowledge components than did novices, but that the mean rankings on process components were relatively equivalent—or vice versa.

Figure 11 presents a graphical comparison of the aggregated mean standardized ranks of Factor 1 variables versus Factor 2 variables. This data seemed to imply that the first two sub-groups (HSECON and HS NOECON), the relative rankings of the economic process component variables were substantially higher, in the aggregate, than the economic knowledge component variables. The pattern continued, albeit on a somewhat diminished level for the next three sub-groups (UND NON-ECON, UNDECON, and GRAD). However, the pattern was reversed for the final two sub-groups (PHD-FIELD and PHD-OSU).

These results implied that, at least for novices—and perhaps for relative experts as well—the combination of both economic knowledge and economic problem solving procedures was important in determining categorical membership. This relationship seemed to be less important for the Ph.D. sub-groups. This may be related to the diminishing returns phenomenon outlined
earlier. It may also be the case that the type of economic knowledge brought to bear by the experts was overly specific and thus the issue of process was incidental at best. Conversely, it may be the case that the novices and relative experts require a knowledge of economic problem solving processes to make the knowledge they do possess relevant in some manner for solving the problem.

Finally, it should also be noted that the data presented in Figure 11 lent support to the supposition that the acquisition of expertise involved a "leap" along some non-linear path. Such a "leap" may be clearly seen in Figure 11 as level of economic education moves from undergraduate major to graduate student. Although Figure 11 reports a comparison of the mean rank of
Economic Knowledge Factor variables and Economic Process Variables, it was possible to interpolate the jump of nearly twenty points in the mean rankings on both Factor 1 and Factor 2 as associated with the move from undergraduate economics students to graduate students in economics.

Again, it cannot be over stressed that these results implied that both the knowledge and the process component seemed to play an important role in distinguishing the relative levels of expertise that existed in the current study's sub-groups. Indeed, these results seemed to confirm the integral relationship between economic knowledge and economic problem solving processes as uncovered by the exploratory and confirmatory factor analysis.

Analysis Related to the Development of the EEPSSM

As noted in Chapters II and III, the current study employed an ordered Probit technique in the development of the Expertise in Economic Problem Solving Scaling Model (EEPSSM). The decision to employ such a technique was based upon the theoretical underpinnings of scale theory (See, for example, Guttman, 1944; Stouffer, 1950 and Reckase, 1984) and a knowledge of the output of ordered Probit analysis (Greene, 1986; Maddala, 1983).

Ordered Probit analysis is essentially a technique for providing estimates of the maximum likelihood of a series of events or, more precisely, the maximum likelihood of a combination of independent variables resulting in one of several levels of a limited, dependent variable. Thus, for the current study, it seemed theoretically plausible to create a model based on the ordered category probability estimates associated with various combinations of the independent variables. In fact, given the categorical nature of the variable PARTLEV, the ordered Probit technique seemed to hold an intriguing potential.
For purposes of the current study, all of the thirteen relevant indicators of expertise in economic problem solving were used in the analysis. Expected level of expertise (as indicated by level of formal economic education, PARTLEV) was used as the limited dependent variable—limited in the sense that the variable levels were categorical in nature (e.g., HS-NO ECON, PHD-OSU, etc.).

In ordered Probit analysis, the limited dependent variable (in the current study, level of expertise in economic problem solving) is assumed to represent categorical values for an underlying continuous variable (Y*)—for the current study, Y* = expertise in economic problem solving. According to Miller (1989), "(t)he Probit procedure models the probability distribution of the underlying y*" (p. 5). As Becker and Waldman (1987) noted, in ordered Probit analysis "the probability of the event is modeled and not the occurrence itself" (p. 1). Stated another way, the ordered Probit reported the probability—as a function of a particular combination of independent variables—of an event's occurrence. In the case of the current study, the event in question was that of membership in one of the seven levels of expected expertise in economic problem solving.

Within the ordered Probit technique, a primary assumption was that y was normally distributed about the expected value of y at each value of x. As Becker and Waldman (1987) stressed, "this is the Probit specification and forms the basis for the maximum likelihood estimation technique" and this maximum likelihood "produces the line that maximizes over the x values the 'closeness' of the observed relative frequencies of Y* equaling each of its values" (p. 2). Further, the error term is assumed to be distributed normally. Moreover, the resulting values associated with the model are interpreted as z-scores in the normal distribution (Miller, 1989).
Following Greene (1986), the specification for the model used in the current study was:

\[ z = B'x + \hat{\epsilon} \]
\[ \hat{\epsilon} \sim N(0,1) \]
\[ y = 0 \text{ if } z \leq \mu_0 \]
\[ y = 1 \text{ if } \mu_0 < z \leq \mu_1 \]
\[ y = 2 \text{ if } \mu_1 < z \leq \mu_2 \]
\[ y = 3 \text{ if } \mu_2 < z \leq \mu_3 \]
\[ y = 4 \text{ if } \mu_3 < z \leq \mu_4 \]
\[ y = 5 \text{ if } \mu_4 < z \leq \mu_5 \]
\[ y = 6 \text{ if } \mu_5 < z, \]

where \( \mu_i \) was the calculated cut-point determined by LIMDEP.

The calculations for the current study were conducted using the computer program LIMDEP (Greene, 1986). This analysis included a constant term (identified in the program as ONE) and normalized \( \mu_0 \) at 0. The specification outlined above essentially calculated threshold--or 'cut'--points which were used to determine, based on the probability distribution of \( y \), the maximum likelihood of membership in one of the seven categories. Thus, "the resulting output permits an estimate of the probability of a particular response on the observed \( y \) (e.g. '1'), given a value of the independent variable of interest and the value of the rest of the function" (Miller, 1989, p. 5). LIMDEP calculated the remainder of the function based on the mean levels of all independent variables less the variable of interest. That is, during the calculations LIMDEP essentially held all independent variables, other than the variable of interest, 'constant' at their mean levels.
Using the output of the LIMDEP package, it was possible to calculate the probability associated with membership in each of the seven categories based on the mean level of each of the independent variables. The initial output from LIMDEP, however, reported only the coefficients and significance levels associated with each of the independent variables (See Table 34). In order to calculate the probability distribution associated with membership then, it was necessary to use these coefficients to compute the attendant z-scores for each of the seven levels of the dependent variable (See Table 33). The LIMDEP program calculated only five cut points as any attendant z-score less than $z_{u1}$ was considered to fall in the "0" category and any z-score greater than $z_{u5}$ was considered to fall in the "6" category. (Note: in this discussion section, the LIMDEP categories for PARTLEV of 0-6 correspond with the previously designated categories 1-7. The researcher realizes that this may be potentially confusing to the reader, but this distinction is a function of the LIMDEP application.) Using these threshold points calculated by LIMDEP, and the coefficients associated with the mean levels of each independent variable, a 'product' for each independent variable was calculated. This product represented the calculated coefficient for each independent variable multiplied by the mean level of that variable.

The Z-scores were determined by summing all products. Table 34 reports the coefficients (and levels of significance), means and products for each of the thirteen independent variables and the constant term (ONE). The threshold points calculated by LIMDEP are reported as the MU Z-Value in Table 33.
Table 33

Calculated Attendant Z-Scores For MU 0-5 (All Independent Variables at Mean Levels)

<table>
<thead>
<tr>
<th>MU</th>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3.0019</td>
</tr>
<tr>
<td>1</td>
<td>1.2269</td>
<td>2.5749</td>
</tr>
<tr>
<td>2</td>
<td>2.7521</td>
<td>1.0497</td>
</tr>
<tr>
<td>3</td>
<td>4.3990</td>
<td>-0.5971</td>
</tr>
<tr>
<td>4</td>
<td>6.0064</td>
<td>-2.2045</td>
</tr>
<tr>
<td>5</td>
<td>7.9589</td>
<td>-4.1570</td>
</tr>
</tbody>
</table>

Table 34

Coefficients and Products of the Ordered Probit Analysis on All 13 Variables

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>Mean of X</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE (CONSTANT)</td>
<td>-1.9856</td>
<td>1.000</td>
<td>-1.9856</td>
</tr>
<tr>
<td></td>
<td>(.0143)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATE</td>
<td>.0543</td>
<td>13.512</td>
<td>.7337</td>
</tr>
<tr>
<td></td>
<td>(.2871)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RELPER</td>
<td>2.5907</td>
<td>.8260</td>
<td>2.1399</td>
</tr>
<tr>
<td></td>
<td>(.0401)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODELS</td>
<td>.1851</td>
<td>3.5833</td>
<td>.6632</td>
</tr>
<tr>
<td></td>
<td>(.2252)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONCEPTS</td>
<td>-.1010</td>
<td>15.8210</td>
<td>-1.5979</td>
</tr>
<tr>
<td></td>
<td>(.0037)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONMABS</td>
<td>.2136</td>
<td>2.9280</td>
<td>.6632</td>
</tr>
<tr>
<td></td>
<td>(.1409)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAUSERP</td>
<td>5.9701</td>
<td>.0910</td>
<td>.5432</td>
</tr>
<tr>
<td></td>
<td>(.0310)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROPERP</td>
<td>-3.5901</td>
<td>.0550</td>
<td>-.1974</td>
</tr>
<tr>
<td></td>
<td>(.1254)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROBERP</td>
<td>2.5460</td>
<td>.1410</td>
<td>.3590</td>
</tr>
<tr>
<td></td>
<td>(.1004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PITTRED</td>
<td>.1322</td>
<td>1.7730</td>
<td>.2343</td>
</tr>
<tr>
<td></td>
<td>(.5455)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PITTPCPS</td>
<td>.8124</td>
<td>1.5950</td>
<td>1.2957</td>
</tr>
<tr>
<td></td>
<td>(.0015)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PITTRED</td>
<td>.1185</td>
<td>1.9880</td>
<td>.2355</td>
</tr>
<tr>
<td></td>
<td>(.6808)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PITTMAP</td>
<td>.2241</td>
<td>1.7140</td>
<td>.3841</td>
</tr>
<tr>
<td></td>
<td>(.4561)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PITTIEVAL</td>
<td>.2023</td>
<td>1.8214</td>
<td>.3685</td>
</tr>
<tr>
<td></td>
<td>(.5797)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at .05  **significant at .01
Once the products were calculated and summed, the results represented z-scores associated with the probability distribution for each of the seven levels of the dependent variable (with all independent variables held at mean levels). A standard z-table was used to determine the probability associated with each z-score. For example, Table 35 reports the probability distribution associated with membership in each of the seven sub-sample categories for the entire sample assuming a respondent used the mean number of economic concepts (CONCEPTS; x=15.82)) while also holding all other independent variables at their mean levels.

Table 35

Probability Distribution Associated with the Ordered Probit Analysis on the Variable CONCEPTS

<table>
<thead>
<tr>
<th>MU</th>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score</th>
<th>P</th>
<th>P</th>
<th>X = 0, 1, 2, 3, 4, 5, 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3.8019</td>
<td>.9999</td>
<td>.0004</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.2269</td>
<td>2.5749</td>
<td>.9951</td>
<td>.0049</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.7521</td>
<td>1.0497</td>
<td>.8531</td>
<td>.1620</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.3990</td>
<td>-0.5971</td>
<td>.2257</td>
<td>.6274</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6.0064</td>
<td>-2.2045</td>
<td>.0139</td>
<td>.2118</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7.9589</td>
<td>-4.1570</td>
<td>.0001</td>
<td>.0138</td>
<td></td>
</tr>
</tbody>
</table>

Chi-square (13)=173.57

*Represents the probability of membership in category 6 (PHD-OSU); LIMDEP calculates six threshold points for this study and the probability associated with membership in Group 6 is equal to 1-(sum of probabilities associated with membership in Groups 0-6).

The results reported in Table 35 implied, obviously, that the probability associated with membership in Group 3 (UND-ECON MAJOR) at the mean level of concepts, was by far the greatest (.6274) followed by the probability associated with membership in Groups 4 (GRAD; .2118) and 2 (UND-NONECON; .1420). Figure 12 represents this probability distribution. These
results seemed consistent with expectations. In fact, given a hypothetical respondent who used the mean level of all independent variables, the highest

![Graph](image)

Figure 12. Ordered Probit Probability Distribution for the Variable CONCEPTS

probabilities should cluster near the middle sub-sample groups. More importantly, however, this trend held for LIMDEP calculations of the probability distribution associated with sub-sample group membership across each of the twelve other relevant indicators.

It should be noted that the question of "goodness-of-fit" for the application of the ordered Probit model has been called into question (Greene, 1986; Becker and Waldman, 1987). Indeed, given the aforementioned concern regarding ordinary least squares estimates for limited dependent variables, a
researcher using the ordered Probit analysis is left with only the application of a chi-square test of association to determine the strength of the model.

The application of this test seemed logical, however, as the ordered Probit also calculated and compared frequencies of categorical membership as predicted by the model with actual membership (See Table 36) An examination

Table 36

Frequencies of Actual Categorical Membership vs. Categorical Membership Predicted by the Ordered Probit Model (Model 1: 13 IV's)

<table>
<thead>
<tr>
<th>Predicted</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>84</td>
<td>11</td>
<td>14</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>0</td>
<td>12</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Chi-square (13) = 173.57

of the frequencies reported in Table 36 revealed that, for example, of the twelve actual cases in Group 0 (HS NON ECON), the model predicted that eleven of these would be in category 0. Of these eleven cases, eight of these corresponded exactly with Group 0, while three corresponded with Group 1 (HS ECON). In addition, the degree of accurate correspondence could be gauged by drawing a
diagonal from the upper left-hand corner of the matrix to the lower right-hand corner. These numbers indicated the number of cases correctly positioned in this category by the model. The current study reported these findings as confirmation of the goodness-of-fit of the analyses.

The results presented in Table 36 indicated a high degree of correspondence between the model's predictions and actual category membership. In fact, the calculated coefficient of contingency for this model was .82. It must be noted that the coefficient of contingency statistic, as a measure of association, cannot attain the upper limit of one, and thus the coefficient .82 is considered quite high (See Kerlinger, 1973).

A second major assumption of the ordered Probit technique was that a unique probability distribution existed for each value of each x (Miller, 1988; Becker and Waldman, 1987). This assumption implied that, for the current study, it was possible to calculate the impact of a change in the level of one independent variable--while holding all other independent variables at their mean level--on the probability distribution associated with membership in each of the seven sub-sample categories.

For example, Table 37 reports the probability distribution for the sample based on an increase in the number of statements used by a respondent from the mean level of 13.512 statements to 15. This increase in the number of statements used raises the probability associated with membership in Group 5 (GRAD) from .2118 to .2845. Similarly, the probability associated with membership in Group 4 (UND-ECON) decreased from .6274 to .5693. As the number of statements used were increased from 15 to 50, the probability of membership in Group 5 rose from .2845 to .5033 and the probability associated with membership in Group 6 increased from .0138 to .3883. Thus, the data indicated
### Table 37

Probability Distribution Associated with the Ordered Probit Analysis on the Variable STATE

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=13.512)</th>
<th>P</th>
<th>P Y = 0.1.2.3.4.5.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.8019</td>
<td>.9999</td>
<td>.0004</td>
</tr>
<tr>
<td>1.2269</td>
<td>2.5749</td>
<td>.9951</td>
<td>.0048</td>
</tr>
<tr>
<td>2.7521</td>
<td>1.0497</td>
<td>.8531</td>
<td>.1420</td>
</tr>
<tr>
<td>4.3990</td>
<td>-0.5971</td>
<td>.2257</td>
<td>.6274</td>
</tr>
<tr>
<td>6.0064</td>
<td>-2.2045</td>
<td>.0139</td>
<td>.2118</td>
</tr>
<tr>
<td>7.9589</td>
<td>-4.1570</td>
<td>.0001</td>
<td>.0136</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=15)</th>
<th>P</th>
<th>P Y = 0.1.2.3.4.5.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.8852</td>
<td>.9999</td>
<td>.0004</td>
</tr>
<tr>
<td>1.2269</td>
<td>2.6557</td>
<td>.9961</td>
<td>.0038</td>
</tr>
<tr>
<td>2.7521</td>
<td>1.1306</td>
<td>.8708</td>
<td>.1253</td>
</tr>
<tr>
<td>4.3990</td>
<td>-0.5163</td>
<td>.3015</td>
<td>.5693</td>
</tr>
<tr>
<td>6.0064</td>
<td>-2.1233</td>
<td>.0170</td>
<td>.2844</td>
</tr>
<tr>
<td>7.9589</td>
<td>-4.0762</td>
<td>.0001</td>
<td>.0169</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=50)</th>
<th>P</th>
<th>P Y = 0.1.2.3.4.5.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.7831</td>
<td>.999999</td>
<td>.000001</td>
</tr>
<tr>
<td>1.2269</td>
<td>4.5562</td>
<td>.9999</td>
<td>.000009</td>
</tr>
<tr>
<td>2.7521</td>
<td>3.0311</td>
<td>.9998</td>
<td>.0011</td>
</tr>
<tr>
<td>4.3990</td>
<td>1.3841</td>
<td>.9162</td>
<td>.0826</td>
</tr>
<tr>
<td>6.0064</td>
<td>-0.2232</td>
<td>.4129</td>
<td>.5033</td>
</tr>
<tr>
<td>7.9589</td>
<td>-3.1757</td>
<td>.0146</td>
<td>.3803</td>
</tr>
</tbody>
</table>

Chi-squared (13) = 173.57

*Represents the probability of membership in category 6 (PHD-OSU); LIMDEP calculates five threshold points in this study and the probability associated with membership in Group 6 is equal to 1-(sum of probabilities associated with membership in Groups 0-6).

**Sums to greater than 1.0000 due to rounding.
that as the number of statements used rose, so too did the associated probability of membership in a higher category of the dependent variable: expected expertise in economic problem solving. Figure 13 represents a comparison of the three probability distributions associated with the aforementioned changes in the variable STATE.

The researcher decided to investigate the results of similar analyses on six of the thirteen independent variables (STATE—as noted above—RELPER, CONCEPTS, CONMAPS, MODELS and PITTGPS). This decision was based solely upon the relative size of each variables' calculated 'products' (See Table 34). These six variables all carried products (recall, product = calculated coefficient x mean level of variable) whose absolute value was greater than .60.
Thus, it was deemed, further examination of these variables might prove more fruitful than the remaining seven in developing a scaling model for use in determining relative expertise in economic problem solving.

An ordered Probit analysis of the percentage of relevant statements used (RELPER) revealed that as the percentage of relevant statements used increased

Table 38

Probability Distribution Associated with the Ordered Probit Analysis on the Variable STATE

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=.826)</th>
<th>P</th>
<th>P Y = 0,1,2,3,4,5,6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.8019</td>
<td>.9999</td>
<td>.0004</td>
</tr>
<tr>
<td>1.2269</td>
<td>2.5769</td>
<td>.9951</td>
<td>.0048</td>
</tr>
<tr>
<td>2.7521</td>
<td>1.0497</td>
<td>.8531</td>
<td>.1420</td>
</tr>
<tr>
<td>4.3990</td>
<td>-0.5971</td>
<td>.2257</td>
<td>.6274</td>
</tr>
<tr>
<td>6.0064</td>
<td>-2.2045</td>
<td>.0139</td>
<td>.2118</td>
</tr>
<tr>
<td>7.9589</td>
<td>-4.1570</td>
<td>.0001</td>
<td>.0138</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=.95)</th>
<th>P</th>
<th>P Y = 0,1,2,3,4,5,6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.1231</td>
<td>.999999</td>
<td>.0001</td>
</tr>
<tr>
<td>1.2269</td>
<td>2.6962</td>
<td>.9861</td>
<td>.0019</td>
</tr>
<tr>
<td>2.7521</td>
<td>1.3710</td>
<td>.8700</td>
<td>.0834</td>
</tr>
<tr>
<td>4.3990</td>
<td>-0.2758</td>
<td>.3015</td>
<td>.5250</td>
</tr>
<tr>
<td>6.0064</td>
<td>-1.8832</td>
<td>.0170</td>
<td>.3596</td>
</tr>
<tr>
<td>7.9589</td>
<td>-3.8357</td>
<td>.0001</td>
<td>.03009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MU Z-Value (LIMDEP)</th>
<th>Z-Score (x=.60)</th>
<th>P</th>
<th>P Y = 0,1,2,3,4,5,6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.2163</td>
<td>.9993</td>
<td>.0007</td>
</tr>
<tr>
<td>1.2269</td>
<td>2.0613</td>
<td>.9778</td>
<td>.0215</td>
</tr>
<tr>
<td>2.7521</td>
<td>0.7783</td>
<td>.7823</td>
<td>.1955</td>
</tr>
<tr>
<td>4.3990</td>
<td>-0.6916</td>
<td>.2420</td>
<td>.5403</td>
</tr>
<tr>
<td>6.0064</td>
<td>-2.2586</td>
<td>.0119</td>
<td>.2301</td>
</tr>
<tr>
<td>7.9589</td>
<td>-4.0346</td>
<td>.00001</td>
<td>.0119</td>
</tr>
</tbody>
</table>

Chi-squared (13)=173.57

*Represents the probability of membership in category 6 (PHD-OSU); LIMDEP calculates six threshold points in this study and the probability associated with membership in Group 6 is equal to 1-(sum of probabilities associated with membership in Groups 0-6).

**Sums to greater than 1.0000 due to rounding.
from the mean level of .826 to .950, the probability associated with membership in Groups 5 (GRAD) and 6 (PHD-FIELD) increased and the probabilities associated with membership in Groups 1-4 decreased. Similarly, if the percentage of relevant statements used decreased from .826 to .60, the probabilities associated with membership in Groups 1-3 rose and the probabilities associated with group membership in Groups 4-7 fell. Table 38 reports the results of the ordered Probit for the variable RELPER. Table 39 reports the changes in probability distribution associated with a change in the level of the variable RELPER. Figure 14 presents a graphical analysis of these changes.

Table 39

Changes in Probability Distribution for the Variable RELPER

<table>
<thead>
<tr>
<th>Group</th>
<th>$X = .60$</th>
<th>$X = .826$</th>
<th>$X = .95$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.0007</td>
<td>.0004</td>
<td>.0001</td>
</tr>
<tr>
<td>1</td>
<td>.0315</td>
<td>.0048</td>
<td>.0019</td>
</tr>
<tr>
<td>2</td>
<td>.1955</td>
<td>.1420</td>
<td>.0834</td>
</tr>
<tr>
<td>3</td>
<td>.5403</td>
<td>.6274</td>
<td>.5250</td>
</tr>
<tr>
<td>4</td>
<td>.2301</td>
<td>.2110</td>
<td>.3596</td>
</tr>
<tr>
<td>5</td>
<td>.0119</td>
<td>.0132</td>
<td>.03009</td>
</tr>
<tr>
<td>6</td>
<td>.00001</td>
<td>.0001</td>
<td>.00001</td>
</tr>
</tbody>
</table>

It was important to note that the analyses for each of the remaining four variables followed the trend outlined above. That is, that as changes were introduced in the independent variable of interest, a comparable change in the associated probability distributions also occurred. Indeed, these changes modeled a cogent pattern: as the level of the independent variable of interest rose, the probability of membership in a higher sub-sample group also rose.
Thus, members of this small sample of economic problem solvers demonstrated more frequent usage of the relevant indicators of expertise in economic problem solving as they moved further along the path toward acquiring expertise.

However, all of these results should be treated carefully for the true nature of the impact of changes in, for example, the number of statements used, was difficult to interpret from the LIMDEP calculations. In particular, it should be noted that as all other variables were held at mean levels when examining a change in a particular $x$, the relative impact of the change may have been diluted. That is, it is quite conceivable that a change in the number of statements used was correlated with a change in the number of concepts used.
and the number of PITGSPS statements used. There was no way to factor this possibility into the ordered Probit analysis.

Moreover, as all other variables were held at their mean levels, it may be true that changes in the probability distribution associated with the lower categories as result of changes in one independent variable may be underestimated based on the underlying the assumptions regarding the other variables. Indeed, it was unlikely that someone in category "1" would have demonstrated mean levels of all other independent variables. In fact, we should see the opposite; there was a relatively low probability associated with membership in this group. Therefore, in actuality, a change in one variable might have a tremendous impact on the change in probability of membership in a higher category, but only if the other variables in the function were at a similarly low level.

In spite of the above disclaimer, and given that the results of this initial ordered Probit analysis lent significant support to the plausibility of developing a scaling model for expertise in economic problem solving, the researcher concluded that a second, more parsimonious ordered Probit might yield a scaling model whose application would be more practical. Put another way, such an effort might yield a model that may be more easily applied by classroom teachers who have had little experience in interpreting complex economics.

The researcher determined that a second ordered Probit analysis should be conducted using the six variables with the highest products as independent variables in the Probit model. This approach seemed appropriate as the implication of product size was that the larger the product of an the independent variable, the larger the relative impact on the associated
probability distribution of changes in the level of that particular independent variable. Thus, for purposes of scaling model theory, this second analysis was an attempt to identify what variables played the largest role in determining group membership, or, more accurately, in determining the probability associated with group membership.

A second ordered Probit was conducted using the six independent variables whose products carried an absolute value greater than .60. As with the first ordered Probit, variables were entered into the identified model and LIMDEP calculated coefficients and significance levels for each of the six as well as a constant term (ONE). These coefficients were then multiplied by the mean values of each of the six variables resulting in new products for this model (See Table 40). The results of this analysis indicated that, for this new model, the percentage of relevant economic statements used (RELPER) carried the largest

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>Mean of X</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE (CONSTANT)</td>
<td>-2.3077</td>
<td>1.000</td>
<td>-2.3077</td>
</tr>
<tr>
<td></td>
<td>(.0119)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATE</td>
<td>.0646</td>
<td>13.512</td>
<td>.0733</td>
</tr>
<tr>
<td></td>
<td>(.0013)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RELPER</td>
<td>3.4636</td>
<td>.0260</td>
<td>2.6609</td>
</tr>
<tr>
<td></td>
<td>(.0080)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODELS</td>
<td>.1651</td>
<td>3.5833</td>
<td>.5916</td>
</tr>
<tr>
<td></td>
<td>(.0058)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONCEPTS</td>
<td>-.0376</td>
<td>15.0210</td>
<td>-.5949</td>
</tr>
<tr>
<td></td>
<td>(.0607)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONMAPS</td>
<td>.3136</td>
<td>2.9280</td>
<td>.9182</td>
</tr>
<tr>
<td></td>
<td>(.0013)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FITGPS</td>
<td>.6394</td>
<td>1.5952</td>
<td>1.0191</td>
</tr>
<tr>
<td></td>
<td>(.0024)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at .05 **significant at .01
product. In fact, RELPER had a product that was nearly three times that of the PITTGPS, the next highest variable product. These results suggested that, with respect to developing a scaling model that may predict level of expertise based on analysis of transcripted responses for several variables, the variable RELPER held the greatest predictive potential. The researcher was extremely cautious not to imply that by cataloguing this single variable, an accurate depiction of the level of expertise in economic problem solving can be achieved. However, within the framework of this one model, RELPER held significant potential.

In fact, when the chi-square tests on both models were compared, the association between predicted categorical outcomes and actual outcomes was just as strong in the second, more parsimonious model as in the first ($X^2(6) = 146.49; X^2(13) = 173.57$). Table 41 reports the frequencies of actual outcome

<table>
<thead>
<tr>
<th>Table 41</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequencies of Actual vs. Predicted Categorical Membership</strong></td>
</tr>
<tr>
<td>(Model 2: 6 IV's)</td>
</tr>
<tr>
<td><strong>Predicted</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Actual</strong></td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

**Chi-square (6) = 146.49**
versus predicted outcome for the second model. As with Model 1 (all thirteen independent variables) these results indicate a high degree of correspondence between actual and predicted membership. For Model 2 (six independent variables) the calculated coefficient of contingency statistic was .80 (compared to .82 for Model 1). Recall that this is still quite high.

Finally, in an effort to determine whether the presence of certain indicators of relative expertise in economic problem solving was more integral for membership in one category of expertise than for others, the researcher conducted a third ordered Probit analysis. This analysis consisted of running data from Groups 2-5 (DATA2345) and all data from Groups 3-6 (DATA3456). The underlying premise for this analysis was that by comparing results across these cross-sections of the data, some pattern with respect to the importance of each of the variables for determining group membership within each truncated data set might emerge. In addition, data for the entire set (DATASET) was ranked for further comparison.

The researcher used the output from the LIMDEP program to calculate products for each of the variables in each of the four cross-sections of the data. The absolute value of these products were then converted into standardized ranks using the RANK command in the statistical package SPSS. The results of these analyses are presented at Table 42.

The data suggested two conclusions. First, it was obvious that, for this small sample of economic problem solvers, each variable carried a different product (both in absolute value and in standardized rankings) in each of the four cross-sections. For example, the absolute value of CAUSERP was ranked thirteenth (out of thirteen) for DATA0123, tied for eleventh (SPSS averaged
these ties, thus actually 11.5) for DATA1234, eighth for DATA2345 and fourth for DATA3456. For the DATASET, CAUSERP was ranked seventh.

Table 42

Standardized Ranking of Products for Disaggregated Data Versus Entire Dataset

<table>
<thead>
<tr>
<th>Variable</th>
<th>DATA0123 Product Rank</th>
<th>DATA1234 Product Rank</th>
<th>DATA2345 Product Rank</th>
<th>DATA3456 Product Rank</th>
<th>DATASET Product Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>MODELS</td>
<td>11</td>
<td>9</td>
<td>6.5</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>CONCEPTS</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CONNMAPS</td>
<td>6</td>
<td>10</td>
<td>12.5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>RELSER</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>CAUSERP</td>
<td>13</td>
<td>11.5</td>
<td>8</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>PROSERP</td>
<td>12</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>PROPERP</td>
<td>8</td>
<td>13</td>
<td>12.5</td>
<td>11</td>
<td>9.5</td>
</tr>
<tr>
<td>FITTED</td>
<td>10</td>
<td>6</td>
<td>6.5</td>
<td>0</td>
<td>11.5</td>
</tr>
<tr>
<td>FITTOPS</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>FITTPRED</td>
<td>1</td>
<td>5</td>
<td>11</td>
<td>6.5</td>
<td>11.5</td>
</tr>
<tr>
<td>FITTPAT</td>
<td>3</td>
<td>7</td>
<td>9</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>FITTEVAL</td>
<td>9</td>
<td>11.5</td>
<td>5</td>
<td>11</td>
<td>9.5</td>
</tr>
</tbody>
</table>

A second, less obvious, conclusion concerned the relationship of the rankings. That is, were the rankings of the variables related; did a pattern emerge? In order to determine this relationship, the researcher conducted a Spearman rank order correlation analysis on the standardized rankings of the absolute values of the products across all four cross-sections and the entire data set. The results of this analysis are reported at Table 43. These results suggested that the relationship between rankings, for the cross-sections and the data as a whole, was relatively weak with several notable exceptions.

Indeed, most of the correlation coefficients indicated a low, positive relationship. Only three relationships were greater than .35: DATA0123 with DATASET (.3627, p = .223); DATA1234 with DATA3456 (.3559, p = .223) and
Table 43

Spearman Rank Order Correlation Coefficients: Disaggregated Data by Dataset

<table>
<thead>
<tr>
<th></th>
<th>DATA0123</th>
<th>DATA1234</th>
<th>DATA2345</th>
<th>DATA3456</th>
<th>DATASET</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA0123</td>
<td>1.000</td>
<td>.3293</td>
<td>.0082</td>
<td>.1192</td>
<td>.3627</td>
</tr>
<tr>
<td>(p=.000)</td>
<td>(p=.272)</td>
<td>(p=.979)</td>
<td>(p=.698)</td>
<td>(p=.223)</td>
<td></td>
</tr>
<tr>
<td>DATA1234</td>
<td>--------</td>
<td>1.000</td>
<td>.3559</td>
<td>.0845</td>
<td>.1917</td>
</tr>
<tr>
<td>(p=.000)</td>
<td>(p=.223)</td>
<td>(p=.784)</td>
<td>(p=.530)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA2345</td>
<td>--------</td>
<td>--------</td>
<td>1.000</td>
<td>.0845</td>
<td>.3149</td>
</tr>
<tr>
<td>(p=.000)</td>
<td>(p=.784)</td>
<td>(p=.295)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA3456</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>1.000</td>
<td>.5914</td>
</tr>
<tr>
<td>(p=.000)</td>
<td>(p=.033)</td>
<td>(p=.033)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATASET</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>1.000</td>
</tr>
<tr>
<td>(p=.000)</td>
<td>(p=.000)</td>
<td>(p=.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DATA 3456 with DATASET (.5914, p = .033). Of these relationships, only the last was significant at the .05 level.

Thus, these results seemed to indicate that particular variables played a more important role in determining group membership for certain cross-sections than for others. The implication of these results was that for the 'lower' novices (DATA0123), some variables carried more predictive power with respect to category membership than other variables. Indeed, the results of this analysis for the products associated with the variable RELPER (following the model noted above) indicate that for the first three cross-sections (DATA0123, DATA1234 and DATA2345), the mean ranking was two (out of thirteen). Therefore, this analysis added further support to the results reported earlier regarding the plausibility of using RELPER in a parsimonious scaling model.

As represented in Table 42, the size of the products generated by the ordered Probit analysis for the variables RELPER and CONCEPTS ranked first
and second respectively among the thirteen relevant indicators. Therefore, identifying these two variables for use in a pared-down analysis seemed reasonable. Indeed, the use of these two variables meets the two underlying criteria for the EESPM. First, the coding of these variables is relatively straightforward. Most high school economics teachers should be able to recognize the use of economic concepts and irrelevant statements within the context of a transcribed response. Second, scores on these two variables can be calculated quite easily. Thus, using these two variables seemed plausible as the basis for developing the EEPSM.

In an effort to ascertain the viability of such a parsimonious version of the EEPSM for scaling respondents relative expertise in economic problem solving, the researcher compared the mean standardized ranking data for the 13 variables with the mean standardized ranking data using just RELPER and CONCEPTS. Obviously, one underlying assumption of such a comparison was that the use of the mean standardized ranking data was an appropriate proxy for scaling relative expertise in economic problem solving. In the researchers' opinion, enough evidence has been put forth to make this a cogent argument (See, for example, pp. 113-119 of this report).

The results of this comparison are presented at both Figure 15 and Table 44. Figure 15 suggested that the pattern of mean rankings created when all thirteen relevant indicators were analyzed (See pp. 116 of this report) was closely approximated by the mean rank analysis done using only RELPER and CONCEPTS. This level of correspondence was confirmed by the correlation analysis presented in Table 44.
Again, the data, and these results, should be carefully considered as the correlation analysis was carried out using only the limited data set generated by the RANK command in SPSS. In spite of this issue, it was obvious that the two sets of ranked results were quite closely related. Indeed, it was evident from the results of the correlation analysis reported in Table 44 that these separate results are highly correlated.
The results of the analysis on these data seemed to provide support for the potential of the EEPSM as a parsimonious model for scaling relative expertise in economic problem solving. Indeed, while one must remain fully cognizant of the assumptions and limitations of this analysis, the results seemed to suggest that gathering data on the number of economically relevant state-

Table 44

Correlation Coefficient: Mean of the Mean Standardized Rankings of All Thirteen Variables with Mean of the Mean Standardized Rankings for the Variables RELPER and CONCEPTS.

<table>
<thead>
<tr>
<th>EEPSM (RELPER, CONCEPTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPSM</td>
</tr>
<tr>
<td>(.9050** (13 Vars.)</td>
</tr>
</tbody>
</table>

** - Signif. LE .01 (2-tailed)

ments made, and the number of economic concepts used, by respondents could yield powerful insight into the level of economic expertise demonstrated by students.

Expert Panel Ratings

As noted in Chapter 3, the final data collection and analysis for the current study involved identifying a panel of experts in either economics, economic education or both and having these expert jurors read and rate a random sample of respondent transcripts. Recall that the expert jurors rated respondent's protocols on seven criteria. These included: (1) use of economic concepts, (2) use of concept networks, (3) use of problem representation
statements, (4) use of propositional statements (5) use of causal statements, (6) use of economic models and, (7) overall economic knowledge.

The jurors responded using a Likert-type scoring sheet that ranged from 1 (NOVICE) to 10 (EXPERT). Jurors rated each respondent protocol on each of the criteria according to how the jurors felt respondents fell between the two extreme categories of "novice" and "expert." This rating system produced a categorical score 0 to 70, as there were a total of seven rating categories. Finally, jurors were instructed to assign an overall expertise in economic problem solving rating. This expertise rating was a function of both the respondent's score on the seven criteria noted above, and the juror's overall reaction to the respondent's protocol. Thus, this overall economic expertise rating score fell between 0 and 100.

The transcripts were randomly divided amongst the expert panel in such a manner that two experts rated each transcript. These individual expert ratings were also analyzed in an effort to determine the level of correspondence between expert raters across each of the three problems. This analysis consisted of a correlation analysis comparing the expert rating's across each problem. That is, each of the twenty-eight transcripts (three problems in each) was rated by two experts, and these ratings were compared across each of the three problems. The results (Table 45) indicated an extremely strong, positive relationship between the ratings across each of the problems (correlation coefficients ranged from .8851 to .9581; p<.01). These results also suggested that not only was there a high degree of correspondence between raters of the same transcript, but there was also a high degree of correspondence in ratings across the entire expert panel.
### Table 45

**Correlation Coefficients: Expert 1 Panel Ratings by Problem with Expert 2 Panel Ratings by Problem**

<table>
<thead>
<tr>
<th>Prob.1 Expert1</th>
<th>Prob.2 Expert2</th>
<th>Prob.3 Expert2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob.1 Expert1</td>
<td>.9108**</td>
<td></td>
</tr>
<tr>
<td>Prob.2 Expert1</td>
<td>.9536**</td>
<td>.9065**</td>
</tr>
<tr>
<td>Prob.3 Expert1</td>
<td>.8851**</td>
<td>.8892**</td>
</tr>
</tbody>
</table>

* - Signif. LE .05  ** - Signif. LE .01  (2-tailed)

### Table 46

**Correlation Coefficients: Mean Expert Ratings by Problem with Level of Participant (PARTLEV)**

<table>
<thead>
<tr>
<th>PARTLEV</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MUPR1.OV</td>
<td>.9394**</td>
</tr>
<tr>
<td>MUPR2.OV</td>
<td>.9262**</td>
</tr>
<tr>
<td>MUPR3.OV</td>
<td>.9452**</td>
</tr>
</tbody>
</table>

* - Signif. LE .05  ** - Signif. LE .01  (2-tailed)

### Table 47

**Mean Expert Ratings by Level of Participant (PARTLEV)**

<table>
<thead>
<tr>
<th>PARTLEV</th>
<th>Mean Expert Rating</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.7500</td>
<td>5.4760</td>
</tr>
<tr>
<td>2</td>
<td>10.0400</td>
<td>3.5068</td>
</tr>
<tr>
<td>3</td>
<td>25.5416</td>
<td>9.7909</td>
</tr>
<tr>
<td>4</td>
<td>51.7750</td>
<td>17.0857</td>
</tr>
<tr>
<td>5</td>
<td>84.1330</td>
<td>7.3272</td>
</tr>
<tr>
<td>6</td>
<td>86.7083</td>
<td>6.4223</td>
</tr>
<tr>
<td>7</td>
<td>90.0416</td>
<td>5.2871</td>
</tr>
</tbody>
</table>
Because of this very high degree of correspondence between raters, the researcher decided to collapse the overall rating scores into one category—mean overall ratings. These mean expert ratings were then used in a correlation analysis to determine if a relationship existed between level of economic education and experience (PARTLEV) and overall expertise in economic problem solving (as indicated by MUPR1, MUPR2 and MUPR3; the mean rating scores for each of the three problems). The results of this analysis (Table 46)
indicated an extremely strong positive relationship between the mean ratings--
across all three problems--and the level of economic education of the
participants (PARTLEV). These results implied that, as has been noted
throughout this report, the level of economic education and experience of
participants corresponded well--but not perfectly--with level of expertise in
economic problem solving as indicated by expert panel ratings.

After a one-way ANOVA revealed no significant differences among the
mean exert ratings across the three problems, the data were further collapsed
into a single mean rating score. These data are presented in Table 47 and a
graphical comparison is presented in Figure 16. These results confirmed the
earlier analysis concerning the presence of diminishing returns to certain levels
of economic education and experience; at least as far as problem solving was
concerned. In addition, the mean expert ratings maintained the order of
participant categories--from novice to expert.

It was the original intent of the researcher to conduct a series of multiple
regression analyses using the expert panel rating data as the dependent
variable. However, it was obvious from the analyses conducted thus far that the
thirteen independent variables (the relevant indicators of expertise) showed a
very high degree of intercorrelation. This further implied that these relevant
indicators demonstrated a high level of multicollinearity and, therefore, were
unlikely to provide any independent explanation for the variance found in the
expert ratings. Borg and Gall (1989) suggested that collinearity was the "overlap
between two predictor variables, that is, the extent to which they intercorrelate
with each other" (p. 606). Borg and Gall went on to note that "if there is a high
degree of collinearity between predictor variables, only some will enter the
regression as predictors, even though all of them may predict the criterion variable to an extent" (p. 606).

Evidence of this intercorrelation among the thirteen independent variables was found during the exploratory factor analysis. Indeed, the correlation matrix constructed prior to the factor analysis procedure indicated that all thirteen variables were intercorrelated to some extent (See Appendix G). Further proof of this was found in the confirmatory factor analysis. The fact that all thirteen variables load appreciably onto two factors confirms this high degree of collinearity.

In addition, it was not clear that the variable expertise in economic problem solving was either a continuous variable or a linear one. Evidence presented in the course of this current study indicated that the variable was not at all linear, and strong support was presented for the supposition that the variable exhibited dis-continuous characteristics.

In fact, however, several attempts were made to construct a useful regression equation. The researcher believed that perhaps by using only the six variables identified in the second ordered Probit analysis, some analytical ground might have been purchase relative to the predictive capability of such a regression model. This attempt proved fruitless. Due in part to the issues noted above, and in part to the equation construction techniques in the program SPSS, several equations were developed that generated results that were highly counter-intuitive. For example, one result suggested that the Pitt Problem Solving variable PITTFEED was the most powerful predictor of expert ratings (adjusted R= .6843)—a highly unlikely result given the analysis conducted to this point.
Chapter V

Summary, Interpretation and Recommendations for Further Research

Introduction

The primary purpose of this study was to investigate the nature and constructs of relative expertise in economic problem solving. This study identified thirteen relevant indicators of expertise in economic problem solving and examined the mean level of these indicators across seven sub-sample levels of expected expertise in economic problem solving (PARTLEV). The percent change of these thirteen variables across PARTLEV was also analyzed. These data were re-coded into standardized mean rankings and analyzed to determine if patterns regarding the acquisition of expertise were present. Factor analysis techniques were applied to the data in an effort to determine the role and relationship of both economic knowledge and economic problem solving processes in the acquisition of expertise in economic problem solving. The study employed an ordered Probit analysis to developed a model for scaling transcribed responses to economic problems: the Expertise in Economic Problem Solving Scaling Model (EEPSSM). This study used an expert jury's ratings of the transcribed responses to help determine the validity of the relevant indicators in measuring expertise in economic problem solving and to help determine the relationship between economic education and expertise in economic problem solving.
Four research questions were presented in Chapter I. The summary portion of this chapter presents the findings of the current study relative to each of these questions. The next section attempts to explain and interpret the results of the study in light of the assumptions and problems presented in Chapter I. Finally, the recommendation portion of this chapter outlines some specific suggestions for further research in this area.

Summary of the Results of the Study

Chapter I presented the following research questions:

(1.) Based upon a sample of economic problem solvers and various relevant indicators, what are the nature and constructs of relative expertise in economic problem solving?

(2.) What is a viable method for developing the Expertise in Economic Problem Solving Scaling Model (EEPSSM)?

(3.) Is EEPSSM an operational, parsimonious and theoretically valid scaling model?

(4.) Based on the investigation into the first three research questions, and upon the results of expert panel ratings of participant transcripts, what is the impact of various levels of economic education on relative expertise in economic problem solving?

The results of the current study provided at least partial answers to each of the four questions undertaken at the outset of the study. These answers are based, in part, upon the assumptions and limitations of the study as outlined in Chapter I. In addition, many other questions were raised by the current study. These will be dealt with in the recommendation for further research portion of this chapter.

The Nature and Constructs of Relative Expertise

With respect to research question number one, a comparison of the summary statistics reported in Chapter IV and subsequent correlation analysis
confirmed the existence of a very strong, positive relationship (correlation coefficients ranged from .3863 to .8082, p< .01; with most falling above .71) between the mean levels of each of the thirteen variables and level of expected expertise as indicated by the economic education level of participants (PARTLEV). Thus, for this group of economic problem solvers, the demonstrated mean levels of the variables in question were closely related to PARTLEV.

A series of one-way analyses of variance (ANOVA) indicated differences among the mean levels of the first eight variables (STATE, RELPER, CONCEPTS, CONMAPS, PROBERP, PROPERP, CAUSERP and MODELS) across level of expected expertise (PARTLEV). While not all of these differences proved statistically significant, several important results should be noted. Among these was the identification of only marginal differences in the observed levels of all eight of these variables for the high school economics students over those who had not taken high school economics. The same pattern was present with respect to undergraduate majors over undergraduate non-majors. Finally, the Ph.D. economist groups differed significantly from all groups except the graduate students. Significant differences also existed between graduate students and the undergraduate economics majors.

Using the same one-way ANOVA, the five Pitt Problem Solving Coding System (PPSCS) variables were analyzed for differences across level of expected expertise in problem solving as indicated by level of economic education (PARTLEV). This ANOVA led to the identification of a pattern in the observed level of PPSCS variables across the levels of expected expertise. Indeed, this pattern involved a "leap"--or significant increase demonstrated in use of Pitt variables over previous groups--of qualitatively different proportions. That is,
at some categorical level of expected economic expertise—in most cases between
the undergraduate non-major and undergraduate economics major categories or
between the undergraduate economics major and graduate student in
economics categories—participants demonstrated a substantially greater usage
of the Pitt Problem Solving attributes than had groups with less expected
economic expertise. As noted in Chapter IV, the results here were intriguing
because they seemed to confirm the discontinuous continuum of expertise
acquisition proposed in Chapter I. Indeed, it was apparent that, for this group
of economic problem solvers, the path to expertise was not a continuum with
equi-distant categories along it.

The data were transformed by the SPSS program into standardized rank
data, ranking all responses (1 to 84) across all variables. Given that the data
were standardized across variables, it was possible to compare mean rankings
across all the variables. The results of this analysis lent further support to the
pattern noted above. Thus, both the strong relationship between level of
economic education and the demonstrated level of all variables and the
discontinuous continuum pattern were confirmed by the standardized rank
analysis.

This last point cannot be overstated. Indeed, the results of these analyses
were most important in that they refuted the supposition that the path to, or the
acquisition of, expertise in economic problem solving was a continuum with
equi-distant points along it. These results also suggested that, as far as the
underlying variable expertise in economic problem solving was concerned,
greater gains might be found at different points along the path to expertise. Put
another way, it may be the case that the allocation of resources toward
duplicating the experiences associated with one category of expertise might
bring similar, and more observable, benefits to other, less expert, categories. This finding holds significant potential for re-thinking economic education at the pre-collegiate, and collegiate, level.

The analysis of the standardized rank data implied that the participants might be grouped into three closely associated clusters. Indeed, a subsequent hierarchical cluster analysis confirmed that three clusters could be created around: (1) the two high school student groups, (2) the two undergraduate groups and (3) the graduate students and both Ph.D. groups. These findings confirmed the existence of a "leap" in expertise at some level of economic education and expertise. More importantly, these results called into question the effectiveness of economic education at the pre-collegiate, or undergraduate levels relative to demonstrated expertise in economic problem solving.

The results of an analysis of the percentage change associated with each of the thirteen variables, across level of expertise, also supported this supposition. In fact, the results of this analysis indicated that, for certain categories, there existed something akin to diminishing returns to economic education or experience. For other categories, something akin to increasing returns existed. Thus, further examination of these results implied that resources might be more efficiently and effectively allocated at particular points along the continuum. Moreover, these results also served to refute the supposition that the path to expertise was a smooth continuum.

An exploratory factor analysis indicated that the thirteen variables under investigation might be described in terms of two underlying hypothetical variables. Based on the minimum Eigenvalue requirement of the analysis (Eigenvalue > 1), two underlying variables were identified. An analysis of the factor correlation matrix produced by the exploratory factor analysis revealed
the two factors to be highly intercorrelated. Thus, a second, confirmatory factor analysis was conducted using an oblique rotation to separate out the two factor loadings. The results of this analysis indicated that five variables loaded appreciably onto the first factor and that the remaining eight loaded appreciably onto the second factor.

Given the nature of the variables that loaded onto each of the factors, the two factors were named Economic Knowledge and Economic Problem Solving Processes. The presence of both of these factors indicated, as noted in Chapter I and II, the importance of both knowledge and process in the acquisition of expertise. This supposition was further supported by the results of a comparison of the aggregated mean standardized ranks of Factor 1 variables versus those of Factor 2. The results suggested that both the knowledge and process components played a key role in indicating expertise in economic problem solving. However, the relationship between economic knowledge and economic problem solving processes was not the same across all levels of participants. Again, this supports the proposition that at some levels of expertise, economic knowledge is paramount in determining expertise in economic problem solving while at other levels of expertise, the reverse is true.

Finally, this comparison of Factor 1 and Factor 2 mean rankings yielded further support for the discontinuous continuum supposition. For example, it was possible to interpolate a jump of nearly twenty points in the mean standardized rankings associated with the move from undergraduate economics students to graduate students in economics. Intuitively, this jump should be approximately twelve points and thus these results provide further evidence for a 'leap' in expertise of qualitatively different proportions.
Analysis Related to the Development of the EEPSSM

As noted in Chapters II and III, the current study employed an ordered Probit technique in the development of the Expertise in Economic Problem Solving Scaling Model (EEPSSM). The decision to employ such a technique was based upon the theoretical underpinnings of scale theory and a knowledge of the output of ordered Probit analysis.

The results of the application of the order Probit analysis indicated that it was possible to develop a model that closely predicted categorical membership based on analysis of the thirteen relevant indicators of expertise. This model demonstrated a coefficient of contingency of .82 and the probability distributions associated with categorical membership produced by the model closely followed the patterns established within earlier analysis. In fact, subsequent analysis of the six variables with the highest ordered Probit products (coefficients multiplied by mean level of the variable) indicated that changes in the mean level of each variable resulted in corresponding changes in the probability distribution associated with categorical membership and calculated for a variable.

The data were disaggregated into smaller clusters: groups 1-3 (DATA012), groups 2-4 (DATA123), groups 3-5 (DATA234), groups 4-6 (DATA345) and groups 5-7 (DATA456). Ordered Probit analysis was conducted on each of these disaggregated clusters in order to determine whether some pattern within each truncated data set might emerge. The products associated with these truncated data sets were calculated and then ranked across each data set. In addition, data for the entire set (DATASET) was ranked for further comparison.
The results of these analyses indicated that, in fact, for this small sample of economic problem solvers, each variable carried a different product (both in absolute value and in standardized rankings) in each of the four cross-sections. A Spearman rank order correlation analysis was conducted on the standardized rankings of the absolute values of the products across all four cross-sections and the entire data set. Only three relationships were greater than .35: DATA0123 with DATASET (.3627, p = .223); DATA1234 with DATA3456 (.3559, p = .223) and DATA 3456 with DATASET (.5914, p = .033). Of these relationships, only the last was significant at the .05 level. These results suggested that particular variables played a more important role in determining group membership for certain cross-sections than for others.

Given these findings, the researcher attempted to develop a parsimonious EEPSSM using just two of the thirteen variables: CONCEPTS and RELPER. These variables were chosen due to the fact that their products were ranked either first or second across the truncated data sets and the entire data set. An ordered Probit was conducted using this parsimonious model. The results of this comparison suggested that the pattern of mean rankings created when all thirteen relevant indicators were analyzed was closely approximated by the mean rank analysis done using only RELPER and CONCEPTS. These results suggested that the EEPSSM closely modeled the original ordered Probit model's ability to predict categorical membership and thus designate a respondent's level of expertise relative to the sample of economic problem solvers in this study.

**Education and the Acquisition of Expertise in Economic Problem Solving**

*Expert Panel Ratings.* A panel of experts in economics or economic education rated respondents' transcripts for overall expertise in economic
problem solving. The results of the analyses on these ratings indicated that the expert ratings demonstrated a strong positive relationship across each of the three problems. The results also suggested a high degree of correspondence between raters.

After a one-way ANOVA revealed no significant difference among raters and across problems, the data were collapsed into a single mean expert rating variable. Analysis of the mean expert ratings suggested that the discontinuity demonstrated earlier was continued here. In addition, the results also indicated the presence of the increasing/decreasing returns phenomenon noted in previous discussion. Finally, the expert panel ratings confirmed the importance of the role of economic education and experience in the acquisition of expertise. However, the results also indicated that education and experience seemed to be a rather 'lumpy' input. That is, the apparent returns to education and experience were not consistent across the sample and seemed to vary across participant level.

In some sense, questions concerning the role of economic education in the acquisition of expertise in economic problem solving have already been dealt with during the investigation of the first three research questions. In fact, much of the analysis that has been reported here has been based upon the assumption that, to some degree, expertise and education and experience are inextricably linked. However, it was possible to summarize several points explicitly related to this question based upon the results of the previous analysis.

1. Those participants with greater levels of economic education and experience were more likely to demonstrate higher mean levels of all relevant indicators of expertise, including both knowledge and process factors, although these levels vary across the sample.
2. Certain levels of economic education and experience seemed to have only a marginal impact on the level of expertise in economic problem solving. For example, across many of the thirteen variables, high school students who had taken high school economics demonstrated only slight gains over students who had not taken high school economics. In many cases, the same pattern held for the undergraduate majors and non-majors.

3. Economic education corresponded well with the expert panel ratings of expertise. That is, those participants with higher levels of education generally received higher expert ratings, although this was not always the case.

**Interpretations**

The purpose of this section is to examine the findings of the current study in light of the assumptions and limitations outlined in Chapter I. As the researcher was aware of no study that investigated either relative expertise in any domain, nor of any study that focused on the expert novice paradigm in economics, these interpretations will be made within the context of the appropriate expert novice research in cognitive psychology. This section will focus upon: (1) expert novice differences, (2) the acquisition and nature of relative expertise, (3) the role of economic knowledge and economic problem solving processes in acquiring expertise and (4) the relationship between economic education and expertise in economic problem solving.

**Expert/Novice Differences**

Chapter II presented a thorough treatment of the relevant research in the expert/novice paradigm in cognitive psychology. From an examination of the key studies in this area (e.g., Chi, Glaser and Rees, 1982; Lesgold, 1984; Voss, et al., 1984, 1989, etc.), the researcher was able to distill a list of attributes that experts in a domain possess that novices do not. This list was used in the
development of the relevant indicators of expertise in economic problem solving used in the current study.

In addition, almost all of the relevant studies cited in Chapter II noted that experts approach and solve problems in qualitatively different ways than do novices. Among these differences were: experts spend more time in problem representation (Simon and Simon, 1978), experts possess more domain specific knowledge (Voss, et al., 1989), experts possess more procedural knowledge (VanSickle, 1992), experts possess specialized schema for problem solving within a domain (Lesgold, 1981), experts call on more conceptual knowledge (VanSickle and Hoge, 1991) and experts employ more models in the solution of problems (Glaser and Chi, 1988).

As noted in Chapter IV, the experts in this study (for purposes of this discussion the two Ph.D. sub-groups) routinely used significantly more problem representation statements than did the novices (the two high school sub-groups). In fact, the expert groups used problem representation statements an average of 20.5 percent and 23 percent of the time respectively compared to the novice groups who used problem representation statements only an average of 4.8 percent and .67 percent respectively.

The experts demonstrated overwhelmingly greater domain specific knowledge—seen in the variables STATE, CONCEPTS AND RELPER—than did the novices. For example, the experts used an average of 27.08 and 24.67 relevant statements respectively while responding to the economic problems. In contrast, the novices used an average of 3.42 and 5.67 statements.

The experts used significantly more problem solving statements, as measured by the Pitt Problem Solving (PPSCS) variables, than did the novices. Indeed, the experts used, on the average, more than three PPSCS variable
statements per response while the novices used an average of less than one PPSCS variable statement per response.

For purposes of the current study, the variable concept maps (CONMAPS) was used as a proxy for specialized schema. The results of the study indicated that the experts consistently invoked significantly greater numbers of CONMAPS than did the novices. On the average, the experts invoked more than seven CONMAPS per response. The novices averaged less than one.

Perhaps the most striking differentiation between the expert groups and the novice groups in the current study was found in the conceptual depth of various responses. The experts used an average of 37.83 and 30.33 concepts respectively in the course of a response. In stark contrast, the two novice groups used an average of 2.08 and 3.167 concepts respectively.

Finally, as suggested by previous studies in cognitive psychology, the expert economic problem solvers in the current study demonstrated a much greater use of economic models than did the novice problem solvers. The two Ph.D. economist groups invoked, on average, approximately eight economic models per response. The high school students, on the other hand, invoked an average of less than one economic model per response.

Interpreting the previous section is relatively straightforward. Indeed, the results of current study seem to reproduce the findings of many of the key studies discussed in Chapter II: that experts differ significantly from novices in domain-related problem solving. What the current study offers that these previous studies do not, however, is an analysis of problem solving within the domain of economics. As these results suggest, the expert/novice distinction is evident within this domain as well.
The Acquisition and Nature of Relative Expertise

With the exception of reproducing the findings of previous research on differences between the extreme categories of expert and novice problem solvers, the previous section offered little interpretation of the current study's findings regarding the acquisition of relative expertise in economic problem solving. As noted in Chapter II, little study has been undertaken to investigate the acquisition of expertise in any sense: relative or otherwise. Recall that Chi and Glaser (1980) called for knowing more "about the changes from novice to expert performance" in order to focus on "more efficient educational strategies that will perhaps take the novice through a different succession of stages...and bring about the higher levels of achievement" (p. 38). Given the relative dearth of work that has been done in this area, this section will highlight the findings of the current study with respect to categories of expertise that fall between the extreme categories of novice and expert.

The results of several analyses in the current study suggested that the acquisition of expertise, for this sample of problem solvers, was not a smooth, continuum with equi-distant categories along it. In fact, an analysis of the summary statistics presented for each of the thirteen relevant indicators of expertise implied that a 'leap' in economic problem solving expertise was occurring at some point between the designations expert and novice. This 'leap' was indicated by a significant increase in the usage of relevant indicators by one categorical sub-group (PARTLEV) over another. For example, such a leap was manifest in the undergraduate economic majors (UND ECON) across three of the PPSCS variables: PITTEVAL, PITTFEED and PITTPAT. Thus, the UND ECON sub-group demonstrated a significant increase in the usage of these
PPSCS variables over the counterpart sub-group: undergraduates who had not taken economics. A similar phenomenon was noted, across other variables, for the graduate students (GRAD) over the UND ECON.

A second finding concerning the acquisition of expertise—or rather relative expertise—involved the standardized rank data. Recall that all responses were ranked by SPSS (1-84) across each of the thirteen variables. The results of these rankings suggested that respondents fell into three groupings. A hierarchical cluster analysis was conducted and the results suggested that the participants could indeed be grouped into three clusters: (1) the high school students, (2) the undergraduates and (3) the graduate students and the Ph.D. groups.

These findings seem to indicate the presence of three, somewhat distinct groups relative to expertise in economic problem solving. Evidence indicated that—as one might expect—the high school students groups represented the novice group and that the grad students and Ph.D.'s represented the expert group. However, unlike previous analysis in this area, the results of this study indicated the presence of a third grouping: the two undergraduate sub-groups.

Analysis across all thirteen variables—using the mean standardized ranking data—indicated that on some variables (e.g., CONMAPS, PROPERP, etc.), this third group more closely resembled the novice group; on other variables, this group resembled the expert group (e.g., CONCEPTS, STATE, etc.). Indeed, it was obvious from the analyses undertaken that this group demonstrated significantly greater usage of the relevant indicators than did the novice sub-group, but demonstrated less of the relevant indicators than did the expert sub-groups. This seemed to indicate the presence of a third category of expertise: relative expertise.
Finally, analysis associated with the design and development of the EEPSSM supported the supposition that, not only was there an additional categorical distinction other than the extremes of expert and novice present within this sample of problem solvers, but that it was also possible to scale these categories along some overarching variable of interest. The results of an ordered Probit analyses indicated that a variety of factors were integral in determining membership in these intermediary categories and that various combinations of these factors resulted in distinct levels of expertise.

Two important, but related, results of the current study should be noted. First, the study refuted the supposition that, for this sample of problem solvers, the acquisition of expertise was a continuum with equi-distant categories along it. These results seem important in that they suggest that one may be able, through various forms of economic education and experience, to move beyond one's immediate category of expertise. Put another way, it may be possible to facilitate movement to certain categories of expertise without having to go through preceding categories—without having to have all of one's tickets punched, to invoke a colloquialism. Indeed, if the types of education and experience that facilitate the acquisition of these expert traits can be identified, the pre-collegiate economics curriculum could be re-focused accordingly.

The second important result lies in the presence of the 'leap' in expertise in problem solving that occurred at some point during the acquisition process. This is indeed exciting as these findings imply that some combination of factors, the relevant indicators of expertise, is present when the 'leap' occurs. Again, if this bundle of factors, and their associated levels can be identified, then perhaps it will be possible to facilitate this 'leap' in pre-collegiate economic education. That is, with the correct combination of educational experiences, perhaps we can
make high school students look more like experts in economic problem solving than high school students.

**The Role of Knowledge and Problem Solving Processes**

From the earliest studies into expert novice differentiation, it was evident that domain-specific knowledge was essential for acquiring expertise (deGroot, 1966; Newell and Simon, 1972). VanSickle (1992) stressed the importance of declarative—or discipline-based—knowledge as "a valuable resource for solving economic problems" (p. 58).

However, as Simon and Simon (1978) and Chi, et al. (1982) found, more than superior content knowledge alone was present in expert problem solvers. Voss (1989) noted the importance of procedural knowledge—a knowledge of 'how to'—in acquiring expertise. In fact, the majority of the studies reviewed for this report have, to some degree, noted the role of both domain-specific knowledge and problem solving processes in differentiating experts from novices.

The current study undertook an exploratory factor analysis to determine whether the thirteen variables under study might be better described in terms of a smaller number of underlying hypothetical variables. The results of this exploratory factor analysis—and a subsequent confirmatory factor analysis—indicated the presence of two underlying factors. The first factor was defined as Economic Knowledge as four of the five variables that loaded appreciably (> .90) were treated as indicators of economic knowledge in the current study.

The second factor was defined as Economic Problem Solving Processes. Seven of the eight variables that loaded appreciably (> .75) onto this factor were identified specifically for the purpose of analyzing cognitive processing (Miller
and VanFossen, 1994) and/or problem solving (Pitt, 1983). Thus, these variables corresponded with key problem solving processes identified as essential for acquiring expertise (Lesgold, 1981; Pitt, 1983; Chi and Glaser, 1983).

In an effort to better identify the relationship between the Economic Knowledge factor and the Economic Problem Solving Processes factor, the mean standardized rankings of the eight Economic Knowledge variables were compared to the mean standardized rankings of the five Economic Process variables. As these rank means were standardized it was possible to calculate a mean of the means for each factor.

The results of this comparison indicated that for the first two sub-groups in this sample (HSECON, HS NON-ECON), the relative ranking of the economic process component variables were substantially higher, in the aggregate, than the economic knowledge component variables. This pattern continued, albeit on at a somewhat diminished level for the next three sub-groups (UND NON-ECON, UNDECON, and GRAD). However, the pattern was reversed for the final two sub-groups (PHD-FIELD and PHD-OSU).

These results indicated two important conclusions. First, the analysis served to confirm the findings of the previously noted studies. It was quite evident that both economic knowledge and economic problem solving procedures were being used by the problem solvers in this sample. The high degree of intercorrelation found in the factor analysis was also powerful evidence for this conclusion.

The second conclusion concerned the relative importance of one or the other of the two factors across the seven sub-group levels (PARTLEV). It was apparent that, at least for novices—and perhaps for relative experts as well—the combination of both economic knowledge and economic problem solving
procedures was important in determining categorical membership. This relationship seemed to be less important for the Ph.D. sub-groups. This may be related to the diminishing returns phenomenon outlined earlier. It may also be the case that the type of economic knowledge brought to bear by the experts was overly specific and thus the issue of process was of incidental importance at best. Conversely, it may be the case that the novices, and relative experts, require a knowledge of economic problem solving processes to make the knowledge they do possess relevant in some manner for solving the problem. These findings could also be a function of the types of problems used. Experts may not need advanced problem solving processes for solving elementary economic problems.

The implications of these results for economic education and economic educators seem obvious. Indeed, if the goal of pre-collegiate economic education is to train more effective economic problem solvers, then a crucial component for acquiring expertise appears to be missing. In fact, the results of this study suggested that an explicit treatment of problem solving in the pre-collegiate economics course, in conjunction with extended content knowledge, is needed. The findings outlined above clearly indicated the very high degree of intercorrelation between economic knowledge and its application. If we are to move our students toward expertise--or relative expertise--in economic problem solving, we must find ways to integrate such experiential problem solving processes into the economics curriculum at both the pre-collegiate and collegiate level.

The Role of Economic Education

Buckles (1991) noted that the most important justification for economic education is that "it can enhance our students' abilities to analyze situations and
Symmes and Gilliard (1981) stressed that the key element in economic literacy was the ability to "analyze the probable consequences of choosing each alternative; and take action based upon the evaluation of the costs and benefits of various alternative choices" (p. 5). Miller (1991) argued that the goal of economic education should be to help "students acquire the ability to use economics as independent decision makers confronting problems...rather than merely helping them gain the knowledge...that comprises part of the discipline" (p. 37).

Unfortunately, the results of the current study call in question whether, at least for this small group of problem solvers, these lofty goals are being met. In fact, evidence gleaned from this study seemed to indicate that pre-collegiate economic education and, to some extent, undergraduate economic education had only a marginal impact on the acquisition of expertise in economic problem solving.

The current study examined the mean levels of the thirteen variables of interest and, as part of this analysis, conducted a one-way analysis of variance on these means to determine if significant differences existed across the participants (PARTLEV). The results of the analysis suggested that for twelve of the thirteen relevant indicators of expertise, no significant differences existed between the mean levels of high school students who had taken economics (HS ECON) and those who had not (HS NONECON). The only variable on which HSECON differed significantly from HS NONECON was the percentage of relevant economic statements used (RELPER).

The author is fully aware of the implications and assumptions of statistical significance in these cases (See Chapter IV, pp. 76-77). Indeed, given a larger sample size, some of these differences may have attained significance.
However, the issue of statistical significance here is also accompanied by the fact that the absolute differences that did exist were marginal. In fact, on several variables, the mean level demonstrated by the HS ECON sub-group was actually lower than that demonstrated by the HS NOECON sub-group.

Nowhere is this lack of difference more telling than in the Pitt Problem Solving (PPSCS) variables. Across the five PPSCS variables, the average absolute difference in number of statements used was less than one-fifth of one PPSCS statement made. Given the overall importance of these PPSCS variables in determining expertise, this marginal difference implies that, as far as the acquisition of expertise in economic problem solving for this small sample was concerned, high school economics seemed to have had a very minor impact.

A similar pattern was noted when comparing the undergraduate non-majors (UND NONECON) with the undergraduate economic majors (UND ECON). The results of the ANOVA suggested that for ten of the thirteen relevant indicators of expertise, no significant differences existed in the mean levels between UND NONECON and UND ECON. The variables on which UND ECON differed significantly from UND NONECON were the PPSCS variables PITTPAT, PITTFEED and PITTEVAL.

These results indicated that the undergraduate majors in economics demonstrated only marginal greater levels of most of the relevant indicators of expertise in economic problem solving. Keeping in mind the caveats offered earlier it appeared that, for this small sample of problem solvers, undergraduate economic education added little in terms of acquiring economic problem solving expertise.

The current study transformed the raw data into standardized rank data for all respondents across the sample. As the data were standardized, it was
possible to calculate a mean of the mean rank of the participants across level of economic education (PART). The results of this analysis indicated that the mean of the mean ranking for HS ECON and HS NONECON differed only slightly (mean rank of HSNONECON=17.53; HSECON=22.71 out of 84). The difference between the mean ranking of UND NONECON and UND ECON was a bit more pronounced, but still relatively marginal (UND NONECON=31.11; UND ECON=40.91). While these results are not as conclusive as the ANOVA, they still suggest that pre-collegiate and undergraduate economic education resulted in only marginal differences for members of these sub-group.

In addition to the mean ranking analysis, the standardized ranking also facilitated the use of a hierarchical cluster analysis. The cluster analysis technique compared the similarity or distance associated with a group of cases and classified like cases into groups. In the current study, the ranked data was analyzed across all thirteen variables to determine if underlying groupings were present. The results of this analysis indicated that three groupings were present.

The first of these clusters consisted of the HS NONECON and HS ECON sub-groups. The cluster analysis assigned cases to groups based on similarities and the mean group assignment for these sub-groups was 1.04. In other words, all but 2 of the first twenty-four cases were assigned to the first cluster--a very high degree of similarity. The second cluster consisted of UND NONECON and UND ECON sub-groups. The mean group assignment to this cluster was 1.74. Nineteen out of these twenty-four cases were assigned to the second cluster.

These results followed the pattern identified by the standardized rank analysis. That is, the two high school groups were very closely related and the two undergraduate groups were also related, although not quite as closely. This analysis served to confirm the supposition that economic education at the pre-
collegiate and, to some extent, the undergraduate level resulted in only marginal greater expertise in economic problem solving over counterpart subgroups.

The implications of the analysis presented above are quite weighty. In fact, if it is true that economic education, at the pre-collegiate level, seeks to empower future citizens with economic decision-making capabilities, then economic education seems to be falling far short of that mark. Keeping in mind all of the assumptions and limitations of the current study—in particular, to the very small sample size—and the drawbacks associated with the methodology, it is still relatively easy to see how little difference taking high school economics made.

Similarly, there is some obvious question as to the impact of undergraduate economic education on problem solving expertise. However, undergraduate economic education may not have as its primary goal the empowerment of citizens to make economic decisions. Rather, one underlying goal of the undergraduate program may be to serve as a gate for entering the business world or graduate school.

As tentative as the conclusions in this study must necessarily be, it seems logical to ask: why didn't pre-collegiate economic education make a difference in economic problem solving ability? One potential answer lies at the very heart of the pre-collegiate curriculum: the debate over problem solving and depth versus conceptual understanding and breadth. Such debate may be seen as far back as 1961 when the Report of the National Task Force on Economic Education "pointed to the need for more and improved economic instruction in elementary and secondary schools, (and) stressed the importance of taking a more
systematic, reasoned approach to the study of economic problems" (Saunders, et al., 1993, p. 3).

Unfortunately, the most widely-used pre-collegiate curriculum in economic education (the National Council on Economic Education's EconomicsAmerica) continues to focus on conceptual understanding as a basis for economic literacy. This is evidenced in the fact that the most significant research studies, and most high-stakes testing, involving pre-collegiate economics still revolves around the Test of Economic Literacy, a normed and standardized test of economic concept knowledge (See, for example, Walstad and Soper, 1991).

Conclusions

The current study has been an attempt to learn more about expertise in economic problem solving, the nature of relative expertise, the role of economic education in acquiring expertise and how to measure or scale relative expertise in economic problem solving. Given the plethora of data, and the analytical techniques brought to bear upon them, it would be nice to draw some clear-cut conclusions about problem solving in economics. This, however, is not the case. Based upon the litany of limitations and assumptions associated with the study, one should only seek to draw the most guarded and tentative conclusions. The reader is also reminded that the application of many of the analytical techniques used in the current study was done to more accurately describe the sample and should not be generalized to larger populations without careful consideration and critique. Having stated these caveats then, what follows is a brief list of the outcomes of the current study.
1. A very strong, positive relationship existed between each of the thirteen variables and the level of expected expertise as indicated by participant level (PARTLEV).

2. Pre-collegiate, and to some extent undergraduate, economic education had little impact on level of expertise in economic problem solving.

3. The acquisition of expertise in economic problem solving was not a continuum. In fact, participants demonstrated a 'leap' in expertise at points along the path to expertise.

4. Economic knowledge and problem solving processes both played vital roles in determining expertise in economic problem solving.

5. Expertise in economic problem solving appeared to be a scalable variable.

6. Economic education and experience appeared to be a proxy for level of expertise in economic problem solving.

7. An intermediate category of problem solver—between the extremes of expert and novice—was identified.

**Recommendations for Further Study**

In Chapter I, a justification for this study was discussed. This justification argued that some knowledge of student economic reasoning, and student problem solving in particular, was needed in order to design effective pre-collegiate economic education programs. Further, it was noted that some doubt existed as to whether economic education in general, as it is currently manifested, was capable of achieving the goal of increasing economic problem solving ability in pre-collegiate students. Finally, this justification proposed an investigation of expert problem solvers in economics to gain critical insight into the acquisition of such expertise. The conclusions regarding these issues and the four research questions investigated were presented in the previous sections.
This section poses some questions yet to be resolved and calls for further research in this area.

Perhaps the most intriguing finding of the current study was that concerning the marginal impact of high school economics. Further study in this area should focus more explicitly on comparing high school students who have taken an economics class with those who have not. Implicit in this call for further study is the need for larger sample size. Indeed, by focusing on the high school student sub-groups, and by using larger samples, the issues of statistical significance and the use of inferential statistics can be addressed. Moreover, such research should seek to pre- and post-test students on the Test of Economic Literacy and compare these results to findings regarding problem solving expertise. Such a comparison might yield a more meaningful and detached critique of the role of pre-collegiate economic education in obtaining economic literacy.

More attention should be also be focused on the economic problems used to generate participant responses. In fact, counter to the supposition made by the researcher, the current study indicated that no apparent differences existed across responses to the three problems used. Further study should seek to replicate or refute these findings and thus speak to the issue of whether various aspects of economic theory are likely to produce idiosyncratic participant responses.

Another important question for further consideration involves the role and background of the pre-collegiate economics teacher. That is, what level of expertise do pre-collegiate economics teachers possess? How is this level of expertise (or noviceness) correlated with student results?
It is absolutely essential that the EEPSSM be re-examined and pilot tested. Beyond building a strong case for construct validity, the current study made no attempt to validate the EEPSSM. If this scaling model is to be employed in further study of expertise in economic problem solving, a systematic examination of its applicability and reliability must also be conducted. More information is needed about the ability of this model to scale expertise in economic problem solving.

Finally, the question of identifying and defining relative expertise in economic problem solving needs to be re-visited. This study represented a first small step in this area. The results of the study clearly indicated the presence of an intermediate category between the two extremes of expert and novice. The study also described this category relative to the other categories of expertise. However, a comprehensive and detailed description of relative expertise in economic problem solving was beyond the scope of this study. Indeed, as noted earlier, further study on economic problem solving using this expert novice paradigm must be conducted. Moreover, further study must seek to expand the number of participants and the scope of the study.

Having said this, the researcher is also aware that studies of this nature are laborious and costly. However, it is the opinion of the researcher that such further study offers significant potential for gaining stronger insight into the economic reasoning and problem solving of students and consequently providing a broader research base for future curriculum development in economic education.
APPENDIX A

HYPOTHETICAL MODELS OF THE ACQUISITION OF EXPERTISE IN ECONOMIC PROBLEM SOLVING
1. Continuum

Novice -- Expert

2. Discontinuous Continuum

Novice --- Expert

3. Multiple Continua

Novice

4. Curvilinear*

Novice

* The dotted line in this construct connects the means of a range of scores, or other indicators, associated with a sub-sample of the study and represents one hypothetical "shape" of expertise.
APPENDIX B

STANDARDIZED PARTICIPANT DIRECTION SHEET FOR 'TALK-ALOUD' PROTOCOLS
Directions for Economic Problems Exercise

In a moment, you will be given the first of three economic problems. Once you have the problem sheet in front of you, please note the following directions:

1. you will have one minute to familiarize yourself with the problem

2. at the end of this time, please begin to discuss the problem:
   - speak clearly
   - be as detailed as you are able
   - take as long as is necessary to discuss the problem thoroughly

3. feel free to write or draw on the blank paper below the problem

4. you may ask for general assistance, but the interviewer cannot suggest solutions, etc. to the problem

If you are confused in any way as to what these directions instruct you to do, please ask at this time. This procedure will be repeated for each of the three problems.
APPENDIX C

EXPERTISE IN ECONOMIC PROBLEM SOLVING MODEL
(Miller and VanFossen, 1994)
Low Real Wages

3. Difficulty maintaining minimal standard of living

4. Min. wage boosts income

Social Policy of Min.

1. MINIMUM WAGE

15. Work develops skills

16. Examples of skills

17. Unemployed at Min. wage: Don't get skills

SKILL LEVELS & WAGES

5. Work develops skills

6. HIGH SKILL LEVEL

7. LOW SKILL LEVEL

8. WAGE < MIN. WAGE

9. Pay above market wage

10. Unemployed at Min. Wage

11. DOUBLE MIN. WAGE

12. SOME GET HIGHER WAGES

13. Better off at expense of unemployed

14. More Unemployed

MINIMUM WAGE

1. Work develops skills

2. Difficulty maintaining minimal standard of living

3. Low Real Wages

4. Min. wage boosts income

Social Policy of Min.
APPENDIX D

LIST OF ECONOMIC CONCEPTS USED BY RESPONDENTS
Economic Concepts Used by Respondents

supply and demand
equilibrium price
market clearing price
unemployment
labor supply
labor supply curve
quantity of labor adjustment
wage bill
efficiency
net value
assets
economic price
price
markets
deflation
inflation
money supply
budget deficit
the Federal Reserve system
full employment
fiscal policy
competition
producers
consumers
price levels
subsidies
exports
dumping
externalities
anti-trust
trade barriers
scale economies
interventionist
comparative advantage
human capital
real wage rates
minimum wage
wage floor
investment expenditures
aggregate demand
aggregate supply
fiscal policy
monetary policy
taxation
fixed exchange rates
flexible exchange rates
currency
real value of the dollar
short-run
long-run
distribution of income
Gini co-efficient
tariffs
quotas
business
cycle
elasticity of demand
speculation
nominal interest rates
real interest rates
contractionary policy
expansionary policy
trade balance
industrial policy
opportunity costs
productivity
marginal productivity
capital
free trade
APPENDIX E

LIST OF ECONOMIC MODELS USED BY RESPONDENTS
Examples of Economic Models Used by Respondents

- labor market model
- capital market model
- exchange rate model
- Keynesian AD model
- Industrial organization/policy model
- public choice model
- monetarist model
- general market model
- IS-LM model
- micro price theory model
- long-run growth model
APPENDIX F

EXPERT PANEL RATING MATERIALS
Criteria for Expert Juror Rating

Differentiating between expert and novice problem solvers has been the goal of numerous research efforts in cognitive psychology (See Chi and Glaser, 1988, Voss, et al., 1984, Lesgold, et al., 1981 for examples). Among the results of these studies has emerged a profile of the expert problem solver. This profile consists of specific attributes that are possessed solely, or to a greater degree, by experts rather than novices. The following table, taken from Miller and VanFossen (1993), represents the results of a content analysis conducted on a variety of studies in expert novice problem solving and summarizes these key attributes.

Attributes of Expert Problem Solvers

1. Experts excel mainly in their domain.
2. Experts perceive relevant patterns in their domains. These meaningful patterns assist in the application of domain-specific knowledge.
3. Experts see and represent problems at a deeper, more principled level than do novices.
4. Experts spend more time on problem representation. Experts employ a 'work forward' strategy that requires greater time allocation for problem identification before the application of theory or knowledge.
5. Experts have strong self-monitoring and self-evaluation skills.
6. Experts demonstrate more flexibility in the process of problem solving.
8. Experts possess more domain-specific, declarative knowledge.
9. Experts have extensive procedural knowledge.
10. Experts have more highly developed specialized schemata (cognitive structures) than novices.

The purpose of the current study is to determine the salient characteristics of relative expertise in economic problem solving and to identify the nature of relative expertise in economic problem solving. That is, what characterizes the problem solver who is neither expert nor novice?

Based upon the attributes outlined above, I have constructed a device designed to facilitate the rating of transcribed responses to economic problems. This device outlines each of the criteria guidelines along which you will rate each of the responses.

The device employs a Likert scale construction. Your task is to assign a score, under each of the criteria guidelines. This score will represent your interpretation of the level of "expertise" demonstrated by each response. The scale runs from NOVICE (0) to EXPERT (10). An explication of each criteria guideline and, where relevant, an example, precedes each section.

The final section asks you to assign an "overall expertise rating" to each response. This should be determined by both the respondent's ratings on the previous criteria AND your own determination of the level of expertise in economic problem solving demonstrated by the respondent.
Expert Rating Criteria Guidelines

What follows is an explication of the various criteria on which each respondent will be rated. Where appropriate an example has been provided for further clarification. These criteria correspond to the Likert scale items on the Expert Juror Rating Sheet and should be used in conjunction with this instrument. Please read each response with the following in mind, and then complete the rating sheet on each of the criteria.

1. Use of Economic Concepts

Does the response contain relevant economic concepts? Are concepts missing from the response? Are the concepts used in appropriate ways? How sophisticated are the concepts that are employed in this response? Does the respondent successfully discriminate between similar concepts?

2. Conceptual Cross Referencing

To what extent does the respondent demonstrate conceptual cross referencing? That is, to what extent does the invoking of one economic concept lead to the invoking of a second or third concept? One example of this might be:

"if it is true that demand decreased dramatically then what the government could have done was either increased expenditures to make up for the drop in aggregate demand or significantly increased the money supply so that interest rates would have gone down."

Another example might be:

"if you are living in a world of fixed exchange rates, then what will happen is that the deficit could continue to grow at the fixed exchange rate level and your dollar could become, the real value of the dollar, could become too high and you might have to devalue the dollar."

3. Use of Problem Representation Statements

To what extent does the respondent define, clarify, restate or subdivide the problem before responding. To what extent does the respondent use planning statements to guide problem solving? To what extent does the respondent qualify the response based on some understanding of the 'real-life' implications of the problem? An example of problem representation might be:

"if you're living in a world of fixed exchange rates, that sets up one set of problems. If you're living in a world with flexible exchange rates that sets up a different set of problems."

Another example might be:

"Well, first of all, a minimum wage is a policy that was designed on the basis of good intentions."
4. Use of Propositional Statements

To what extent does the respondent use statements that resemble the 'if' segment of an 'if...then' statement? Does the respondent use a contingency proposition? Examples might include:

"if you double the minimum wage, that means that more people will not be employed."

"if you're running a surplus that means you might be investing more abroad."

"if you're interested in long run growth, that's one thing; if you're interested in short run stimulus, that's another."

5. Use of Causal Statements

To what extent does the respondent use statements of the 'A causes B' type? Does the response contain clear statements about certain conditions, circumstances, inputs or stimuli leading to specific ends? Does the response contain statements that resemble the following?

"those people who are receiving a higher wage are better off, but they are better off at the expense of those who are unemployed."

"so in order to balance the federal budget, they increased taxes."

"if you subsidize domestic industries, you can lower the trade deficit."

6. Use of Economic Models

Does the respondent invoke relevant economic models (e.g., a market, aggregate supply and demand, price theory, etc.) in the response? At what level of sophistication is each model used? Are there models better suited to this problem? Are models missing?

7. Overall Economic Knowledge

Does the respondent seem to possess adequate knowledge to address the problem sufficiently? Does the respondent demonstrate effective use of economic knowledge during the problem solving process?

8. Expertise in Economic Problem Solving Rating

This score is based on your overall impression of the respondent's economic problem as demonstrated in this response. This is NOT NECESSARILY just the sum of the the scores assigned in the previous 7 categories. Rather, this score is a function of BOTH the respondent's previous scores and your opinion as to where the respondent falls relative to your conceptualization of the categories "expert" and "novice." This score should be out of a possible 100 points.
Expert Juror Rating Sheet

Please circle the number that corresponds with your rating of this response along the following criteria. Note that the scale runs from NOVICE (0) to EXPERT (10). This implies that a rating of 10 would suggest that the respondent demonstrated a very high level of the attribute under consideration. Conversely, a rating of 2 would suggest that the respondent demonstrated a relatively low level of the attribute under consideration.

1. Use of Economic Concepts
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

2. Conceptual Cross Referencing
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

3. Use of Problem Representation Statements
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

4. Use of Propositional Statements
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

5. Use of Causal Statements
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

6. Use of Economic Models
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

7. Overall Economic Knowledge
   1 2 3 4 5 6 7 8 9 10
   NOVICE EXPERT

8. Expertise in Economic Problem Solving Rating / 100
APPENDIX G

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* = Signif. LR .05  ** = Signif. LR .01  (2-tailed)  * * * printed if a coefficient cannot be computed
APPENDIX H

EXAMPLES OF EXPERTS' SELF RATING
Participant Questionnaire

1. Please identify your area(s) of interest in economic research and study (be specific):
   A. Labor Economic Econ. specifically "Glass Ceiling" for minority workers; Information problems.
   B. 
   C. Macro Economic.

2. Please list the two courses you teach most frequently:
   A. Econ 200
   B. Econ 400

3. Please indicate the "level of expertise" you would assign yourself in responding to each of the three economic problems.

   A. Minimum Wage Problem
   \[1 \quad 2 \quad 3 \quad 4 \quad \boxed{5} \quad 6 \quad 7 \quad 8 \quad 9 \quad 10\]
   LOW \[\text{HIGH}\]

   B. Great Depression Problem
   \[1 \quad 2 \quad 3 \quad 4 \quad \boxed{5} \quad 6 \quad 7 \quad 8 \quad 9 \quad 10\]
   LOW \[\text{HIGH}\]

   C. International Trade Problem
   \[1 \quad 2 \quad 3 \quad \boxed{4} \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10\]
   LOW \[\text{HIGH}\]
Participant Questionnaire

1. Please identify your area(s) of interest in economic research and study (be specific):
   
   A. US Economic History
   B. Labor - human capital - demography
   C. Comparative systems - efficiency of cooperation

2. Please list the two courses you teach most frequently:
   
   A. European economic history
   B. Microeconomic principles

3. Please indicate the "level of expertise" you would assign yourself in responding to each of the three economic problems.
   
   A. Minimum Wage Problem
      
      \begin{tabular}{ccccccccccc}
      \hline
      1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \\
      LOW \ & \ & \ & \ & \ & \ & \ & \ & \ & HIGH \\
      \hline
      \end{tabular}
   
   B. Great Depression Problem
      
      \begin{tabular}{ccccccccccc}
      \hline
      1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \\
      LOW \ & \ & \ & \ & \ & \ & \ & \ & \ & HIGH \\
      \hline
      \end{tabular}
   
   C. International Trade Problem
      
      \begin{tabular}{ccccccccccc}
      \hline
      1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \\
      LOW \ & \ & \ & \ & \ & \ & \ & \ & \ & HIGH \\
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References


