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ABSTRACT

This paper reports preliminary research into the nature of relative expertise in economic problem solving. Specifically, this report seeks to address the question of whether the presence of economic knowledge alone accounts for expertise in economic problem solving or whether both economic knowledge and the development and employment of economic problem solving strategies are necessary prerequisites for acquiring expertise in economic problem solving. The researchers examined literal transcripts generated from the "talk-aloud" protocols of 28 participants responding to three economic problems. Each sub-group contained four participants: (1) high school students who had taken economics and those who had not taken economics; (2) undergraduate economics majors and non-majors; (3) graduate students in economics; and (4) Ph.D. economists employed in public and private forecasting and academic Ph.D. economists. The study employed a causal-comparative design with members of the seven sub-sample groups identified by the researcher. Three economics problems were employed in the study with several phases of data gathering involved in the analysis of data. Extensive charts and graphs accompany the text. Contains 41 references. (EH)

Relevant Indicators of Relative Expertise in Economic Problem Solving: A Factor Analysis

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Introduction

Economic educators have long emphasized that the teaching and learning of economics should result in the increased willingness and ability of students to use the discipline of economics in solving problems, both personal and social. Given this emphasis, the focus of much research in economic education has been on the factors affecting student understanding and application of economic concepts. However, recent research calls into question the adequacy of this approach as a means to explore the relationship between educating for economic understanding and the goal of better economic problem solving. Researchers have investigated the literature concerning schemata and expert problem solving drawn from cognitive psychology (Miller and VanFossen, 1994; VanSickle, 1992 and VanSickle and Hoge, 1991), which seems to hold promise for linking economic education and economic problem solving.

A previous study by Miller and VanFossen (1994) has described key differences between expert and novice problem solvers in economics. However, explicating the distinctions between novices and experts only begins the quest to understand how one acquires expertise in economic problem solving and, further, to promote expertise through economic education. A crucial step is to understand the attributes associated with the construct of relative expertise. That is, differences in expertise not just between experts and novices, but among individuals at various points--other than expert and novice--along the path to expertise. Indeed, as the characteristics of relative expertise in economic problem solving become known, it may be possible to design curriculum in economic education that might better assist students in moving closer to a more sophisticated level of economic problem solving ability.

This paper reports preliminary research into the nature of relative expertise in economic problem solving. Specifically, this report seeks to address the question of whether the presence of economic knowledge alone accounts for expertise in economic problem solving or whether *both* economic knowledge *and* the development and employment of economic problem solving strategies are necessary prerequisites for acquiring expertise in economic problem solving.

The first section briefly describes, within the context of research on expert and novice problem solving, why such research is needed. Subsequent sections present the problem within the context of research on expert and novice problem solving and the methods, results, and conclusions of the study.

Context of the Research and the Problem

Economic Education and Problem Solving

Since at least the 1961 *Report of the National Task Force on Economic Education*, economic educators have long contended that economic education should develop the ability of students to use economics to solve problems, a goal that has been reiterated many times over the years (Saunders, et al., 1993; Buckles, 1991; Miller, 1988; Schug, 1985; and Symmes and Gilliard, 1981). Moreover, at least one important result of this enhanced economic problem solving ability should be manifest in more effective and responsible citizenship (Miller, 1991 and 1989; and Brenneke, 1992). Indeed, increasing democratic citizens' abilities to engage in more effective economic problem solving is the *raison d'être* of economic education.

Thus the rationale for economic education posits a chain: that more and better economic education will lead to greater student understanding of economics which will lead to better economic problem solving which, in turn, results in more responsible citizenship (Miller and VanFossen, 1994). Of the links in the chain, the first -- the relationship of economic education to greater student understanding of economics -- has received the most attention, with particular emphasis on studies of the impact of economic instruction on scores of students on standardized economics tests (See Walstad and Soper, 1991, for numerous examples). Until very recently, however, research on the relationship of conceptual understanding to problem solving, the second link, was largely confined to studies comparing students' and economists' opinions on various economic issues. The third link has been left largely unexplored.

There is, however, reason to question whether competence in economics should be equated with understanding of economic concepts alone and, further, whether knowledge of economic concepts is sufficient, in and of itself, to lead to greater expertise in economic problem solving. Research in expert and novice problem solving and schema theory (Voss, et al., 1984, 1989; Chi and Glaser, 1980; Chi, Glaser and Rees, 1982; Glaser and Chi, 1988) suggest the need for a more complete conceptualization of economic knowledge (VanSickle, 1992; Miller and VanFossen, 1994). "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" (Miller and VanFossen, 1994).

Expertise and Problem Solving

In studies in fields as diverse as radiology, physics, and, political science, differences in how experts solve problems have been shown to depend upon more than simply knowledge of the content of their respective disciplines. To take a specific example, Lesgold, et al. (1981) found that experienced radiologists were nearly always more successful in their diagnoses than recent interns, despite nearly equal content knowledge. Van Sickle (1992) has noted that experts possess more declarative, procedural, and schematic knowledge than non-experts.[1] Of these, only declarative knowledge refers to the extent knowledge of a specific body of content or discipline. Voss, et al.,(1989) defined procedural knowledge is "the knowledge of how to," or perhaps more accurately, as the application of specific procedures or strategies associated with the use of declarative knowledge.

Miller and VanFossen (1994) summarized ten attributes of expert problem solvers drawn from a lengthy content analysis of the relevant research literature in cognitive psychology and found evidence that these attributes also exist in the domain of economics and were demonstrated by expert economic problem solvers. These attributes are listed at Figure 1.

A brief examination of the attributes listed at Figure 1 reveals that more than simply content or domain-specific knowledge alone is present in expert problem solvers. Indeed, many of the attributes noted in Figure 1 deal specifically with problem solving procedures or strategies that experts employ in the process of solving problems (e.g., attributes 1,2,3, and 7). This relationship--between content knowledge and problem solving strategies--has been an area of investigation for a number of studiesin this area.

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[1] Miller and VanFossen have pointed out that the term "schematic knowledge" is potentially confusing since it implies that it is a component of domain specific knowledge that is somehow separate from declarative and procedural knowledge. They argue that it is perhaps better to conceive of this as more highly developed domain specific schemata, the integration of declarative and procedural knowledge.

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.

7. Experts identify models as tools in problem solving rather than real-life processes.

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

9. Experts have extensive procedural knowledge.

10. Experts have more highly developed specialized *schemata* than novices.

Figure 1. Attributes of Expert Problem Solvers (Miller and VanFossen, 1994)

For example, Chase and Simon (1973) concluded that while content knowledge competence was obviously a prerequisite for acquiring expertise, more than superior content knowledge alone was present in expert problem solvers. Simon and Simon (1978) and Chi, et al., (1982) found that the use of problem representation strategies were 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). The overarching consensus of these studies--and others--was that *both* domain-specific content knowledge *and* the application of specific problem solving processes were important factors in expert problem solving.

Expertise and Economic Education

That there should be evidence that economic problem solving expertise depends on more than just knowledge of economic concepts has been implicit in much of the activity of economic educators over the years. For instance, Buckles (1991) has written: "Our teaching of economics can be most effective if we focus on the ideas that economics is a 'method' an 'apparatus' and a 'technique'" (p. 24). This statement implicitly assumes the existence of something like procedural knowledge or specific problem solving strategies; an *economic reasoning*, if you will. Much of the writing about the need or rationale for economic education has discussed economics in similar terms. Moreover, some of the materials developed by economic educators distinctly emphasizes employing the "method" of economic reasoning, including, for example, *Mini-Society* (Kourilsky, 1983), *Capstone: The Nation's High School Economics Course* (Reinke, et al., 1989) and *United States History: Eyes on the Economy* (Schug, et al., 1993).

If this has been the case, why has so little research been devoted to the acquisition of expertise in employing the "method" of economics or the relationship between economic concept knowledge and the application of that knowledge via an economic reasoning? Also, if the goal of economic education is more effective economic problem solving, it is important to know how students become more effective problem solvers and what instructional strategies and curriculum materials produce greater expertise. "Toward this end, it is crucial to know how well the patterns of economic reasoning conform to those of economic experts. Economic educators might then be better able to design curriculum and instruction that addresses the development of economic reasoning based on a firm research foundation" (Miller and VanFossen, 1994).

This report is intended to be a first effort in determining the relationship between the development of economic knowledge, the application of economic reasoning (or the use of economic problem solving strategies) and the acquisition of expertise in economic problem solving.

Models of the Nature and Construct of Relative Economic Expertise

In the absence of research, one might conceive of any number of possible models that depict the construct of expertise in economic problem solving, each with attendant implications for instruction and curriculum design (See Appendix A). For instance, one possibility is a simple continuum. As students acquire more domain-specific declarative knowledge, they progress in regular increments toward greater expertise in economic problem solving. This model seems unlikely given the expert novice research outlined above and research on schema theory (See Torney-Purta, 1991, for a summary of this line of study) but this representation corresponds best with the much of the existing research in economic education. It implies that material designers and teachers can concentrate on teaching economic concepts and content, and that we can assess expertise by measuring how well students have grasped economic concepts.

A more complicated construct is that greater instruction in economics has little noticeable impact on expertise in problem solving until one or more threshold levels are reached. One might think of this as a "discontinuous continuum," wherein a student moves ahead on the declarative knowledge dimension of expertise without making much discernible progress in problem solving until reaching a threshold, where a "leap" in problem solving expertise occurs. That such a leap is plausible is suggested by the knowledge integration aspect of schema theory (VanSickle, 1992; Torney-Purta, 1991; VanSickle and Hoge, 1991) . The student suddenly "gets it" as disparate economic ideas and strategies for economic reasoning become incorporated into her or his schemata. This construct would imply the need to study how this level of economic knowledge and reasoning integration takes place and what instruction and materials best promote it.

Another possibility is suggested by the attributes of expertise as drawn from existing cognitive research (Glaser and Chi, 1988; Chi, Glaser and Rees, 1982). In this model, students proceed--probably at different rates--down multiple dimensions of the attributes of expertise in problem solving. The third model in Appendix A shows one such representation that includes dimensions for problem representation and procedural and declarative knowledge--three of the ten attributes listed by Miller and VanFossen (1994). This model suggests that researchers should concentrate on understanding how each of the attributes is acquired with an eye toward instruction that promotes their acquisition.

Perhaps the path to expertise is curvilinear. As depicted in Appendix A, there might be a series of levels of expertise with some distribution of, for example, standardized test scores at each level. Greater expertise in problem solving might at first respond slowly to successive increments of declarative content knowledge (e.g., knowledge of economic concepts). Later, the path of expertise turns more sharply upward as students build more highly developed economic schema that integrates elements of economic reasoning (the "method" of economics). While the depiction in Appendix A shows this possibility as a curve concave to the x-axis, a curve convex to the y-axis is also possible. The latter implies rapid progress in the acquisition of expertise with diminishing returns to further experience setting in at some point. The former implies that there might need to be substantial conceptual understanding before there is much noticeable improvement in economic problem solving. Perhaps researchers would then focus on techniques to change the shape of the curve.

Statement of the Problem

Obviously, there are other possible models. However, while we know something of the differences between expert and novice problem solving in economics (VanFossen and Miller, 1994; Miller and VanFossen, 1994; Son and VanSickle, 1993; VanSickle, 1992), we know almost nothing of how such expertise is acquired and the relationship of economic education to the acquisition of expertise. This study is intended as a first step in describing the relationship among level of economic knowledge, use of economic problem solving strategies and the acquisition of expertise in economic problem solving.

Method

The researchers examined literal transcripts generated from the 'talk-aloud' protocols of twenty-eight participants responding to three economic problems. Each of the following sub-groups contained four participants: high school students who had not taken economics (HS NOECON), high school students who had (HS ECON), undergraduate non-majors (UND NOECON), undergraduate economic majors (UND ECON), graduate students in economics (GRAD), Ph.D. economists employed in public and private forecasting (PHD-FIELD) and academic Ph.D. economists (PHD-UNIVERSITY).

Research Design

The study employed a causal-comparative design. 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) and also "involve comparing known groups who have had different experiences to determine possi le causes or consequences of group membership" (p. 15). Causal-comparative research employs the static group comparison design (Campbell and Stanley, 1963). For this study, the group difference variable was defined as expected level of relative expertise in economic problem solving. This variable was defined as the level of formal economic education attained by a participant (the variable PARTLEV). Figure 2 provides a schematic that represents the static group comparison research design used in the current study.

Group	Independent Variables	Dependent Variable
I	13 relevant indicators of expertise, (group characteristics)	relative expertise in economic problem solving
(Groups II-VI)		
VII	13 relevant indicators of expertise, (group characteristics)	relative expertise in economic problem solving

Figure 2. Design of the Current Study

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 (PARTLEV). Thus, sub-sample group members were relatively equivalent in level of formal economic education and economic experience attained. As it was not a goal of this study to engage in an experimental design, the issue of manipulating an independent variable was unimportant.

The question of data collector bias in the analysis of transcribed responses was addressed by having two raters independently examine and code a random sample of the respondents' protocols. The author was the first rater. The second rater was extremely familiar with this line of study and was trained using the coding rubrics employed by the author. The results of the second rater's coding indicated a very high degree of correlation between the researcher's original 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 in this study.

<u>Selection of Participants</u>

Members of the seven sub-sample groups were identified, either directly, or indirectly, by the researcher. For example, the academic Ph.D. economists (PHD-UNIVERSITY) 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.

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 participants. The four economists who participated were employed in either public or private economic forecasting or analysis.

A list of second- and third-year OSU graduate students in economics (GRAD) was used to generate a mailing to which four OSU graduate students (three second-year and one third-year) responded and subsequently participated in the study. 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 members of a social studies education methods course taught by the researcher. 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 primary 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 performance throughout the one-semester course. The students had just completed the economics course when the data were 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* (Saunders, et al., 1993), considered by many to be the major pre-collegiate economics curriculum in use today.

This high school economics teacher also selected the four student participants who had not taken high school economics. These 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 primary researcher. This data collection strategy is well supported by much of the previous expert problem solving 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 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 were given a set of standardized instructions that allowed one minute for the respondent to familiarize themselves with each problem. 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 participants were told that they should begin when ready and continue speaking until they had, to their own satisfaction, dealt sufficiently with the problem. Participants were told to continue analyzing 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.

Three economic problems--based upon those constructed by Miller and VanFossen (1994)--were employed in the 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 or idiosyncratic. 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. The problems developed were:

1. Suppose Congress were to double the current minimum wage of $4.25 an hour to $8.50 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)?

The first phase of analysis involved the coding of protocols for eight variables: absolute number of relevant statements (STATE), percentage of relevant statements (RELPER), number of economic concepts (CONCEPTS), number of economic models (MODELS), number of concept maps (CONMAPS) and expert ratio profiles (ERP) for causal, (CAUSERP) propositional (PROPERP) and problem representation statements PROBERP).

These eight variables, along with the five Pitt Problem Solving Coding System variables outlined below, constituted a set of indicators of expertise in economic problem solving. These indicators were developed through a content analysis of studies in expert-novice problem solving (See, for example, Voss, 1989; Glaser and Chi, 1988 and Glaser, 1987) and from a pilot study conducted to develop a model for assessing expertise in economic problem solving (Miller and VanFossen, 1994).

The number of relevant statements (STATE) 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 (RELPER).

The number of economic concepts (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 generally accepted, or were considered low-inference concepts.

Data were collected regarding the total number of economic models (MODELS) used in a participant's protocol. The primary researcher coded and counted the number of times a participant used various economic models during a response. 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. 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.

Data on the use of economic concept maps (CONMAPS) were collected by first identifying the economic concepts used in a protocol by a respondent. 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 was 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*.

Given this, the researchers 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 use 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..." occur only in the short run. Moreover, this map is directly related to the application of a generalized market model. This case is 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 Expert Ratio Profiles (ERP's) were coded using criteria previously employed by Miller and VanFossen (1994). Statements were classified as problem representation (PROBERP) 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 (PROPERP) 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 (CAUSERP) 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. One can classify such a statement as fitting the 'A causes B' model.

The second phase of data gathering 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 (See Figure 2) coded qualitative data, such as the current study's transcripts, into one of six categories of strategies used in problem solving (general problem solving, feedback, pattern extraction, hypothetico-deductive, evaluation and heuristics) 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).

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

General Problem Solving
- SR10. Define initial state
- SR11. Define goal state
- SR12. Identify data needed

Feedback
- SR17. Identify feedback
- SR18 Tag new information
- SR19 Organize new information

Pattern Extraction
- SR22. Extract patterns from data
- SR23. Summarize relevant patterns

Hypothetico-deductive
- SR 7. Formulate hypothesis
- SR 8. Define predictions
- SR20. Match data to predictions
- SR21. Determine truth values of predictions

Evaluation
- SR 2. List assumptions
- SR 4. Select evaluative criteria
- SR 5. Assign priorities
- SR 6. List relevant information
- SR15. Edit algorithm

Basic Heuristics
- SR 1. List given information
- SR 3. List questions
- SR 9. Select questions
- SR13. Identify set of available algorithms
- SR14. Select algorithms
- SR16. Execute algorithm
- SR24. Output conclusions

Figure 3. Components of the PPSCS Model: Problem Solving Strategies and Subroutines (SR)(Pitt, 1983)

problem. *Feedback* strategies identified and incorporated new information as it became 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 researchers believed that the *basic heuristics* category generated data that was very 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 levels for each PPSCS variable were then calculated for each of the seven sub-sample groups.

Data Analysis

Data on the variables identified in the current study (the indicators of relative expertise in economic problem solving) were examined using factor analytic techniques. These statistical techniques have 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). Factor analysis may also be defined as the use of "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, as Thorndike (1982) noted, used "to find an underlying structure" and to "identify a small number of fundamental trait dimensions" (p. 277).

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 construct known as "expertise in economic problem solving." Thorndike (1982) noted that, "a factor is a new variable generated by a linear combination of the original (items)" and that "the hope is that judicious development of the factors can produce variables that imply clear and meaningful...constructs" (p. 277-279). Factor analysis was employed in this study to determine if any related factors might better define the broad construct "expertise in economic problem solving."

Two categories of factor analysis exist: exploratory and confirmatory. The fundamental difference between exploratory and confirmatory factor analysis concerns whether or not hypotheses 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 are most closely associated with which factor. The current study employed both exploratory and confirmatory factor analysis.

Factor Analysis

The first step in this factor analysis was to generate a correlation matrix for the variables under consideration. This was done in order to determine the degree of intercorrelation that existed among the thirteen variables. It was apparent from the results presented in the correlation matrix (see Appendix B) that each of the thirteen variables was moderately to highly correlated with the twelve remaining variables. This high degree of intercorrelation among the variables implied that the application of factor analytic techniques was indeed warranted (Kim and Mueller, 1978).

Next, an exploratory factor analysis was conducted using a Kaiser normalization and an unweighted least squares solution. The results (Table 1) indicated that two factors satisfied the minimum Eigenvalue requirement (Eigenvalue > 1.0).

Table 1

Initial Exploratory Factor Analysis: Final Statistics

VARIABLE	COMMUNALITY		FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
PITTFEED	.78605	*	1	8.39890	64.6	64.6
PITTEVAL	.73269	*	2	1.31058	10.1	74.7
PITTPAT	.72610	*				
CONMAPS	.90772	*				
MODELS	.84366	*				
PROBERP	.60725	*				
PROPERP	.35475	*				
RELPER	.61177	*				
STATE	.92705	*				
CONCEPTS	.92158	*				
PITTHD	.77564	*				
PITTGPS	.83007	*				
CAUSERP	.68514	*				

OBLIMIN ROTATION KAISER NORMALIZATION OBLIMIN CONVERGED IN 12 ITERATIONS.

Using the results of this exploratory factor analysis, a second, confirmatory factor analysis was conducted. Again, this analysis employed an unweighted least squares solution. In addition, a factor rotation was conducted in order to present a simpler, more easily interpreted solution. Because the factor correlation matrix (See Table 2) suggested the two factors were correlated, an oblique rotation technique (using the SPSS Oblimin command) was employed.

The effect of the oblique rotation was to separate the factor loadings (easily interpreted as a coefficient representing the level of intercorrelation among the two identified factors and each of the thirteen variables in question) onto these two factors. The variables that loaded appreciably (> .70) onto the first factor included number of 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 statements used(PITTGPS).

This first factor was designated as Economic Knowledge and Knowledge Structures. This designation was based on the operational definitions of the variables that loaded onto this factor. Indeed, four of the five variables that loaded very heavily (> .90) onto the first factor (STATE, CONCEPTS, MODELS, CONMAPS) were treated as indicators of economic knowledge by 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 and Knowledge Structures.

Table 2

Factor Correlation Matrix: Factor 1 with Factor 2

	FACTOR 1	FACTOR 2
FACTOR 1	----	.60527
FACTOR 2	.60527	----

Table 3

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

Variable	FACTOR 1	FACTOR 2
CONCEPTS	.95984	
STATE	.95534	
CONMAPS	.94984	
MODELS	.91815	
PITTGPS	.88255	
PITTPAT		.82903
CAUSERP		.82151
PITTHD		.81003
PITTFEED		.80075
PITTEVAL		.78955
RELPER		.78113
PROBERP		.77900
PROPERP		.59391

A strong case can be made for this conclusion, as participant's economic knowledge was most certainly a function of the presence of economic concept knowledge (CONCEPTS), a knowledge of economic models (MODELS) and the linkages between such concepts and models (CONMAPS). Further, the number of relevant economic statements (STATE) 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 and Knowledge Structures factor were variables that corresponded well with the relative level of economic knowledge demonstrated by participants involved in current study.

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 the level of problem solving strategies employed by participants. Indeed, the PITTGPS measure was determined by coding the number of respondent's statements that employed general problem solving strategies.

At least one potential explanation exists for this counter-intuitive result. Indeed, it seems plausible that certain *general* economic problem solving abilities--but not necessarily *advanced* problem solving abilities--are a direct function of the level of participant's economic knowledge. If this is the case, then the PITTGPS could be interpreted as a secondary indicator for the level of economic knowledge demonstrated by participants.

The results of the confirmatory factor analysis offer some support for this position. It is noteworthy that the PITTGPS variable loaded heavily upon *both* factors [Factor 1 (Economic Knowledge and Knowledge Structures) = .8825; Factor 2 (Economic Problem Solving Strategies) = .7143]. These loadings demonstrated a high degree of intercorrelation between the PITTGPS variable and *both* Factor 1 and Factor 2.

The variables that loaded appreciably (≥ .60) onto the second variable included the eight 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 hypothetico-deductive (PITTHD), Pitt feedback (PITTFEED) and Pitt evaluation (PITTEVAL). All factor loadings and the factor structure matrix are presented at Table 3.

Based on the operational definitions of seven of these eight variables, this factor was designated as Economic Problem Solving Strategies. In fact, the seven (PROBERP, PROPERP, CAUSERP, PITTHD, PITTFEED, PITTPAT, PITTEVAL) that loaded appreciably (≥ .60) 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 participants in the current study. 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).

The eighth variable that loaded appreciably (> .60) onto the Economic Problem Solving Strategies factor was the percentage of relevant statements used by respondents (RELPER). This result seemed out of place given the strong correlation 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 was clearly not the case.

However, these counter-intuitive results could be a function of the fact that the use of a lower percentage of relevant statements by participants may reflect 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. That is, if participants used a lower ratio of relevant statements, this may demonstrate a lack of ability to problem solve effectively due to a lack of some necessary minimum level of economic knowledge.

It may also be the case that this variable--RELPER--is a less than satisfactory variable in terms of representing 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. Indeed, this variable was developed to correspond with Ennis and Safrit's (1991) use of "incorrect" response statements as used in exercise science problem solving, something that could be measured given the nature of the problems they presented.

Ennis and Safrit 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, inter-domain agreement in all areas. Thus, as Miller and VanFossen (1994) noted, "the level of theoretical agreement among economists varies across 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 replace Ennis and Safrit's notion of "incorrectness" with that of "non relevance." As noted above, however, the correspondence between "correctness" and "relevance" may be less than assumed for purposes of this study and thus the variable RELPER may not be a reasonable proxy for this concept.

Discussion

A factor analysis was conducted on thirteen variables identified as indicators of expertise in economic problem solving (VanFossen and Miller, 1994; VanFossen, 1994) in order to determine whether any underlying factors might be identified. The results indicated that these variables loaded appreciably upo. . and thus could be used to define, two factors: Economic Knowledge and Knowledge Structures and Economic Problem Solving Strategies. These results also implied that both content knowledge and the use of a problem solving process component seemed to play an important role in distinguishing the relative levels of expertise that existed among this study's sub-groups. Indeed, these results seemed to provide further evidence for the integral relationship between possessing economic knowledge and the use of economic problem solving strategies in acquiring expertise in economic problem solving.

The potential implications of these findings for economic education and economic educators seem quite relevant, especially in the realm of curriculum design and development. Although these results must be interpreted cautiously due to the small size of this sampie, it would appear that success in economic problem solving turns not only on a student's knowledge of economic concepts, but also on the student's application of economic problem solving strategies or reasoning. Indeed, the experts in this study clearly demonstrated the use of both.

This notion of using economic problem solving strategies seems to mirror certain current curriculum in economic education. Notably, the application of what Buckles (1991) referred to as the method of economics is apparent in the National Council on Economic Education's (NCEE) *Capstone: The Nation's Economics Course* (Reinke, et al., 1989) curriculum guides. This integrative economics program helps students to develop an economic way of thinking that relies heavily on so-called "economic mysteries" that require students to apply both economic concepts and a problem solving strategy (e.g., the *Handy Dandy Guide to Solving Economic Mysteries*). Recently, the NCEE's *Eyes on the Economy: Economics inU.S. History* (Schug, et al., 1993) has furthered this pedagogical approach--each major section in the curriculum is predicated on an intriguing mystery that students must use economic reasoning to solve.

If economics education is to continue to claim the development and promotion of economic literacy among high school students as its primary aim, then we must continue to apply the knowledge gleaned from such areas as cognitive psychology in order to develop and integrate more effective economics curriculum along the lines of those noted briefly above. Further study in this area, may indeed prove fruitful to our curriculum development efforts.

Summary Statistics and ANOVA Results by Sub-sample Group

Variable		Group HS NOECON	HS ECON	UND NOECON	UND ECON	GRAD	PHD-FIELD	PHD-UNIVER.
STATE								
	μ*	3.42^{a}	5.67^{ab}	8.83^{ab}	9.33^{ab}	15.58^{b}	27.08^{c}	24.67^{bc}
	SD	1.62	3.67	3.83	2.10	4.60	16.88	13.77
CONCEPTS								
	μ	2.[illegible]^{a}	3.16^{a}	7.67^{ab}	7.92^{ab}	21.75^{bc}	37.83^{c}	30.33^{c}
	SD	1.24	1.85	5.31	2.23	7.81	26.80	17.83
RELPER								
	μ	.55	.71^{a}	.79^{ab}	.90^{bc}	.94^{bc}	.93^{bc}	.96^{c}
	SD	.17	.20	.13	.11	.07	.05	.04
MODELS								
	μ	.42^{a}	.67^{a}	1.[illegible]3^{ab}	2.50^{ab}	3.92^{b}	7.08^{bc}	9.17^{c}
	SD	.52	.78	1.49	.67	1.24	3.92	4.74
CONMAPS								
	μ	.00^{a}	.17^{a}	.92^{ab}	1.25^{ab}	3.75^{b}	6.92^{c}	7.50^{c}
	SD	.00	.39	1.16	.97	1.86	4.68	3.71
PROBERP								
	μ	.05^{ab}	.01	.08^{ab}	.15^{bc}	.23^{c}	.25^{c}	.23^{c}
	SD	.11	.02	.09	.03	1.07	.07	.09
CAUSERP								
	μ	.02^{a}	.02^{a}	.06^{ab}	.07^{ab}	.13^{bc}	19^{c}	.21^{c}
	SD	.06	.06	.09	.07	.07	.10	.10
PROPERP								
	μ	.02^{a}	.05^{a}	.02^{a}	.03^{a}	.09^{a}	.08^{a}	.11^{a}
	SD	.06	.08	.06	.05	.08	.05	.08
PITTGPS								
	μ*	.25^{a}	.33^{a}	.58^{a}	1.00^{a}	2.50^{b}	2.83^{b}	3.50^{b}
	SD	.45	.65	.51	.43	.52	1.12	1.62
PITTHD								
	μ	.17^{a}	.33^{a}	.75^{a}	1.25^{a}	3.33^{b}	3.83^{b}	3.17^{b}
	SD	.39	.49	.75	.75	1.07	1.80	1.52
PITTEVAL								
	μ	.17^{a}	.50^{a}	.58^{a}	2.42^{b}	2.59^{b}	3.25^{b}	3.42^{b}
	SD	.39	.68	.67	.99	.99	.96	1.08
PITTPAT								
	μ	.17^{a}	.50^{a}	.50^{a}	2.25^{bc}	2.08^{b}	3.25^{bc}	3.25^{bc}
	SD	.39	6.7	.67	.86	.99	.75	1.29
PITTFEED								
	μ	.25^{a}	.42^{a}	.83^{a}	2.58^{b}	2.83^{b}	3.42^{b}	3.50^{b}
	SD	.45	.67	.57	[illegible]	1.03	1.31	1.09

*Means with same superscript *do not* differ significantly at .05 level.

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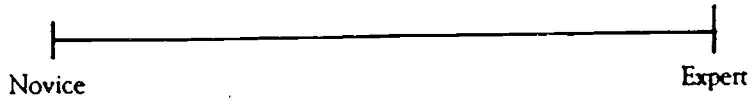
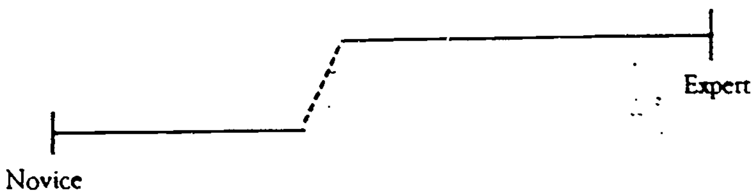
APPENDIX A:

Hypothetical Constructs of Expertise in Economic Problem Solving

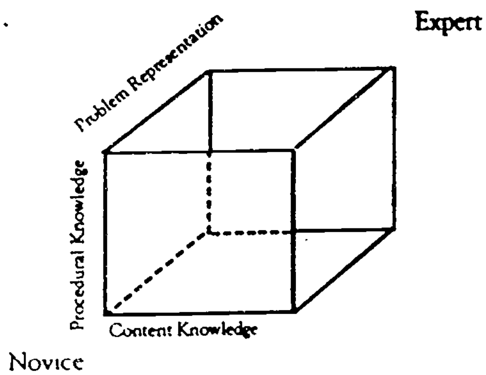
1. Continuum



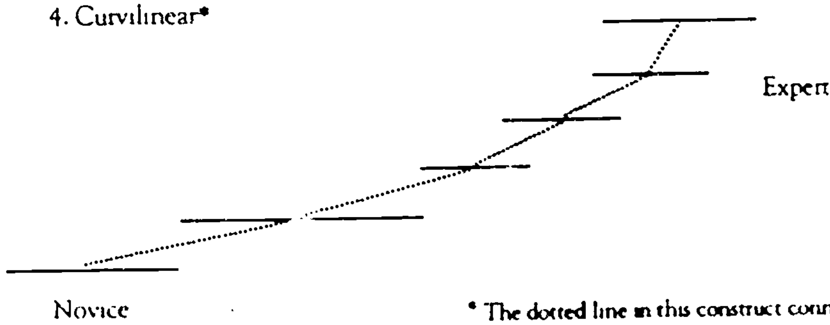
2. Discontinuous Continuum



3. Multiple Continua



4. Curvilinear*



* 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.

APPENIDX B:

Correlation Matrix

	CAUSERP	CONCEPTS	CONMAPS	MODELS	PITTEVAL	PITTFEED	PITTOPS	PITTHD	PITTPAT	PROBERP	PROPERP	RELPER	STATE
CAUSERP	1.0000	.4358**	.5393**	.4554**	.4944**	.5247**	.4815**	.6199**	.5738**	.5239**	.5179**	.5961**	.3319**
CONCEPTS	.4358**	1.0000	.9423**	.8370**	.6419**	.7054**	.8162**	.7631**	.5765**	.4568**	.3603**	.4700**	.9246**
CONMAPS	.5393**	.9423**	1.0000	.8736**	.6767**	.7319**	.8287**	.7597**	.6377**	.4840**	.3997**	.4881**	.8758**
MODELS	.4554**	.8370**	.8736**	1.0000	.6366**	.6818**	.8227**	.6232**	.5642**	.4883**	.3724**	.5165**	.8799**
PITTEVAL	.4946**	.6419**	.6767**	.6366**	1.0000	.8930**	.7363**	.7066**	.8582**	.5785**	.2583*	.6132**	.6174**
PITTFEED	.5347**	.7056**	.7319**	.6818**	.8939**	1.0000	.7435**	.7819**	.8124**	.5695**	.3177**	.6296**	.6726**
PITTOPS	.4815**	.8162**	.8287**	.8227**	.7363**	.7435**	1.0000	.7546**	.6512**	.6588**	.4579**	.5299**	.7865**
PITTHD	.6199**	.7631**	.7597**	.6232**	.7066**	.7819**	.7546**	1.0000	.7567**	.6109**	.4678**	.5473**	.6617**
PITTPAT	.5738**	.5765**	.6377**	.5642**	.8562**	.8124**	.6512**	.7567**	1.0000	.5866**	.3124**	.5769**	.5387**
PROBERP	.5239**	.4568**	.4840**	.4883**	.5785**	.5695**	.6588**	.6109**	.5866**	1.0000	.3526**	.5517**	.3761**
PROPERP	.5179**	.3603**	.3997**	.3724**	.2583*	.3177**	.4579**	.4678**	.3124**	.3526**	1.0000	.3682**	.2811**
RELPER	.5961**	.4700**	.4881**	.5165**	.6132**	.6296**	.5299**	.5473**	.5769**	.5517**	.3682**	1.0000	.4914**
STATE	.3319**	.9246**	.8758**	.8799**	.6174**	.6726**	.7865**	.6617**	.5387**	.3761**	.2811**	.4914**	1.0000

* - Signif. LE .05   ** - Signif. LE .01   (2-tailed)   " . " printed if a coefficient cannot be computed

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