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ABSTRACT

Methods that have been employed in McGill University's (Montreal, Quebec) program of research into the nature of learning are described. The methods illustrate four phases of inquiry: conceptualization or model-building; data gathering techniques; data representation; and data analysis. For the university's learning task project, the development of a conceptual framework moved from a focus on one kind of knowledge structure to two kinds, from a set of study knowledge structures to a set of study intellectual skills, and from questions about the relationship of knowledge structures and intellectual skills to the question of what constitutes a discipline. The university has been investigating the use of semi-structured interviews with review by a third party and confirmation by the interviewed of the report based on the interview. One type of graphic representation that has been useful includes a tree structure of the most closely related concepts in a course in rank order. Data analysis involved testing the construct validity of Perry's scheme of intellectual development in the college years. Four developmental stages were postulated. A questionnaire was administered to first- and second-year students to determine convergence of measures within a stage and divergence between stages. Two pages of references conclude the document. (SW)

The evaluation of learning in post-secondary education

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As an evaluator and an educational researcher into the processes of teaching and learning in post-secondary education, I am fascinated by the array of procedures that can be used to describe and analyze the learning process. Many of the procedures that we have encountered in our studies of university courses and programs have yet to be documented. Most studies of the learning process in post-secondary education suggest a variety of methods without recognizing categories, central tendencies, or prototypes. Disciplinary boundaries are barriers to understanding, but they are minor compared to the barrier created by the lack of a vocabulary to describe the learning process in consistent, explicit and operational terms.

For the past nine years at McGill University our program of research into the nature of the learning task has delved into crannies and explored the peaks of the knowledge territory. At times we have slogged through the swamps and at others we have been terrified of precipices and crevices. One abyss has been the concept of relativity, which I have come to the conclusion was developed as a limit on the concept of determination in physics. But, while in physics, understanding was suffering from hardening of the categories, educational theory appears to be suffering from a lack of categories. In the field of educational theory, we have not yet developed models which would provide us with explanatory structure, yet we are prey to a zeitgeist which questions the possibility of concrete knowledge and grounded theory. The path through the knowledge terrain is not an easy one and, though the land is by no means a desert, there appear at times to be considerable cactus and bramble underfoot.

My intent in this paper is, then, to describe and to illustrate certain methods that have been tested in our program of research on the learning task in the university. The methods are taken from this research with comments added from the more general scene of educational research in Canada. The methods have been selected to illustrate four phases of inquiry: conceptualization or model-building; data gathering techniques; the representation of data; and the analysis of data which focuses on the measures used to assure that the research effort has been meaningful. The methods have aspects of both qualitative and quantitative approaches to research but what is most important is the recognition of criteria to judge their effectiveness.

Conceptualizing the learning task

What does conceptualization or model-building have to do with methods of research? One of the early findings of the Standing Committee for the Promotion of Research of the Canadian Society for the Study of Education concerns how research proposals are conceptualized. The committee was told that many grant proposals in educational research lack a clear presentation of the objectives of the research and why the proposed research is important. We do not put our research in context and explain it to others. During the past three years I have been a member of a committee which reviews some 120 educational research proposals annually in Quebec. The criteria for success are clearly stated in the guide for submitting proposals and the procedures for evaluating the proposals are judiciously followed. The first characteristic on which proposals are judged is the problematique or conceptualization of the problem. The problematique sets the organizational structure which will guide and govern the entire project, from data gathering to conclusions. Too often the decision of the grants committee is that the problematique does not justify doing the research. This may be because the question has not been posed in a sufficiently explicit manner, because the research literature has not been reviewed, or because the would-be researcher has neglected to state what problems would be solved by the investigation.

Why do we not pay more attention to conceptualization or model-building? I would hazard the answer that our profession places greater faith in clinical readiness than in analytic procedures: on the way to learning to survive in the highly complex milieu of education we have developed perspectives and strategies that do not honor deductive logic. Yet it is logical structure that is the hallmark of good research. Another problem that has limited educational research is that classical approaches to research design, borrowed from the natural sciences, allow the researcher to look at very few variables at one time and thus do not fit our multivariate circumstances. The computer and anthropological and sociological methodology have changed that. It is now possible, with the help of Cook & Campbell (1979), Guba & Lincoln (1981), Miles & Huberman (1984) and many others, to create a comprehensive design of what is to be examined. I do not wish to imply that the methods developed for the study of learning by psychologists have thus become invalidated. To the contrary, for methods of studying learning we in education will remain indebted to the discipline of psychology. An obvious corollary to this is that educational researchers should maintain a watch on the methods that are being used in our basic sciences, the social sciences.

To illustrate the development of a conceptual framework, let me describe how the model of the learning task project at McGill University began and changed. In the beginning, we were looking for a unit of analysis, or measurement, and decided that the simplest and most evident one was the concept, a unit of thinking, which could be found in instructional material and which was limited in size (from one word to a phrase) and in form (written). Our work was primarily descriptive: we wanted to determine what concepts professors considered to be important in individual courses that they taught, and we wanted to know what methods best described these concepts. The methods that we tested were from the psychological literature and included cardsorting for similiarity grouping, cluster analysis, word association, tree structuring and similarity rating (Donald, 1983).

After spending three years establishing the domain and the methods most useful to describe it, we then spent the next three testing the extent to which concepts could be used to describe student learning. We found, among other things, that concept knowledge predicted course achievement better in the social sciences than grade point average, although it did not predict better in the physical and biological sciences or in the humanities (Donald, 1984). We still did not understand, however, the role of concepts in the organization of a course. We therefore spent another two years doing a semantic analysis of the concepts. This analysis showed us the basic elements and relationships that occurred among the key concepts in a course, and gave us a means of showing the organizing principles in the course. In a concurrent project, we focused on the next larger unit of analysis, the proposition, and studied its function in a course. We found that by moving from the concept as unit of analysis to the proposition, we had complicated our problem threefold, but we also added to our understanding of the knowledge structures in a course (Donald & Nagy, 1985).

Doing this research we worked closely with professors. In our interviews with them and from our attempts to measure the usefulness of concepts and propositions in the evaluation of learning, we began to see the need for a shift in focus. We had been looking at knowledge structures, but when we asked the professors what they considered important for students to learn, they replied in terms of the skills, such as analysis and synthesis, that they would like their students to acquire. A literature search of the skills considered important in post-secondary education, including critical thinking, problem solving and cognitive processes led to the development of a model of intellectual skills which could then be tested in university courses (Donald, 1985). We thus found ourselves with a second, complementary model of the learning task in post-secondary education. But how did intellectual skills relate to the knowledge structures in a course? Do certain concepts or propositions imply certain skills? Are particular concepts or propositions embedded in the skills?

To answer these questions required a further shift in focus, to the broader question of what constitutes a discipline, because knowledge structures and intellectual skills interact within and are determined by discipline (Donald, 1986a). At this point we were in the realm of philosophy. Philosophers investigating knowledge suggest that different disciplines have different logical structures in their concepts and propositions, different criteria for judging the truth of propositions, and different methods for producing those propositions (Adler, 1982; Hirst, 1974; Scheffler, 1965). These characteristics obviously would have to be taken into account in a conceptualization of the learning task.

Study of the logical structure of disciplines appeared by definition to consist of finding the organization of data or ideas showing the relationships between component parts. Our research on the relationships between concepts in courses provided a starting point for looking at kinds of structure. We knew for example, that sixty percent of the relationships in our study of key concepts were similarity relationships and that forty percent were dependency (procedural, logical or causal) relationships. Recent literature in cognitive science discriminates between well and less well structured disciplines (Frederiksen, 1984). In addition to differences of degree and kind of logical structure, we could expect level of abstraction and generality to affect logical structure. We had found, for example, that key concepts in the social science courses were more abstract than those in the physical sciences. The relationship between logical structure and truth criteria appears to be intimate, since truth criteria are usually measures of the coherence, consistency and precision of logical structures, whether established on the basis of experience or agreement. We could suppose that truth criteria would play a particular role in the intellectual skill of verification, which was the skill that professors in our study of intellectual skills had declared was most important for expertise in a discipline.

The conceptual framework had thus been elaborated into a multidimensional model with four interacting sets of dimensions. Figure 1 shows the interaction between knowledge structures and intellectual skills, with the effect of logical structures and truth criteria on them. The conceptual framework has evident weaknesses. It does not show, for example, the immediate relationship of the truth criteria to verification skills, nor does it show how logical structure is found in the propositions. It does, however, make us cognizant that all of the dimensions are inter-related and that all of them play a part in defining the learning task. From this framework, for any one study, the questions which linked certain dimensions would determine which relationships would be concentrated on for data collection purposes.

Figure 1 here

For the purpose of conceptualizing a problem, my first objective in this paper, the figure provides an example of a representation of the context and scope of a problem. It is important to note that in the development of this framework, we moved from a focus on one kind of knowledge structure to two kinds, from a set to study knowledge structures to a set to study intellectual skills, and from questions about the relationship of knowledge structures and intellectual skills, to the encompassing question of what constitutes a discipline. Each step required investigation of the literature in the area, and each step was clarified by the collection and analysis of data. The importance of conceptualizing a problem by representing the component parts lies in its ability to tell me what I can expect to learn and what questions I must ask. It also forewarns me of the difficult or fuzzy areas that lie ahead.

Data collection

Collecting information about learning could be expected to be a straightforward process, since it is a necessitatum in education. Whether it consists of collecting and grading assignments or preparing school leaving certificates, information has been collected so regularly that it is background in the educational endeavor. The use of standardized tests is routine. At the post-secondary level, however, little agreement has been reached on measures of learning or achievement, and the current movement in the United States to ensure academic competencies through testing can be predicted to have a rough road ahead of it. A review of the conceptual framework in Figure 1 shows why : we do not yet have a sufficient understanding of how knowledge structures are developed and what level of consistency can be expected from them. We do not know what role intellectual skills play and how they are related to knowledge structures. We cannot yet pinpoint the logical structure of a unit of instruction, and we do not know how logical structure and truth criteria apply to the knowledge and intellectual skills that make up the subject matter. Add to this lack of knowledge the known inconsistency between experts in a subject matter area, as witnessed in the Goldman, Schoner & Pentony (1980) study of concepts considered important in the field of political science. Out of a concept inventory of just under 22,000 terms, 10 experts could agree on only eleven terms as being most important for undergraduate knowledge of political science. If we accept the principle that disciplines are continually developing, then data collection on the learning task requires interactive qualitative methods that can be used to measure both consistency and rate of development over time.

This is not to say that quantitative methods are not useful. In our study of student learning of concepts we had students define the key concepts, and we then scored them and performed multivariate analyses on the variables affecting learning. The results were worth the trouble in one final year course in the sciences where the sources of extraneous variability were at a minimum. What I am suggesting is that, given the state of our knowledge about the variables affecting learning, and the nature of the learning task itself, a great deal of frankly exploratory work has to be done before we can achieve the level of conceptual precision which merits the use of quantitative methods.

Given these limitations, we have been investigating the use of semi-structured interviews with review by a third party and confirmation by the interviewee of the report based on the interview. The step of producing and reviewing a report of the interview is the closest we have come to a reliability check, and even though it requires a great deal of labor to produce it, it appears to be integral to the process in terms of maintaining both our records and the support of the professors who work with us. The interview structure is developed from the questions that arise in the conceptual framework of the project. We have learned to go to an interview equipped with a model of what we want to know, and to be prepared to come away with the professor's perspective of what we should want to know. Flexibility in our approach to interviewees is essential. Some professors require time to explain their own perspective before they will look at our conceptualization. Some require that the conceptual model be left with them so that they can examine it and formulate their responses over time. Some reject the notion that their subject matter can be described. We have to be both elastic and persistent over a period as long as a semester, and we must expect to be open to a broad spectrum of ideas of what constitutes the learning task. Each professor has a perspective on learning, some of which are quite elaborate, and the perspectives provide tests of the consistency and scope of our model.

Why, then, go in with a structure at all? There are two reasons that our experience would support. First, without a structure we would be in danger of information overload from the wealth of experience each professor possesses on the subject matter of teaching. Second, we have found in our research that the framework that professors have of what constitutes teaching may be far removed from the framework we are investigating. We discovered this several years ago when we interviewed professors about their evaluation techniques and found that they, instead of talking about how they evaluated learning, talked about the instructional process. The interviewer, therefore, in addition to being flexible and persistent, must be able to reroute the conversation back to the specific interview questions. A final criterion of the successful interview is that it be enjoyable and worthwhile to the professor. We have interviewed students and reimbursed them for their time spent, but the time of the professor is both much more limited and nonreimbursable. It is therefore important that the professor come to the end of an interview with positive affect, feeling that he or she has made a contribution and that it has been appreciated. In the written report that we ask the professor to verify, we express our appreciation of their contribution and invite their advice.

What form should such an interview structure take? We operate with the expectation that the professor's time is limited and valuable and we therefore proceed immediately to a description of what kinds of information we would like them to give us. We provide them with a copy of our conceptual model, inviting them to become co-researchers with us, and we also provide them with the set of questions we need answers to. There is no requirement that the questions be answered linearly, that is, without returning to previous questions. One of the interviewer's responsibilities is, however, to record the interview on a taperecorder so that the answers can be located with reference to the questions. At the same time the interviewer is expected to explain and to work with the professor to elucidate the model and provide examples of it. Over the years I have found that senior undergraduate students who have a good sense of the university context make superb interviewers, and I have found that they are more doggedly persistent and can use a naive strategy which supposes nothing and therefore garners more specific information in answer to the questions than I could. We try to do interviews in parallel, that is, with two professors from an area of specialization, in order to increase our understanding of what is essential to the domain, and we have two editors from the research project producing each report to ensure its readability and meaning.

This data collection procedure, cumbersome though it may appear, allows us to go beyond our framework while getting answers to the questions we intended, and it enlists the aid of the people who are most important to our project, the subject matter experts. They are invariably willing to discuss and to continue working with us, and some have stayed with our project for over eight years now. This is an essential resource if we are to understand the learning task.

Representation of the data

A few years ago, Tukey (1977), in the book Exploratory data analysis, suggested that data collected deserved a careful perusal before being subjected to statistical analysis. His methods of descriptive analysis of data into, for example, stems and leaves, revealed form and pattern, that is the spatial organization of the data, which allowed us to understand our data graphically. Just as a conceptual framework allows us to see what theoretical relationships we should be testing, representation of the data allows us to see empirical relationships and the overall organization of it. I have argued that the act of representing knowledge has a particularly important function in the learning process, that of embedding declarative knowledge into procedures or larger structures which can then be more readily retrieved and utilized (Donald, 1986b). The act of representing data requires analysis of the elements and relationships and their organization into a structure. Representing data is thus a dynamic inferential process.

In our studies of knowledge structures, two forms of graphic representation produced patterns which the professors found useful. The first produced a tree structure of the most closely related concepts in a course in rank order. This sequential procedure for choosing concepts constrained the representation and tended to limit the total number of interrelationships. Shavelson and Geeslin (1975) had used this method to relate sets of concepts within a small unit of instruction in well structured subject matter areas (physics and mathematics). We applied the method across disciplines on the most important concepts in a university course, and found different patterns across disciplines. For example, the pattern in the physics course was highly regular and hierarchical, while those in the social sciences tended to take the form of webs or clusters. The degree of structure in a course tended to be reflected in the tree structure in the number of links between concepts, so that the tree structure could be used as an index of how well structured learning material actually was.

The second form of graphic representation which we applied to our data in the cognitive structures project was a form of graphic analysis developed by Waern (1972), which did not require a stepwise linkage but instead used a rating of degree of relationship which was then transferred to paper to show equally strongly related concepts. The Waern graphic analysis produced a parallel form of representation which could then be compared with the tree structure for the same set of concepts. The consistencies between the two representations were proof of the relationships between concepts, but the differences were also revealing. For example, concepts which were loosely linked in the philosophy course tree structure showed much more extensive relationships in the graphic analysis (Figures 2 & 3). Groupings of concepts such as virtue, morality, morals and duty were more clearly visible. Thus the graphic representations suggested hypotheses about the concepts which could then be followed up in a interview with the professor.

Figures 2 & 3 here

A third form of graphic representation which we developed in our study of the key concepts from selected courses built in the logical structure of the concept. In order to show how elements of a concept contributed to its meaning, we had to introduce rules which would say whether one element of the concept was hierarchically related to another or whether one element affected another. For example, behavior is changed through a reinforcing agent (Figure 4). This is represented by an arrow from the agent to the behavior. The act of representing the concept required the specification of rules which could then be used to understand the relationships engendered by the pattern.

Figure 4 here

Each form of graphic representation allowed us to become more explicit about the relationships between elements, and suggested the pattern or organization of the important concepts in a course or the individual concepts themselves. The representations not only provoked discussion about the structure of knowledge, but gave direction for instructional paths to be followed or avoided. For example the philosophy course representations would suggest that good and virtue are pivot concepts and should be focussed on as the conceptual foundation of the course.

Figure 5 here

A more classic form of representation which we used to compare the descriptive elements and relations of key concepts in a course was the matrix. In the psychology course on Thinking, for example, the representation of the common concepts and elements showed us that internal models of the world, cognitive structures, and schema were composed of the same elements and had, therefore, a high degree of similarity (Figure 5). In our recent research on the intellectual skills developed in university courses, we have been using spread sheets to show the use of skills in particular courses, their development, evaluation, and their importance for expertise in the discipline. The spread sheet allows one to compare different elements in a model for their utilization in a particular situation. For example, in the educational research course, on entry to the course students were expected to be able to use only one of the selection skills, identify critical elements, out of four (Figure 6). The other three skills, choosing relevant information, ordering information in importance, and identifying critical relations were to be developed in the course. The representations frame the data base, show scope and limitations, identify the organizing principles, arrange the data into a gestalt, and allow us to verify the components and the connections between them. Evaluation research has developed methods and models of illustrating data in order to explain complex findings to a lay audience (Patton, 1981; Stake, 1975). As educational research increasingly deals with more complex variables and relationships, representation becomes a crucial step. It is an essential precursor to making inferences or synthesizing. It is expected that tables and figures will be used to describe statistical, that is, inferential and verification procedures; I am suggesting that we begin to think graphically two steps before.

Figure 6 here

Analysis of the data

The greatest variability occurs in educational research in the degree to which and the methods by which data are analyzed. With backgrounds in such diverse disciplines as history and mathematics, educators have a confusing variety of approaches to choose from. A variety of criteria for judging the validity of results, from coherence to statistical significance also exists. Some would say that the variety is sufficiently great to impugn our credibility as scholars. With this richness of possibilities, how is educational research to be authenticated? An example of the data analysis procedures which we followed to test a model of intellectual development in post-secondary students became a search for criteria of validity. (Bateman & Donald, 1986).

The model, Perry's scheme of intellectual development in the college years, posits four broad stages or positions which students go through (Perry, 1970). In the first stage, dualism, the student views the world and knowledge in absolute terms: things are either right or wrong, and the teacher knows the correct answer. In the second stage, multiplicity, the student begins to recognize the authorities' contrasting viewpoints but sees contrasts as the authorities' way of making the student locate the right answer. Students in the third stage, relativism, are aware that there are no right or wrong answers. They recognize the need to analyze and evaluate. In the final stage, commitment, students have developed their own point of view, recognize that it is their own, and are able to act according to it. The question that we asked was whether this model did indeed describe student development.

But how could we test this? Since we had four stages of development postulated, one test would be to see if different measures of each stage measured the same thing, that is, response to different statements describing each stage should converge. According to Cook and Campbell (1979), convergence of measures within a stage and divergence between stages would be proof of construct validity. We also were aware of research done on the construct validity of measures of cognitive structure by Shavelson & Stanton (1975).

A 16 item questionnaire was developed from items used in the research literature to describe the four stages and was administered to students in their first and second years of college. To test for convergence within stages and divergence between, a correlation matrix was computed between all items. If the model held, we would expect significant correlations within stage and non-significant correlations between the four stages of dualism, multiplicity, relativism, and commitment. We found 67% significant correlations for the four commitment items and 50% for the items from the other three levels. Convergence was therefore not great. Outside the stages, however, the percent of significant correlations was 28%. Thus we had greater convergence in than out. Further exploration showed that few of the significant correlations occurred between dualism items and others (10%), and that the percent of significant correlations among the items describing the more advanced levels of intellectual development (46%) closely approximated the percent of significant correlations among items within three of the groups. This suggested that dualism items were not related to those at other levels, but that the three more advanced stages were somewhat related.

More intensive study of the items based on their correlations suggested that other factors might be better able to explain student development. For example, three of the four statements describing dualism referred to knowledge as the accumulation of facts. Three relativism items had the theme of the development of an individual point of view. A principle factor orthogonal varimax analysis was therefore done to reduce the 16X16 correlation matrix and yielded five factors. The first three factors were students' responsibility for their own learning, using evidence, and recognizing one's own point of view, and each factor had its highest loadings from items from the three more advanced stages. The fourth and fifth factors, finding the right answers and the teacher's role as giver of knowledge, encompassed the four dualism items. Thus instead of four stages, we had found five factors. A second factor analysis was performed to test divergence more directly among the four stages. To do this the scores on the four items in each level were combined by student. Only one factor, dualism, was extracted. There was no evidence of divergence among multiplicity, relativity, and commitment items. We could conclude, therefore, that rather than four stages of development, Perry had found statements which describe two broad levels of intellectual development.

These procedures established that Perry's scheme had limited construct validity, but what would tests of the scheme against other measures of student development reveal? What kind of empirical validity could be expected of the scheme? To test this, the responses of first and second year students were compared, and students' responses were regressed on their cumulative averages. First and second year students did not show a different response pattern, suggesting that if a change occurs, it does not occur between the end of the first year in college and the second. Significant correlations were found however, between students' cumulative averages and dualism scores (negative), and commitment scores (positive). Thus, although a year in college did not affect responses the questionnaire, student ability did. Again, some support was shown for two broad levels of development.

The analysis necessitated a major change in the way we thought about this model of intellectual development. The account has been simplified to spare you the gnashing of teeth and grinding of computer results. Given our results, we ask how many models being used to describe educational processes have been checked for validity? We ask ourselves if the validation process is always this difficult? We know that we must continue to do this kind of exploratory analysis of results, then follow it up with confirmatory analysis. Doing this kind of analysis is both compelling and dangerous. We sought only to confirm a way of describing student development; we ended up with a rival paradigm.

These methods used to study the learning task have certain aspects in common. They are exploratory. They involve a conceptualization which is then represented. They require logical justification procedures and criteria. There is uncertainty in all of them. They make a statement to the effect that they are all conceptualizations, not the ultimate truth. But they can be tested, and they can be replicated. They can be examined for the number and kind of instances in which they hold and for their precision and coherence. They do not confirm, but they challenge. They are time consuming, but they are creative, one could almost say aesthetic, endeavors.

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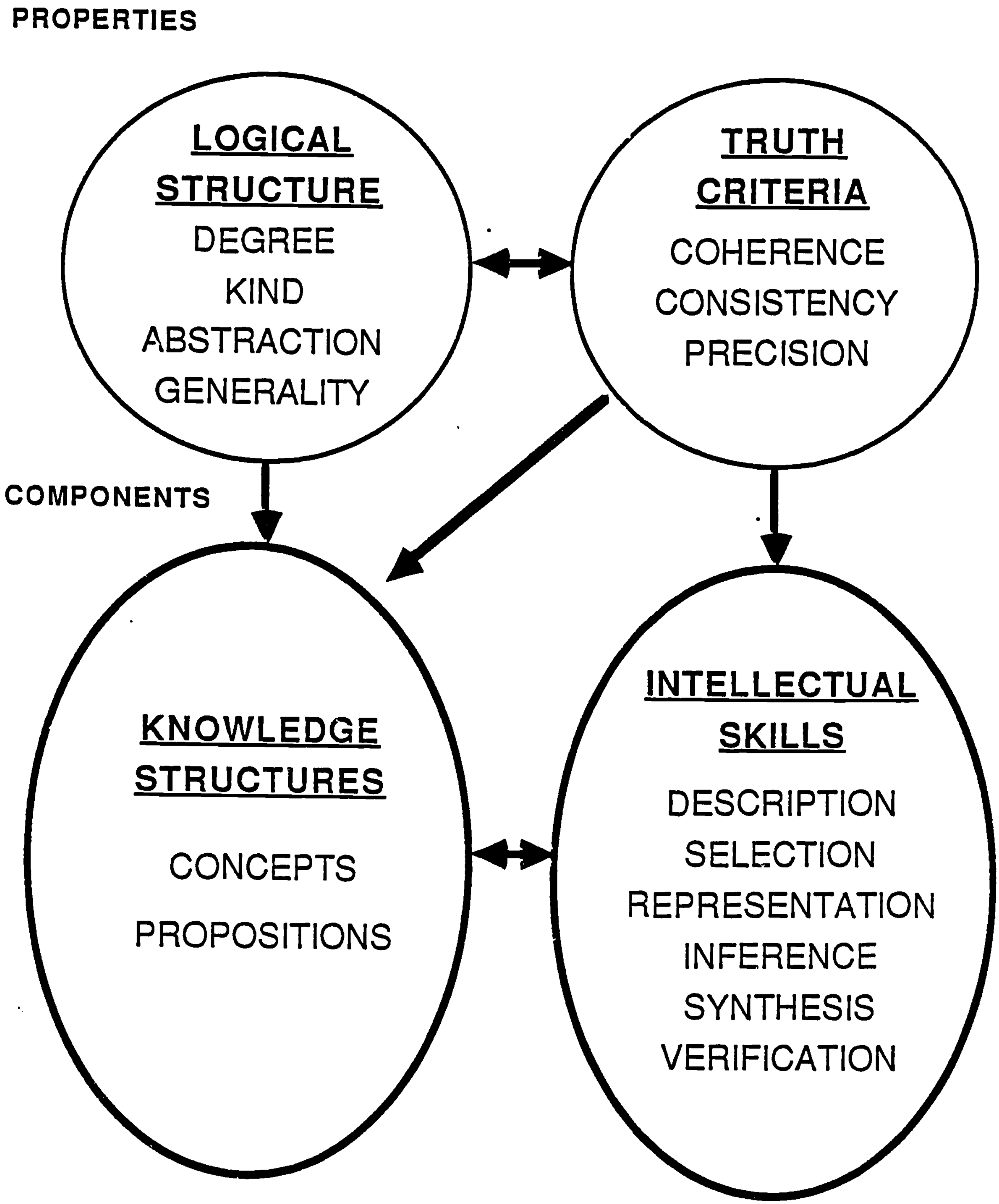

FIGURE 1 CONCEPTUAL FRAMEWORK OF THE LEARNING TASK IN THE UNIVERSITY

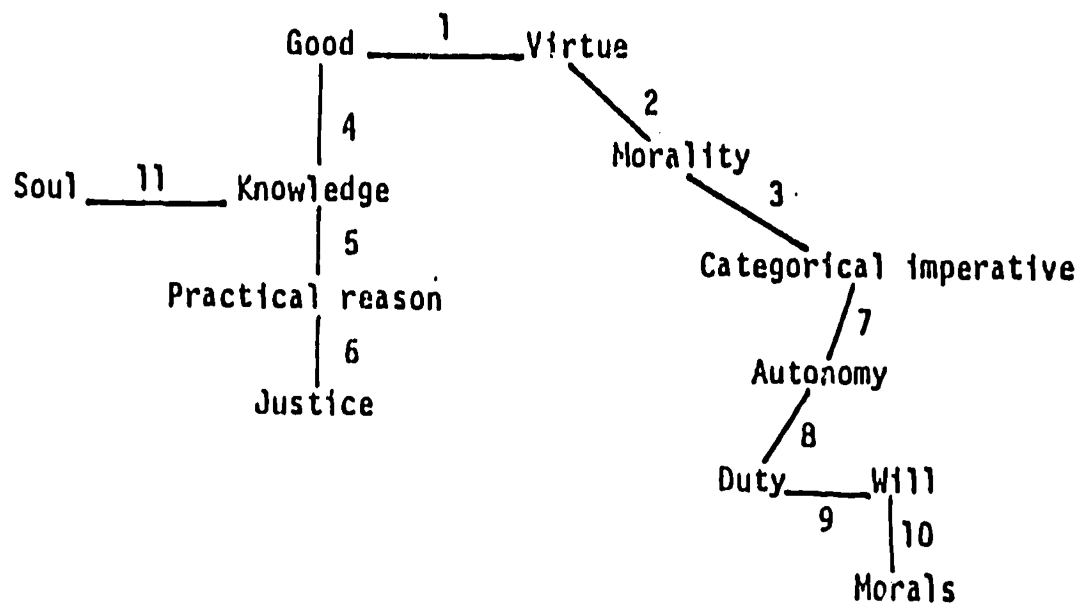

Figure 2: Moral philosophy tree structure.

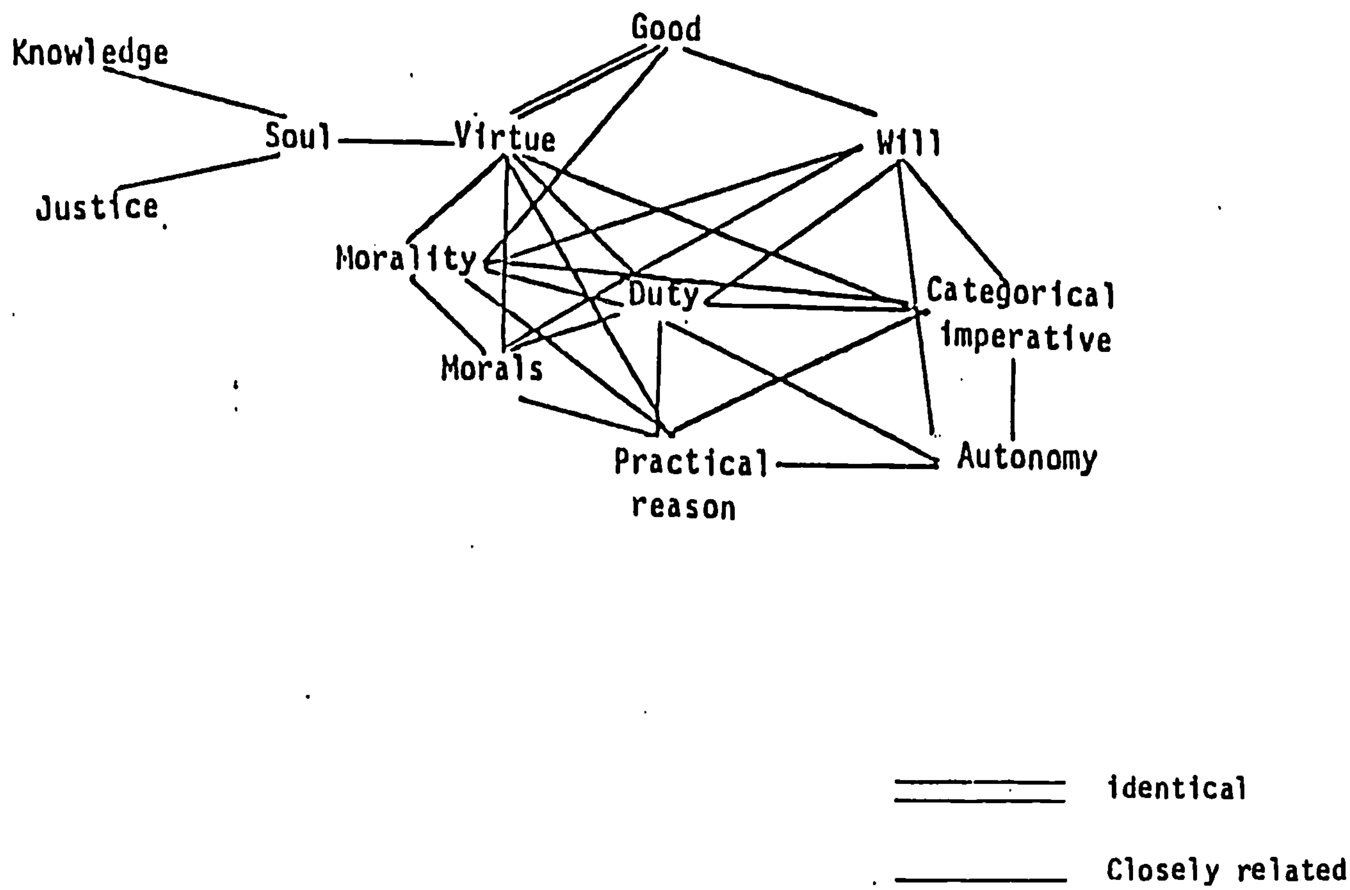

Figure 3: Moral philosophy course Waern graphic representation.

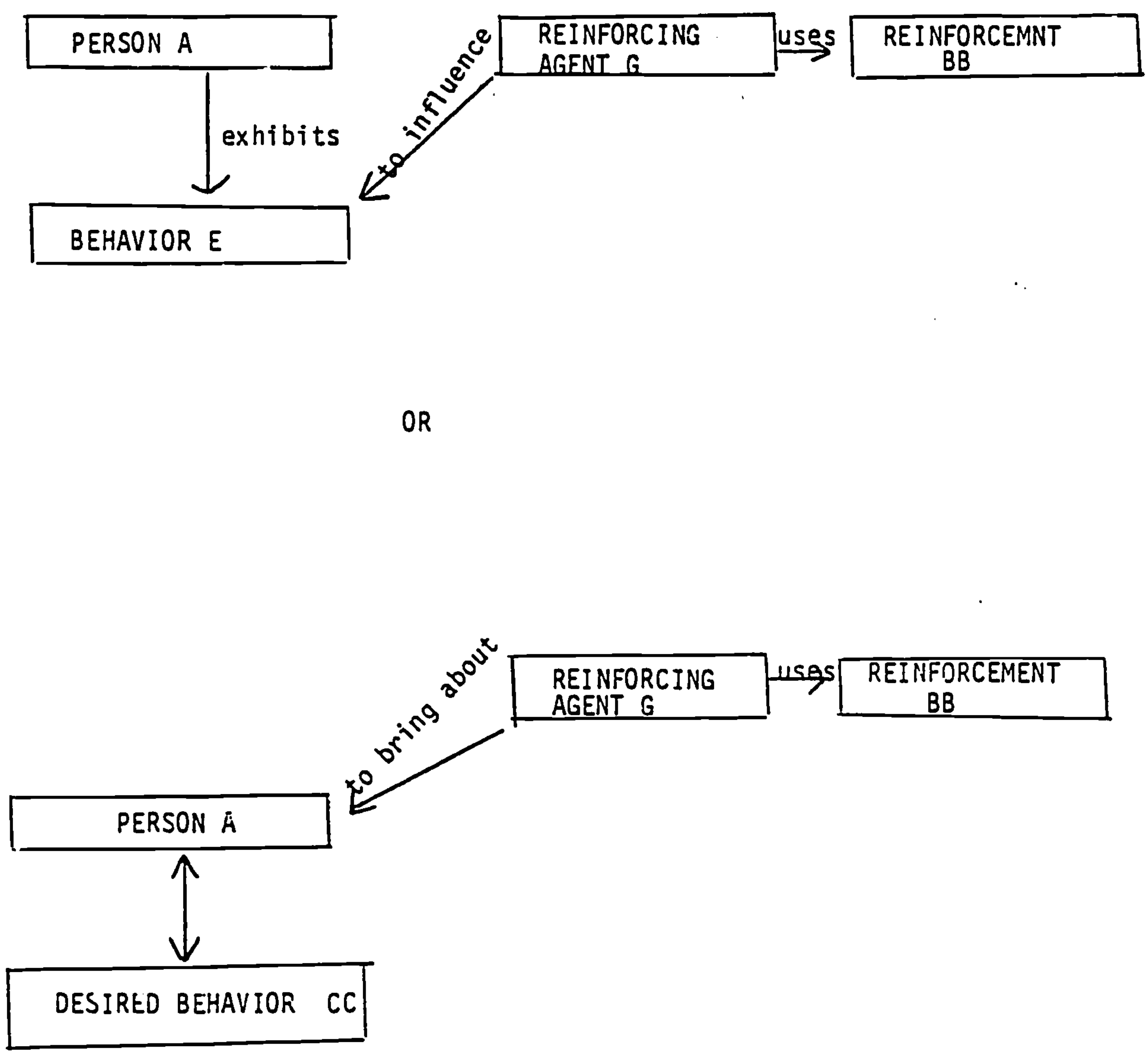

Figure 4: Network diagram of concept behaviorism.

	Mechanism	Goal	Problem	Procedure	Medium	Process	Environment	Retrieval	Storage	Brain	Representation	Symbol	System	World	Information	Knowledge
THEORIES										•	•	•	•	•	•	•
INTERNAL MODELS										•	•			•	•	•
COGNITIVE STRUCTURES										•	•			•	•	•
SCHEMA										•	•			•	•	•
IMAGINAL SYSTEMS										•	•		•	•	•	•
SYMBOLIC SYSTEM										•	•	•	•	•	•	•
LONGTERM MEMORY					•			•	•	•	•			•	•	•
CONTEXT							•			•	•			•	•	•
HEURISTICS		•	•	•												
ALGORITHMS		•	•	•												
SEARCH PROCEDURES	•	•	•	•												
CENTRAL PROCESSING					•						•	•		•	•	•
DATA-DRIVEN PROCESS					•						•	•		•	•	
LANGUAGE											•	•	•	•	•	•

Figure 5: Matrix of common elements in the key concepts in the course on psychology of thinking.

	USED BEFORE	ABLE TO USE IN COURSE	DEVELOPED IN COURSES EXAMPLES	EVALUATED IN COURSES/ METHOD OF EVALUATION	USED IN DISCIPLINE
		•	• vocabulary, statistical terms, define	• student understanding	•
al					
s					
	•				
ons					
			purpose of study		
			• topic and paper selection	• measure organization	•
t information			• what to keep/what to discard	•	
ion in importance			• literature review/course sequence	•	
cal elements		•	• statistical variables	•	
cal relations			• relation between variables	•	
l		•	• think in new paradigm		•
nizing principles			• cause and effect, correlation	•	
nts and relations				•	
ments and relations					
s and relations	•		editing, calculating		
			• generalizations	•	•
elations between elements			• linking separate literature articles	•	
ions between relations			•	•	
alences			• proposing new relations	•	
tive					
			•	•	
			•	• how well work is put together/creative	• a lot
to form a whole					
			•	•	
ng links			•	•	
of action					
			•	• evaluating students' ability to model	• a lot
ative outcomes					
e to standard			• examples, feedback, group work	•	
				•	
s					

Figure 6: Intellectual skills developed in educational research course.