Extracting an Education from a Course of Instruction

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Abstract

Instruction is a valid and useful aspect of education, although for meaningful and valued learning to take place there must be some reorganization of the material by the learner. Psychological tools which have been offered to the learner in the past to bring into his awareness the structure of his models and his model-building facilities have been on the whole unhelpful. The repertory grid is one such tool which with the new methods of computer analysis developed by the authors has been transformed into a sensitive instrument that allows an individual to form a model of any topic he wishes in terms of his personal constructs. The computer programs FOCUS, PEGASUS, MINUS, CORE, SOCIOGRIDS and ARGUS are briefly described.

Introduction

What is an education? Most people have an opinion on what an education should be, but to express the view in precise terms is difficult and achieving it is even more difficult. It seems that there is a current trend towards a more 'humanistic' approach in education, to equip the person to lead a full and satisfying life and to be a competent and creative person in his own world. However, an important part of education is instruction, which involves the convention of doing things in the traditionally most successful way. One example of this is the literacy and numeracy which we see as useful accumulated experience of the human race.

Perspectives of learning

Jahoda and Thomas (1965) have developed a 'science of learning conversations' in which the learning experience can be viewed from different perspectives. Figure 1 shows the four quadrants: quadrant 1 represents the learner's anticipation of the event, whereas quadrant 2 represents the teacher's objectives. Quadrants 3 and 4 denote a retrospective view of the experience from the points of view of the learner and teacher respectively. Each of the quadrants 1 to 4 represents a valid point of view. Much of the learning in quadrant 3 which is retrospectively valued by the learner is unexpected and unplanned, whereas traditional objectives are based on the learning seen in quadrant 2, that which is prospectively defined by the teacher. The latter came to be valued through Skinner's success with the training of animals which later led to the development of programmed instruction for human learning (1959). Learning in quadrant 1 is exemplified by the Japanese archer described by Herrigel (1972). This is where the learner either has identical purposes to the teacher, or at least partially suspends his own values and judgement in order to take on those of the teacher temporarily. Learning is a two-way process in which a special relationship is established between the learner and

teacher. Quadrant 4 denotes the learning which is retrospectively defined by the teacher who is sometimes both surprised and pleased at the changes which have been initiated during the event.

Figure 1. The science of learning conversations

Purpose	Learner	Teacher
Prospective	1	2
Retrospective	3	4

The value of instruction

Much of what is done in secondary schools, colleges, polytechnics and universities comes into the category of instruction. Dearden (1967) has said that we must be on our guard not to think of instruction as being brow-beating and hectoring by an offensive teacher. Indeed, instruction is an important and useful part of education which passes on to the next generation a coherent body of knowledge, skills and values which by tradition and convention have become accepted as the most successful methods of operation. In societies where scientific and technological understanding is in the early stages of development, this is essential to maintain progress and make good use of the accumulated experience of the human race. In industrial training, instruction can be the most efficient way of handing on values and skills. However, for it to become effective learning it must produce a change in the learner which is valued by the learner. If the learner's retrospective values align with the trainer's prospective purposes then the instruction has been successful and the learner is able to incorporate his experience into his meaning system. Illich (1971) warns against instruction which fails this condition, and robs people of their creativity.

It is necessary in secondary and higher education as well as in the primary school to relate the construction of personally relevant meaning to bodies of established knowledge and traditional educational disciplines. The teacher must steer a careful course between the Scylla of unquestioned dogma and 'facts', and the Charybdis of permissiveness which leaves the learner's mind in a state of confusion and avoids the wisdom of past generations. In current times the 'facts' of technology are changing within a five- or ten-year time scale. Over the last decade electronics have developed from the use of valves, through transistors to chips and microprocessors. Consequently education must prepare the learner for a world where knowledge is changing, where flexibility and adaptability are the hallmarks of success. This implies a real need for self-organization in learning. Learning requires an attitude of mind which may run counter to being taught or effectively instructed, although a proficient learner is able to extract an education from a course of instruction.

Facilitating learning

Many bright young people, both children and adults, experience unnecessary learning difficulties. The current experience of the first author with this problem is in an education department of a polytechnic where mathematics are taught not only to

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students who choose to specialize in the subject but also to all the student teachers in initial training. A frequent request to 'show me how to do fractions' indicates how basic some of these difficulties are. This is generally due to an inadequate personal meaning system which fails to provide a general frame of reference in which to lodge the concept firmly. Consequently, it soon shifts a little to become vague and unusable.

Although mathematics seem particularly susceptible to learning difficulties, there is no reason to assume that this is only true of mathematics. The problem is then to investigate the current state of the learner, and start from there to help him rebuild more useful and usable models.

Facilitating learning is usually done in one of two ways: by organizing the content so that it slips in unobserved, or by enabling the learner to handle less palatable material. A good infant teacher intuitively does this very well, but the problems increase with the age of the learner. The techniques used by the teacher of young children take account of the fact that it is relatively easy to gain the attention of the infant, and temporarily interest him or her in new things; the content is not over-emphasized but is often less important than the activities and processes of learning; and most important, there is less discrepancy between what the infant thinks and feels and what he or she says. Consequently, to find where the child is and to start from there is a feasible proposition. In the secondary school and in further and higher education the learners—children or students—may have developed in many directions and the adage 'start from where the learner is' becomes almost impossible for all but the 'born' teacher to do intuitively. Blishen (1969) sums up the situation in terms of the personal involvement of the child in the learning process.

Techniques in psychology

Psychology has offered the teacher many techniques for discovering where the learner is but very few of these have proved to be of lasting value. Questionnaires, attitude scales, and many observation techniques are intended to do just that. However, they all presuppose that the learner can use the terms offered to him, but too often the categories seem inappropriate to the teacher's own understanding of events.

However, there is a technique in psychology which does allow a person to discover the terms in which he experiences attitudes, thoughts and feelings. This is the Kelly repertory grid. George Kelly (1955) developed the theory of personal constructs to explain how similar events could produce quite different behaviour in different people. He suggests that each person has a unique system through which he experiences life, the individual's system of personal constructs acting like a pair of spectacles focusing and colouring the world.

The repertory grid

In a grid the universe of discourse is represented by a set of elements, and a construct is a bipolar ordering of these elements. In the following example, Mr Smith is thinking about various techniques of presentation he could use on a short in-service course for teachers. The elements are the techniques of self-learning, using an overhead projector, lecture, games, film, and case study. In beginning to elicit a repertory grid from Mr Smith three elements are selected (say self-learning, OHP and lecture). He is asked to

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consider them as techniques for presenting the course. 'Now if you consider each of them holistically, as techniques that you could use, which two seem most alike and which one seems most different from the other two?' Mr Smith thinks about this for some time and then he replies, 'OHP and lecture are similar and self-learning is different.' He is then asked what it is about these two which makes them similar and he replies, 'They are unreal'. Mr Smith is then asked what it is about self-learning that makes it different. He says, 'Oh, self-learning is real'. Mr Smith has now revealed his first bipolar construct.

Unreal	V	Real

The person eliciting the grid faithfully records Mr Smith's terminology. The repertory grid and each construct in it are taken to be samples of how Mr Smith thinks and feels about his teaching techniques *in his own terms.* He is now asked to assign the three remaining elements — games, film and case study — to one or other pole of the construct, with the following result.

games and film with OHP and lecture	and	case study with self-learning

The repertory grid form is usually filled in as follows.

Figure 2. Mr Smith's first construct

	o...Pole 1...o	E1	E2	E3	E4	E5	E6	x...Pole 2...x	
C1	Unreal	[x]	[o]	[o]	o	o	x	Real	C1

Case study
Film
Games
Lecture
Overhead projector
Self-learning

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In this form assignment to pole 1 is represented as 'o' and assignment to pole 2 is represented as 'x'. The original three elements which were used to elicit the construct (self-learning, OHP and lecture) are known in the repertory grid jargon as 'the triad'. In this form the responses assigned to the triad are boxed.

The second construct is elicited in the same way. Games, film and case study are used as the second triad. Mr Smith puts games and case study together as 'active' and says a film is 'passive'.

Four more constructs are elicited and each time all the elements assigned to one or other pole. The complete *raw grid* is shown in Figure 3. (It will be noted that each technique has been equally represented in the triads.)

Figure 3. Mr Smith's raw grid

Raw grid for teaching techniques

o....Pole 1....o	E1	E2	E3	E4	E5	E6	x....Pole 2....x	
C1 Unreal	[x]	[o]	[o]	o	o	x	Real	C1
C2 Active	o	o	x	[o]	[x]	[o]	Passive	C2
C3 Safe	[x]	o	o	[o]	[o]	x	Risky	C3
C4 High impact	[o]	x	[x]	[o]	x	o	Low impact	C4
C5 Entertaining	o	[o]	x	o	[x]	[o]	Boring	C5
C6 Formal	x	[o]	[o]	x	o	[x]	Informal	C6

Case study
Film
Games
Lecture
Overhead projector
Self-learning

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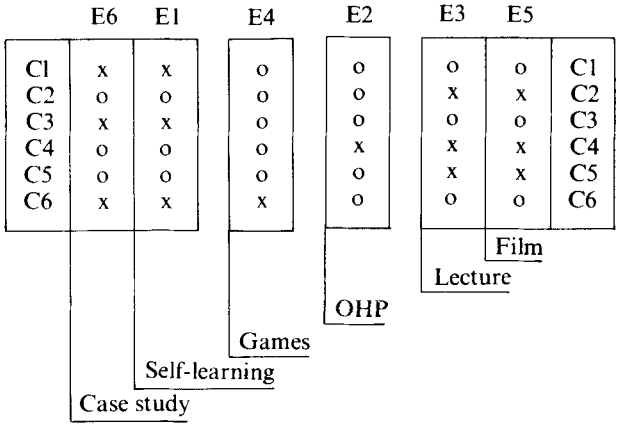
In its raw form the repertory grid presents the elements in the order in which they were originally named and the constructs in the order in which they were elicited. But this is not the best form of presentation from which to abstract the full meaning of the responses. Visual inspection of the elements reveals that self-learning and case study have been similarly assigned to the constructs. Lecture and film have also been assigned similar responses. The meaning of the grid is partly clarified by re-ordering the elements.

Figure 4. Sorting the elements



Now visual inspection reveals that constructs C2 and C5 contain a similar pattern of responses and that C1 and C3 are also the same. Thus re-ordering of the constructs produces the following.

Figure 5. Sorting the constructs

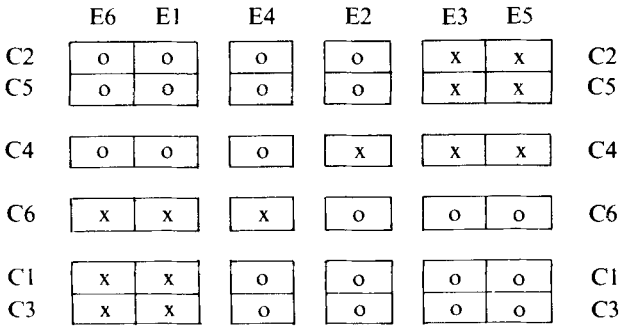


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Figure 6. Mr Smith's focused grid

Focused grid for teaching techniques									
o....Pole 1....o		E6	E1	E4	E2	E3	E5	x....Pole 2...x	
C2	Active	o	o	o	o	x	x	Passive	C2
C5	Entertaining	o	o	o	o	x	x	Boring	C5
C4	High impact	o	o	o	x	x	x	Low impact	C4
R C6 R	Informal	o	o	o	x	x	x	Formal	R C6 R
R C1 R	Real	o	o	x	x	x	x	Unreal	R C1 R
R C3 R	Risky	o	o	x	x	x	x	Safe	R C3 R
		Case study		Self-learning	Overhead projector	Lecture	Film		

Finally, since the constructs are bipolar, the pole descriptions and the associated 'o' and 'x' codings can be reversed without changing the underlying meanings in the responses. Thus, in the example, constructs 1, 3 and 6 can be reversed showing E6 and E1 as having all 'o's and E3 and E5 as having all 'x's.The focused grid shows that Mr Smith sees films and lectures as unreal, passive and boring with a low impact, but safe and formal. On the other hand, he sees self-learning and case studies as real, entertaining, active, informal ways of presenting material, that are risky and have a high impact. He has mixed views of the overhead projector and games. But the grid reveals more about Mr Smith than it does about presenting material to students. It shows the terms in which he thinks and feels about the techniques. (In practice a grid usually contains more than six elements and six constructs.) It shows how his different thoughts and feelings relate to each other. On the evidence of these six elements, Mr Smith feels that

(a) passive methods are boring but when the students are active they are also entertained
(b) formal methods have low impact and informal methods have high impact
(c) the techniques which are real are also risky whereas the safe techniques are unreal.

These meanings in Mr Smith's grid can be discussed with him. The fully *focused grid* presents the meaning contained in the responses recorded in the raw grid in such a way as to make it explicit. Talking people back through their focused grids raises their

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awareness of the structure of thoughts and feelings that lie implicit in their more intuitive judgements and decision-making. Usually a five- or seven-point scale is used to enable a more sensitive positioning of the elements on the constructs.

Analysing the grid

The problems of the analysis of the grid for feedback purposes fall into two major categories: methods for exhibiting pattern and structure in the grid responses, and methods for psychological scaling in general. The traditional methods of grid analysis have been the D^2 (non-metric) method of factor analysis (G A Kelly, 1955; Osgood, Suci and Tannenbaum, 1957; J V Kelly, 1964; Bonarius, 1965), other methods of factor analysis both metric and non-metric (Cronbach, 1955; Coombs, 1964), principal component analysis (Slater, 1964; 1967; 1968; 1972), and multidimensional scaling (Torgerson, 1958; Shepard, 1962; Kruskal, 1964; Coombs, 1964). These three methods are quite closely related, the main differences being in the number of dimensions extracted and the form of representation used. The use of the term 'non-metric' indicates that only ordinal properties of the data are assumed (Shepard, Romney and Nerlove, 1973). There are many arguments to be put forward for and against each of these methods. More recently cluster analysis has been used to identify patterning in the grid responses. (Rosenberg, 1976; Thomas, 1971.)

Whichever method is used to analyse the grid, the subject or user must be reassured that the 'computer' has not invented or misconstrued his/her intentions, or the experimenter imposed his own meaning system on the results. Although willing to be impressed and overwhelmed by complex computer output neither the experimenter nor the subject is always willing to try to understand it. It is important, therefore, that for human interaction the computer is used as a tool by the psychologist as craftsman to help him to tease out forms and structures which are natural rather than imposed. This attitude leaves the computer in a subservient relationship to the psychologist, not one in which the psychologist has to accept the demands of the computer in terms of language or communication.

FOCUSing the grid

There are several types of cluster analysis available, but the FOCUS algorithm was developed by the authors (Thomas and Shaw, 1976) especially to make the patterning of the grid responses meaningful to the subject and suitable for talking him back through the connections made partially visible during the elicitation process. This is done in two ways. Firstly, the procedure is very simple. Although it is carefully validated mathematically, and complex subroutines are used to wind up and unwind the clusters as they are identified, the computer output is very simple. The maximum given is: the two matrices of element and construct matching scores, the focused grid and the two trees of clusters which are fitted on to the grid; and this can be reduced by choice to just those pieces of output required. The focused grid is clearly only a rearrangement of the raw grid responses, as shown in the example and the mathematics is almost hidden. The subject is therefore not disturbed by 'mathematical magic' being performed behind his back, or factors produced out of a hat. He can imagine how the transformation could have been performed, and can see his own actual grid responses

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on display. Secondly, on the level of the actual content of the results, the rows of constructs and columns of elements have been sorted in such a way as to produce least change between any two adjacent rows or columns down and across the grid, together with visual diagrams showing the extent of the similarity of adjacent lines. The grid analysis results can then be fed back to the elicitee, and lend themselves easily to self-interpretation by the user of the grid.

The grid as an articulator of conversation

Used in a conversational mode with this type of analysis, the grid can be an articulator of conversation, the clustering of responses providing a starting point for discussing individual differences and points of view. One may begin to empathize with a person by seeing how he makes his divisions, and why he groups his elements in a particular way.

If the grid user approaches the technique with a view to heightening his awareness of himself in the light of the sorts of differentiation he does and might bring to bear in a particular universe of discourse, he may be able to distinguish the structural foundations of his psychological modelling. Kelly envisaged a personal scientist as anticipating events and acting on the basis of that anticipation; the quality of a person's models are directly linked to his skill and competence in anticipation. If the technique of grid-elicitation together with grid-feedback is used in a 'learning-centred' way the models may be brought into awareness, revised and refined, or even rebuilt to enable learning to be more successful in those areas where inadequate modelling was hindering the learning process. Creative change is the essence of learning, but change can too easily take place in such a way as to have no anchoring points, and hence to act as a disruptive influence so as to force the frustrated learner to resort to his old ways and models. Support is needed for anchoring to take place, and the support can be reliably given by the content-free, elastic but firm structure of the grid.

PEGASUS—a computer-aided repertory grid elicitation

PEGASUS or 'Program Elicits Grid And Sorts Using Similarities' is an on-line interactive computer program which elicits a repertory grid from the user (Thomas and Shaw, 1977). It uses real-time analysis of the structure of the developing grid to provide feedback during the elicitation. This encourages the user to explore, clarify and elaborate his own thoughts and feelings whilst 'in conversation with the computer'.

Before choosing his elements the user is asked to think about his purpose for eliciting the grid. This is of great importance for the interaction which is to follow, as it sets both the intentionalities and the universe of discourse. The mutual dependencies of the elements on the purpose, the constructs on the elements, and the purpose jointly on the elements and constructs, contributes to the satisfaction and satisfactoriness of the process of elicitation. The authors have used a variety of elements related to a wide variety of purposes. Some of these have been significant learning events, audio-visual equipment, graphic art, architectural styles, examination scripts, prospective careers, mathematical concepts, and books.

The feedback concerns the matching or similar use of constructs, and the matching or similar use of elements; and gives opportunities to act on the information given at each stage. Very little structure is imposed on the user, and a variety of choice is given wherever possible.

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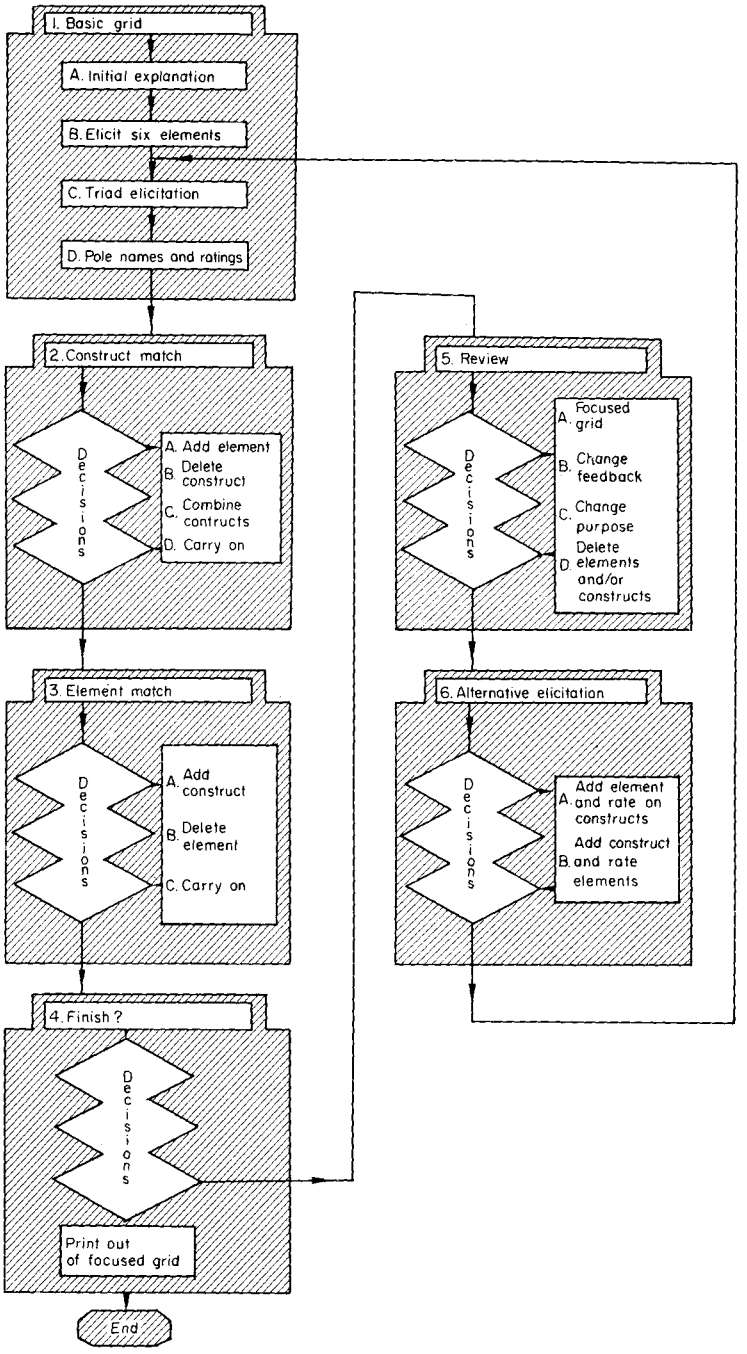
Figure 7. Flowchart for the PEGASUS procedure



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The user may choose to finish when he feels that his grid is complete, and see the analysis of the results. Although the FOCUSing and feedback of results is an important part of the PEGASUS procedure, the elicitation experience is both stimulating and demanding. The computer acts as a cognitive mirror in which the user sees himself through his own eyes, perhaps for the first time. Much of this experience may not be visible in the results, but a greater understanding of oneself and one's models often develops after the interaction with PEGASUS—the mythological winged horse.

The PEGASUS grid differs from the Kelly Repertory Grid in that it encourages the user to explore the differentiations he can learn to make rather than just elicits those he does habitually make. This is due to the rigorous feedback and the opportunities and encouragement to change which is given. It is felt that learning is exhibited by changes in construing which should therefore be actively encouraged.

Computer programs for developing awareness of personal modelling

In addition to the programs briefly described a number of variations are available (Shaw 1977).

FOCI is the FOCUS program with interpretation of the results. It does not attempt to explain the repertory grid or its usage, but concentrates on the units of output given by the FOCUS program, suggesting a framework within which each may be examined and interpreted in the specific context of the given grid.

SPACED is a variation of the final printout which blocks the FOCUSed grid in order to indicate those elements and constructs which are most alike. This is achieved by spacing adjacent rows and columns according to the degree of similarity between them.

PEGASUS is a suite of interactive programs each of which may elicit a repertory grid. MIN-PEGASUS is the version which is closest to the usual paper-and-pencil technique. No on-going feedback is given, but opportunities to review and revise the content are given.

The most commonly used version of PEGASUS already described incorporates continual commentary on patterns in the responses. PEGASUS-BANK provides an 'expert' grid which the user does not at first see, but against which the elicited constructs are matched. Feedback is given not only on how the user's constructs match each other, but also how they relate to the 'expert' constructs. Finally the total grid is focused to show how the two sets of constructs are interrelated. Alternatively, PEGASUS-BANK may be used to negotiate differences between two individuals in conversation. One point of view may be used to form the bank with which the other then interacts. This process may be iterated by adapting and modifying the bank at each stage until a joint agreement is reached.

PRE-PEGASUS allows the user to continue an elicitation started at an earlier date either with the computer or as a separate operation. In all versions, the text is stored in such a way as to make it easily replaceable by text written in another language, or another type of speech.

MINUS subtracts equivalently positioned responses from two grids each with the same elements and constructs. The pattern of differences is printed out, together with the percentage difference between the two.

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CORE is an interactive program which starts with two repertory grids, each with the same elements and constructs. These are either grids elicited from the same person at different times or from different people to investigate agreement and understanding between them. The two grids are processed by successively determining the element which is seen least similarly and the construct which is used least similarly in both grids. The user is then offered the opportunity to delete the element or construct at each stage, given the extent of the discrepancy. The CORE grids may then be focused in the usual way.

SOCIOGRIDS analyses a set of repertory grids elicited from a small group of people who share a set of elements (Thomas, McKnight and Shaw, 1976). It focuses the grids singly and in pairs, the PAIRS algorithm being used to compute the measure of similarity between the two grids; and produces a set of 'socionets' showing the shared construing within the group. A 'mode grid' of the most highly matched constructs is extracted and then focused. Each grid is focused with this mode grid and a measure of overlap of each with the mode grid is calculated. This technique is used for investigating the relative positions of the members of the group, and the content of the sharing of terms and values.

ARGUS elicits a set of grids simultaneously from one person holding several roles or points of view. Firstly, the elements (roles) are elicited, followed by three constructs from fixed triads. These construct labels are then used for a new set of ratings to be entered for each role name in turn, and at each stage another construct which is felt to be important for that role is added. Finally, the set of grids all having the same element and construct labels, but with different ratings, is processed on SOCIOGRIDS, CORE or MINUS.

Such programs which enable a person to become aware of his own models offer him a powerful facility to review and revise the basis of his anticipation. This is the essence of learning. An external observer sees learning as the achievement of certain behavioural objectives, but for the learner himself it is a revision of his cognitive model, that is in the way he perceives and construes events and behaves in the situation. This 'learning-centred' approach is recommending PEGASUS to an increasing variety of users in industry, education and psychotherapy. These include teachers and industrial inspectors, trainers and managers, maintenance engineers, counsellors, selection interviewers, course evaluators, and naval officers (Shaw, 1978).

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