The Repertory Grid Technique:Making Tacit Knowledge Explicit: Assessing Creative Work and Problem Solving Skillls

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THE REPERTORY GRID TECHNIQUE

Making Tacit Knowledge Explicit: Assessing Creative work and Problem solving skills.

INTRODUCTION

By describing a not so known method of interview, Repertory Grid Technique, the author shows how to elicit underlying, often tacit criteria's that professional teachers use when they assess creative work. It seems plausible that these criteria's can be used to enhance the student's development from a novice to an expert. Some of these criteria may have an universal value for the development of skill and creativity in school subjects other than Technology, Art and Craft. The results of further studies also indicate a progression of teachers assessing skills.

Most subjects in modern school have an element of creative work. It is a goal of many curricula, to enhance skill and to foster the ability to design and innovate. In Art and Craft Education this goal plays a major role but it is important in other subjects as well. During the last two decades a new comprehensive subject, "Technology" or "Design and Technology", has been introduced in many countries. In these curricula creative design is a core activity. But, what is creativity? Can it be defined in words? Can it be evaluated? Does any development occur? Can creativity really be taught? These questions are important to address. In the curriculum for the Swedish subject "Teknik" knowledge on these items seems to be taken for granted. The description of the design process is vague:

> A practical and inquiry based work will illustrate the design process;
> Defining the problem, forming a hypothesis, planning, prototyping, testing
> and modification. (Education, 2000)

This is a criticized, simplified, prescriptive and linear description of the design process. Studies of professional designers in action shows that the processes are not linear, they are reiterative and very individual. (Mawson, 2003; Middleton, 2005; Petroski, 1996; Williams, 2000)

Traditionally, assessing the finished product, the constructed artefact, the painting, the model of a bridge has been the way to assess creative work. This will grade the students but will not give any useful clues or feedback to the student as it is focusing on the end result and ignores the process of making. To be able to assess

process we need to know more about the strategies, the skills, the abilities, and the habits of mind of experts in the designing task. What behaviour is to be promoted and which signs of progression are to be identified? At first it seems as every design task is unique but studies of experts in different areas show that there are common properties and behaviour to be seen. An interesting study on Art teachers' criteria for creativity and "habits of mind" was done by Lars Lindström and is described later on in this chapter. (L. Lindström, Ulriksson, & Elsner, 1999)

When you study novices becoming experts you will recognize a development and often a change in behaviour during problem solving activities. (Dreyfus and Dreyfus 1986) The experts seem to be able to concentrate on the salient features of the task, they act fast and proficient and they share some important habits of mind controlling their design process. (Middleton, 2002) Another characteristic of an expert is the inability to verbalize the know how, it's tacit.

Yvonne Hillier describes the use of Personal Construct Theory and Kelly's Repertory Grid as a method for making explicit the tacit, implicit, and informal theories that underlie experts practice. She demonstrates that Kelly's Repertory Grid is an appropriate tool for eliciting informal practitioner theory, which is derived from personal constructs and factors. It is a particularly effective method of reflective practice, providing a focus without imposing structures by the interviewer. It provides a rich source of interpretative data, which can be explored collaboratively with the respondents. From this, propositions can be derived which can be tested. These propositions and tenets form the basis of informal practitioner theory. This methodology may provide the means by which formal theories of adult education can be informed by practical knowledge. (Hillier, 1998)

This chapter will describe the Repertory Grid Technique (RepGrid), the theories behind it, some illustrative examples and the merits and drawbacks of the method. It will end in a review of different uses of the method and an annotated bibliography of some research studies of relevance.

BACKGROUND

Experts and Tacit knowledge

In recent years the interest in expertise and proficiency has been raising, in educational research, knowledge management as well as in cognitive science.
John Stevenson defines expertise as the ability to do something well - better than others just starting out on the undertaking (Stevenson, 2003), He proposes several interesting research questions;

What do we mean by doing something well?

What enables an individual to do something well?

Why does this capacity improve with practice?

Is this capacity confined to a specific field, or is it general?

Can the capacity be learned, and how?

Where is it located?

The quest of eliciting knowledge from experts has eluded science since the beginning of the development of artificial intelligence in the sixties. The database of Expert Systems had to be loaded with knowledge from human experts and these experts seemed to be unwilling to tell about their secrets and methods. When you are using standard interview techniques you are probing the conscious, rational and logic mind of the interviewee. The informant may want to please you and tell you what is appropriate, logic and sound. Your data will be full of general rules and standard procedures and not the individuals' own subjective way of coping with problems. His know how or procedural knowledge is hidden even for him, it is tacit.

We know more than we can tell. (Polanyi, 1966)

This knowledge is apprehended unconsciously in an implicit way often outside our own awareness. It is also used in an automatic way and is therefore difficult to elicit by introspection. In Cognitive Science dual cognitive systems theories has matured during the last 20 years and has given us new ways of understanding tacit knowledge, expertise, intuition, insight and automation. (Cronin, 2004; Epstein, Lipson, Holstein, & Huh, 1992; Ericsson & Charness, 1997; Lieberman, 2000; Nightingale, 1998; Reber, 1989; Sloman, 1996; Sun, Slusarz, & Terry, 2005) Tacit

knowledge may in a very simplified model be described in the following manner. Individuals store sensory information in implicit memory as signal pattern together with an emotional qualitative assessment of the event. This gives them a tool to make meaning of phenomena in the world just by the recognition of the sensory pattern they experience and what is stored in their implicit library of old experiences. In this way we "learn" what is dangerous and what is not, what is beautiful and what is ugly, what is eatable and not. We learn to recognize faces and scenes, sounds and odours. This kind of knowledge might be referred to as patterns of data or information, a "sensogram". There isn't any conscious perception in the classical sense just recognition of similarities and differences with old exemplars. Polanyi, who minted the expression Tacit knowledge, writes about this proximal knowledge that is insignificant by it self, but points to something more important, some distant meaning. The knowledge is contextual and situated as it is apprehended in practice. The professional craftsman learns to feel, listen and smell to decide when the artefact is finished. The surgeon knows how sick tissue feels when she is cutting with the scalpel. The dentist learns how the drill sounds when he reaches fresh pulp. This sensory information is used in several feedback processes and is stored as patterns of sensory information. In the progression from novice to expert this kind of implicit learning is essential. (Dreyfus & Dreyfus, 1986)

In the stored "sensogram" there may also be a documentation of internal sensory signals, of how much adrenalin is pumping, which muscles are activated at the moment and other things. This may be used in automatic response- and feedback-system, of the kind that Skinner and Pavlov were describing. The modern experimental psychologist research differs from the behavioural-movement by allowing, memories and emotions into the stimuli-response process.

If we want to elicit this kind of pattern-knowledge we can't use ordinary interview techniques. The information is not stored in a verbal form and the interviewee maybe doesn't even know it's there and is controlling his decisions and actions.

> "Not only in artistic judgement but in all our ordinary judgements of the qualities of things, we recognise and describe deviations from a norm very much more clearly than we can describe the norm itself". (Schon, 1987)

This is because our ability to recognize patterns and familiarity in an area of our own expertise is strong. We may not always know why but intuitively we feel what is good, bad, beautiful, sloppy, clear, original etc.

The idea that man is behaving as a sort of scientist, recognizing patterns or criteria's to assess the phenomena of the world is older than these findings of modern cognitive science. In the first part of the 20th century an American psychologist, George Kelly, formulated the Personal Construct Psychology, a psychological theory that tried to explain why people have different views and attitudes towards events in the world. (Kelly, 1955) Kelly claimed that people during their upbringing make use of very personal criteria's, construct that they use

to construe a meaningful world. A construct is not the same as a concept; it is defined as at the same time a similarity and a difference. A construct with one pole described as "a friend" must be described with its contrasting poles and since the opposite of a "friend" could be "foe" but also an "acquaintance" the bipolarity is essential. The opposite of "good" could be "evil" but also "bad" or "nasty".

Kelly designed a method to elicit personal constructs, The Role Construct Repertory Test. The method has been redefined and developed by himself and others and is now known under the name of Repertory Grid Technique (RGT).
RGT has been used in clinical psychology for more than 50 years but has since the 1960's found new use in a variety of research areas. The findings from experimental psychology and cognitive science on implicit learning and knowledge, the ideas of dual cognitive systems and the interest in tacit knowledge have given rise to new expectations for the use of the method. (Gaines & Shaw, 2003) The RGT identifies perceptions, together with associated feelings and intuitions held about the issue in question. Kelly's theory and technique have both been used to explore management and intuitions, which affect behaviour in fields as diverse as quality assurance, performance appraisal, new product development, and consumer choice. (Jankowicz & Hisrich, 1987)

The use of the RGT involves agreement on a topic; the identification or provision of a series of cases, examples, or, in Kelly's terminology, "Elements"; and the use of a tightly structured interview in which a systematic comparison of elements enables the respondent to identify "Constructs," i.e., the ways he or she has of making sense of, or construing, the elements. Constructs are frequently expressions of intuitions, "gut feelings," and perceptions, which the individual uses as a guide to action, without necessarily having verbalized them explicitly prior to the interview. There are several software packages that administrate the eliciting process and also supply the researcher with different statistical tools.
It is possible to do it manually though. The elements are written on separate cards, three cards are selected, tryading, and the subject is asked if two of them share something that separates them from the third element. This property of the two similar elements has to be verbalized into an emergent pole of the construct. The subject is asked to name the opposite of this and this names the implicit or contrast pole of the construct. All elements in the set are rated with this bipolar construct as a yardstick, either to one of the poles, a dichotomy, or on a continuos scale between the poles, a Lickert scale, of 5, 7, 9 or more steps. The result is recorded as an array in the first row in a Repertory Grid. This procedure is repeated until the construct generation is exhausted, or the subject is. It is possible to evaluate small grids manually and some authors think this is essential for the understanding of the method.(Jankowicz, 2004)
The following examples were made using the free version of RepGrid IV that could be downloaded from http://www.repgrid.com Another free software, a web based package is WEBGRID III that could be accessed at: http://tiger.cpsc.ucalgary.ca:1500/WebGrid/WebGrid.html

TO MAKE A REPERTORY GRID INTERVIEW, AN ILLUSTRATIVE EXAMPLE

Research question of the study

The Swedish National curriculum of "Teknik" is goal oriented, emphazing documented learning outcome even on the development of design abilities and creativity. We ask: What kind of criteria's do teachers in the Swedish school use when they are assessing and grading a design and construction project in the subject "Teknik".

Background

In a comprehensive, lower secondary school in a medium large Swedish city, a class of 15-16 year old students had been working with a project in technology and design. It consisted of two different parts; first an electronic alarm was built following supplied plans and schematics. The teacher delivered the components and the material for the soldering task. The second part of the project was more creative and free. The electronic alarm was to be put into use in a context. This context, a lighthouse, a car, a secret diary etc, was to be designed and built in the form of a model using different kind of materials. The students were working on individual projects but were allowed to support each other in the tasks.

The subjects of the interview were two experienced teachers, a male and a female. They did not have any special training in the subject Teknik, but were, as a majority of Swedish teachers of Teknik, trained in Science and Mathematics and had been practising the new subject for at least ten years. The two teachers and the headmaster of the school were informed of the scope of the study and agreed to participate. The interview was performed in Swedish and relevant parts of the material have been translated into English especially for this text.

The Interview starts, defining the topic

The subjects were informed of the topic of the study, their own, most subjective criteria's for the assessment and grading of the work of the students. This is a crucial part of the design of a Repertory Grid Interview. The interviewee must know the elements well and understand the topic. The construct of an individual change in different contexts and the interview was therefore performed in the room were the teachers used to do preparation and assessment work. A RGT interview is often complemented with other forms of data sampling; in this case Audio was recorded.

The Elements

The teachers had to be knowledgeable of the artefacts and also of the student and his/her design process. We asked the teachers to select 7-8 different projects from their own class. In order to be able to find most of their constructs and criteria's they had to make a stratified selection; some good, some bad, some strange and some traditional artefacts. The elements would of course represent the artefact, their designers and also the process of design. The teacher was asked to put labels on every artefact like "The Box", "TV", "Safe" etc. The elements chosen by the male teacher, LG1, were; Green, Telephone, Diary, Plate, Lighthouse, Car and House

The eliciting of constructs

The software, Repgrid IV, randomly selected three elements; Diary, Lighthouse, and Plate and asked the eliciting question:

- Can you choose two of this triad of elements, which are in some way alike and different from the other one?

This was the crucial point where the informant used his pattern recognition ability on the three selected elements.

- Yes, the Lighthouse and the Diary

The next question was:

- Now I want you to think what you have in mind when you separate the pair from the other one. Just type one or two words for each pole to remind you what you are thinking about when you use this construct?

The answer to this question is a name for the emergent pole, to the left and a implicit or contrast pole to the right. Although you should be careful in interfering with the process you must see to that theses names are relevant and intelligible, otherwise you may use a "laddering" technique, ask for an explanation e.g.

The left pole is- They both meet the standards of the task!

And the right pole is – It is a failure!

Several studies have showed that this eliciting question could be formulated in different ways and that this has effect on the construct elicited. The advice from many authors is to concentrate on the similarities of a pair and just asking for the opposite of this, read more of this in a later part of this chapter.

The rating of elements

The two poles of the construct were noted in the program and all the elements were rated accordingly, belonging to different extent to one or the other of the poles. We had chosen to use nine levels in the ratings but five or seven are often used. The result when the construct "Failure-Meets the standards" was used to compare the artefacts was:

Implicit pole: Failure

9
8
7 =Plate
6
5
4
3= Telephone and House
2= Lighthouse, Car and Diary
1= Green

Emergent pole: Meets the standards

The construct and the ratings of all the elements were noted in the program and produced the first row of the grid. The eliciting process started all over again with three new elements and the eliciting of poles of the new construct. The selection of elements was random but the software makes it possible to select them manually. Some software packages may interfere in the process by analysing "on the go" and noting constructs that seem to be too similar. The program will then ask for laddering procedures to try to sort out the difficulties and splitting a compound construct in two.

The resulting Grid

When nine different constructs had been elicited the process was ended. In the case of the first teacher, LG1, the following constructs were elicited:

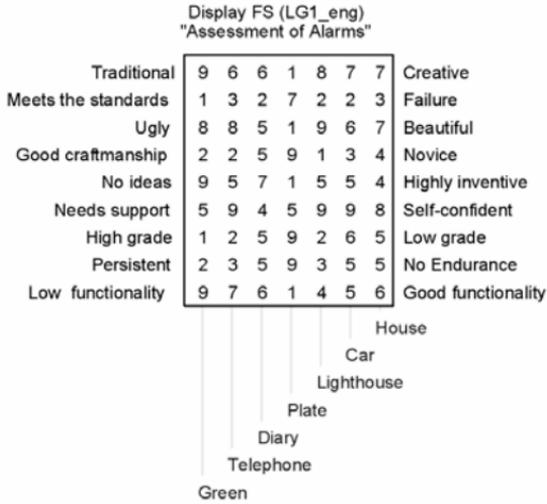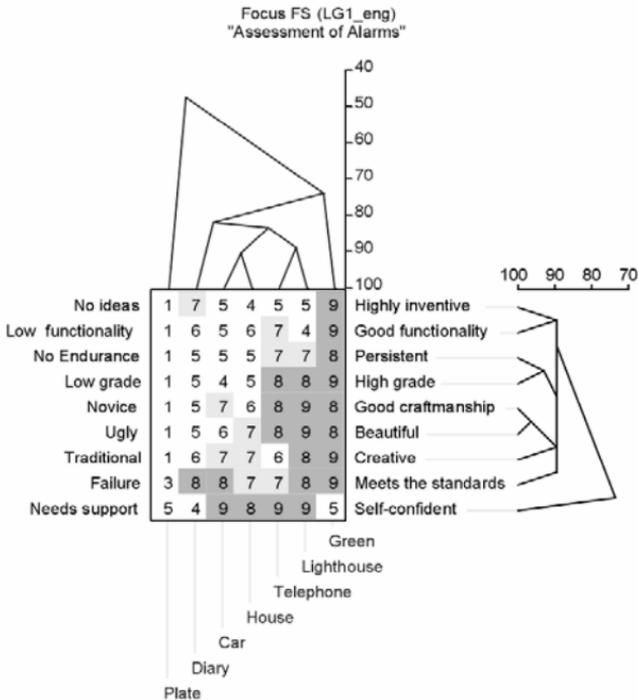| Emergent pole	Implicit pole
Traditional	Creative
Meets the standards	Failure
Ugly	Beautiful
Good Craftsmanship	Novice
No ideas	Highly inventive
Needs support	Self - confident
High grade	Low grade
Persistent	No Endurance
Low Functionality	Good functionality

Figure 1. Display of LG1's constructs in a grid

Figure 2. Focus display of LG1

Analysis of the Grid

The resulting grid is displayed in Figure 1. The elicited constructs forms rows and the elements columns in the grid. To the left is the emergent pole and to the right the implicit pole of a construct. Statistical methods may be used to find similarities or differences in the data but many authors recommend a user to study the raw data first. In the software package we used two different tools of analysis were supplied; The Focus display and the Principal Component Analysis Graph.

In the Focus Display, Figure 2, also called hierarchical clustering analysis, the grid has been sorted and rearranged to bring closely matching elements together, and closely matching constructs together. This "focusing" of the structure gives the method its name. The similarity scores of adjacent elements or constructs are provided in numeric form and graphically in a tree structure, a dendrogram. The actual score can be found if you follow the lines from two constructs/elements to the apex and further to the scale.

In LG1 we will find a strong resemblance, 93%, between the constructs High grade and Persistent. Even more alike, 96% are the two constructs Good Craftsmanship and Beautiful. There are strong similarities, 90%, between every construct but Self-confident-Needs support. This high figure indicates that most of the constructs are relevant to the teacher in his task of assessing. You cannot be sure that constructs are not missing in this kind of analysis though.

Focusing on the columns, the Elements, we will find that the House and the Car are rated very similar and show a similarity of 91%. The Lighthouse and the Telephone are also rated in a similar way but one of the elements stands out, The Plate. As can be observed this is obvious from the numbers in the grid and the Focus Display is just a convenient way to show variance graphically to help the researcher get a first view of similarities or differences.
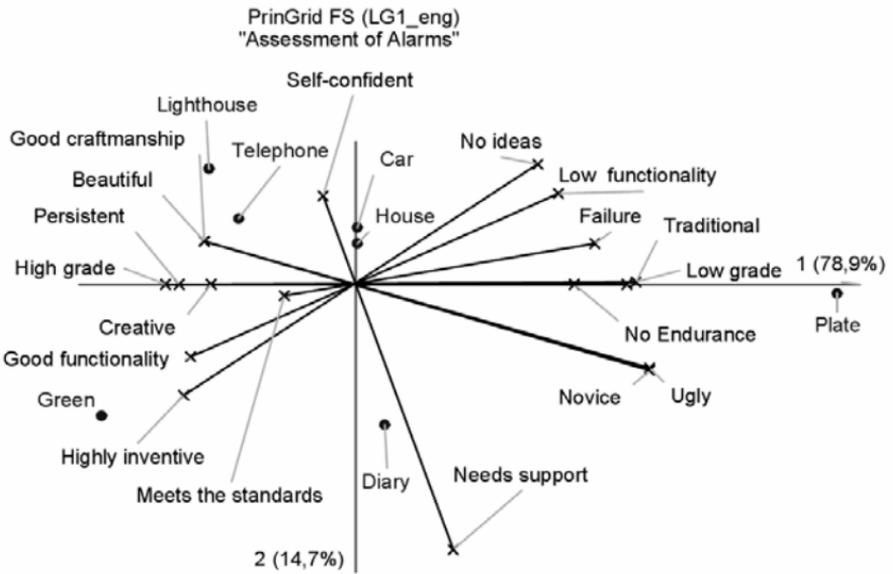
Figure3. Principal Component Analysis of LG1

The Principal Components Analysis identifies distinct patterns of variance on figures in a grid, following procedures, which work out the extent to which the ratings in each row are similar to each other. Iteratively it attributes as much of the total variance to each distinct pattern, component, as possible. If the total of variance accounted for is more than 80% two components will suffice for the analysis and this is supported by most software packages. The grid has been treated as if the elements were points plotted in an n-dimensional space defined by the constructs as axes centred on the means of the elements. The data has then been rotated to spread the elements out as much as possible in a 2-dimensional plot.

The first principal component identified is plotted as a horizontal dotted line with the percentage of variance printed at the right end. The second component is plotted vertically as a y-axis in a Cartesian system of coordinates. The constructs are plotted as straight lines whose angels with respect to each principal component reflects the extent to which it is represented by the component. The length reflects the amount of variance in the ratings on that construct. The elements can be positioned along each component-axis and the distances between elements will reflect their ratings according the set of constructs.

In this PCA-graph the first component accounts for 78.9% of the variance and together with the second, 14.7%, it will identify 93.6% of the variance in the data. Around the x-axis several important constructs are clustered. High - Low grade, Traditional - Creative, Persistent - No Endurance are more or less the same as the first principal component but Functionality, Inventiveness, Meeting the standards, Beautifulness and Craftmanship do form sheaves with small angles around the principal component. They all could be considered important for the grading

process. The outstanding construct of Self confident - Needs support has a relatively small angle towards the second component and a perpendicular angle to the other constructs, which would indicate that it is another dimension in the assessment system of this teacher, independent of the others.

The elements are clustered in two parts of the graph; the Plate is on an extreme position completely reflecting its extreme ratings in the grid. Similarly assessed constructs are close to each other in respect to the constructs.

The second teacher in the study, LG2, cooperated in a class with LG1 and by chance selected three identical projects/elements for the grid. You may, as the researcher, select common elements for the subjects of the study but according to the literature you are advised to do this in close cooperation with the interviewee.
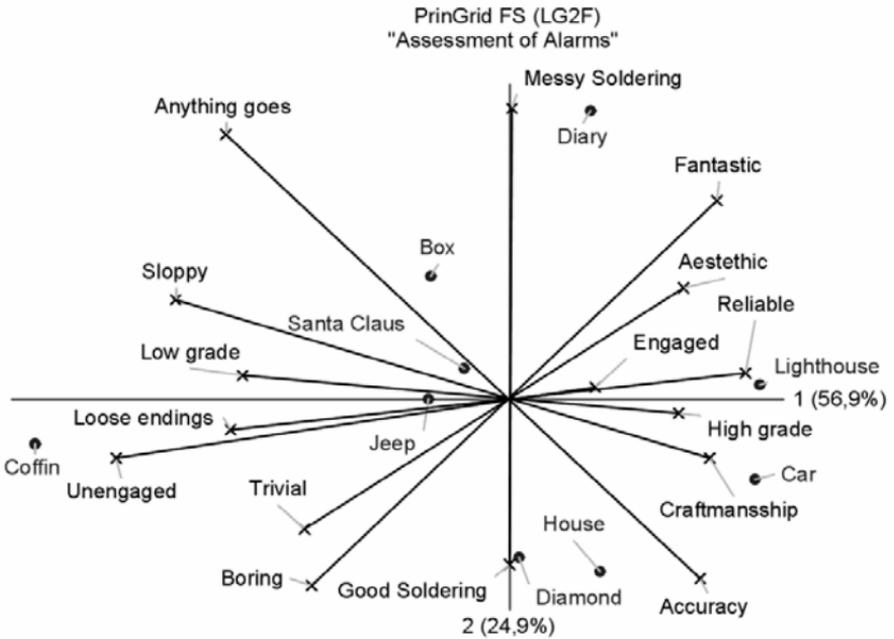

Figure4. Principal Component Analysis of LG2

In LG2's PCA the two principal components accounts for 81.8% of the variance and the constructs are more evenly spread in the graph. Strong coherence to the first principal component could be found in the following constructs; High grade - Low grade, Reliable - Loose endings, Engaged - Unengaged and Craftsmanship – Sloppy. The second component seems to be very similar to the construct Good -

Messy Soldering. If you compare the grids of these two teachers you will find common criteria for assessment but the weight differs. Both of the teachers are positively grading Aesthetic features but LG1 is giving it higher weight; the constructs Beautiful and Good Craftsmanship are close to the first component and High grades. In LG2 the constructs Fantastic and Aesthetic are more remote. LG2 seems to connect Craftsmanship more to Accuracy. Engagement or Persistency seems to be of importance in both teachers and so is the Functionality/ Reliability. LG1 uses the construct Creative in a way that differs from the use of Inventiveness, which is interesting.

The study from where this example is drawn included grid-sessions with teachers from other subjects in the curricula: Essay writing, Web design, History, Philosophy and others. The research question was: Are there common constructs or criteria's in teachers assessing creative work in different subjects?

Discussion

Richard Kimbell et al explored what could categorise creative / innovative work. (Kimbell, 2004; Kimbell et al., 2006) Teachers, advisers, examiners and other experts in Technology Education were consulted and a list of categorising word was derived, here listed in priority order:

> Exciting, unusual, different, novel, risky, bending the rules, brave, determined, marketable, professional, 'wow', confident, powerful, and unique.

Most of the categories deal with having ideas, growing ideas and proving ideas.

We can identify several of Kimbell's "buzzwords" in the constructs of the two teachers; they are using, on the "positive" pole, abilities as Creative, Highly innovative, Beautiful, Self-confident, Accuracy, Aesthetic, Craftsmanship and Fantastic. These criteria will of course grade the student and his product but it is of little value in giving feedback and showing routes to a progression, a development of their creative skills. But there are some constructs; Persistent, Self-confident and Engaged that could be of some value though. They deal more with the process and less with the product. (Lars Lindström, 2005) They are dispositions, habits of mind or habits of work that are identified in the students' behaviour.

It could be that teachers in the fine Arts know more about the design and creative process in their field than technology teachers, they may even be artists themselves. The continuing study of teachers assessing written essays seems to indicate just that. Experienced examiners seem to use more qualitative criteria than novices. Probably they have a much larger base of exemplars to relate to. Several of the criteria Lindström identified with teachers in Art and Crafts education seems to be used by teachers in other subjects of the "making". This will be studied further.

MERITS AND PROBLEMS WITH REPERTORY GRID TECHNIQUES

The Repertory Grid Technique is a type of structured interview which evolved from Kelly's Personal Construct Theory (1955) Its development was Kelly's attempt to present a method of data collection which, first, focused on the individual rather than large groups, as typical of correlation studies of his time. His original technique was the Role Construct Repertory test which was used to investigate role relationships in clinical settings, namely between patients and their families, friends and others, and for assessing relationships between a patient's constructs about people. It needs to be clarified, however, that the Repertory Grid is not a test, but a methodology involving highly flexible techniques and variable application Thus, although its original use was to investigate constructs about people, subsequent application has included inanimate objects, events, situations and abstract ideas. Many researchers and writers of handbooks in methodology have explained these diverse uses. (Cohen & Manion, 1994; Fransella, 2003; Fransella & Bannister, 1977; Jankowicz, 2004)

Topic and Examples

People have constructs about anything and everything, a RGT is always conducted about a particular topic with the intention to find constructs a subject use in making sense of a particular realm of discourse, that particular slice of their own personal experience. The administration of repertory grids often involves the use of one or more examples as an illustration for participants. Descriptive examples elicits more personally revealing, as opposed to factual, construct dimensions. Recent use of the technique has shown significant differences following from sometimes-subtle variations in repertory grid procedures.(REEVE, OWENS, & NEIMEYER, 2002)

Elements

Elements may be generated in several ways; you may supply them to the interviewee in the form of a list of people, incidents, actual artefacts, scenes from a video film etc. They could be selected together with the interviewee in a discussion about the topic at hand. You could define a pool of elements and let the person write down: six leisure activities, eight typical parts of a lesson, seven effective teachers etc. Kelly used to provide role titles; " A friend, someone you don't like, your wife, yourself, the ideal self" and asked the interviewee to select specific people he know that would fit the roles. Elements are the important clues that are

going to facilitate the elicitation of personal and tacit knowledge from the person in focus. They should be:

- Homogenous, from the same category or dimension

- Representative, covering all aspects of the topic under scrutiny

- Unambiguous, specific, simple and readily understood

- As short as possible, eight to ten elements are quite adequate for most purposes (Mark Easterby-Smith, 1980)

Constructs

Constructs can be generated in several ways, they can be:

- Elicited from triads or dyads.

- Supplied by the researcher, but there is always the danger that the grid becomes inflexible like an attitude questionnaire, with the investigator's world being imposed upon the subject.

- Combine elicited and supplied constructs. Eliciting may take a long time. Supplying a few constructs after eliciting can speed up process. Certain common constructs may be useful when you want to compare individuals; examples of supplied construct are Bad- Good, Novice-Expert, Relevant-Irrelevant.

- Non-verbal constructs may be produced simply by sorting element cards into different piles according to whatever scheme seem to fit best. These dimensions need not be expressed. The position of each card is noted at the end of each successive sort, and this provides the basis for a grid matrix.

- Laddering is a process of generating additional constructs from existing ones. It's done by asking why a particular construct poles are important, or by asking for further elaboration of an existing constructs.

Normally it is advisable to avoid constructs, which are:
- Concrete (distinctions based on factual attributes).
- Impermeable (can only be applied to a tiny portion of the range of elements).
- Vague (e.g. is OK—not so good).
- Generated by the role title (e.g. is an effective manager—not so effective).

Eight or ten constructs are quite adequate for most purposes. (Mark Easterby-Smith, 1980)

Methods of elicitation

The literature identifies systematic differences between Kelly's "difference" and "opposite" methods of personal construct elicitation. The "difference method" has been the standard procedure for construct elicitation and is the single-most commonly used method of construct elicitation. The interviewee is presented with three randomly selected elements (e.g. people), and asked to "identify any two people that are alike in some way, yet different from the third." A subject, when restricted to finding a similarity prior to stating a difference, occasionally is unable to respond. When they do respond there is often a contrasts that is not genuinely bipolar. The method has also been said to develop several "bent" (i.e. non antonymous) constructs. In the "opposite" method the interviewee is asked to "identify any two people that are alike in some way." Once that characterization is done the person is then asked to identify the "opposite" of that characterization. This "opposite" then forms the implicit pole, thereby assuring the bipolarity of the construct. The method produces significantly less complex and differentiated personal construct systems. A new method "the Contrast method" yielded personal constructs that were more genuinely bipolar, but without incurring the greater negativity associated with the contrast poles of constructs elicited by way of the opposite method. (Neimeyer, Bowman, & Saferstein, 2005; Yorke, 2001)

The methods above have all been using three elements in the eliciting process but the use of two elements, a dyad, has also been reported in the literature. The task seems to be easier for the interviewee who only has to detect a similarity or a difference in the dyad. On the other hand it has been reported that the constructs produced are not so cognitively complex as when elicited in a triadic fashion.(Caputi & Reddy, 1999)

Reliability and Validity

This is a qualitative method and the result, the grid with lots of numbers may lead us to think we have got quantitative data. We must remember the data are the result of a sorting process by the interviewee and show relations between elements, probably not linear and susceptible to the selection of elements and the interview situation. Too much of statistical processing of this "soft" data may distort information. The elicited names and labels on the individuals constructs are very subjective and we must take great care to interpret them "correctly".

The theory underlying RepGrid, the Personal Construct Psychology, regard upon man as a changing being and this means that the consistence between systems of constructs over time could be low. The subjects may change his attitudes towards certain elements. (Gathercole, Bromley, & Ashcroft, 1970)
The validity of the technique in the terms of PCP is its capacity to enable us to elaborate our construing, our ability to anticipate. Ultimately validity refers to the

way in which a mode of understanding enables us to take effective action. (Fransella & Bannister, 1977) In this respect Repertory Grid has proven its utility.

Reflective scrutiny

Neimeyer advocates a position of critical reflection in relation to common adaptations of repertory grid procedures. The fact that even subtle procedural variations can register a substantial impact on the content and structure of a persons Personal Construct Systems highlights the responsibility that researchers and practitioners have to understand their own contributions to the grid outcomes that they interpret. (Neimeyer, 2002)

The divorce of Repertory Grid Technique from the theory

The Personal Construct Psychology is firmly based in the area of general cognitive processes, but is also applicable to the individual concepts and their relationship to the solution, as well as an individuals' method of progressing towards a solution… and is particularly useful in approaching an understanding of covert behaviour in specific activities, such as designing. (Jerrard, 1998)

Fransella & Bannister calls to attention the fact that a lot of studies using RepGrid do not relate to the Personal Construct Psychology and they suggest that Kelly's' theories should be understood in every use of the method. (Fransella & Bannister, 1977) In the Journal of European Industrial Training important key assumptions with implications for the use of Rep Grid was listed. (Mark Easterby-Smith, 1980)

> "A person's processes are psychologically channelised by the ways in which he anticipates events". (Fundamental Postulate).

> "Persons differ from each other in their construction of events". (Individuality Corollary)

> "A person chooses for himself that alternative in a dichotomised construct through which he anticipates the greater possibility for extension and definition of his system". (Choice corollary)

> "A person's construction system varies as he successively construes the replication of events". (Experience Corollary)

> "To the extent that one person construes the construction processes of another, he may play a role in a social process involving the other person". (Sociality Corollary)

Kelly designed the PCP half a century ago and did not have access to the result of modern cognitive science. His work is still used in clinical psychology and could

certainly be of good value as a theoretic framework for studies in behavioural and attitudes change. Kelly was not aware of theories of the dual minds, implicit learning and implicit knowledge. He did not have access to results from experimental psychology on familiarity and recognition. In this perspective there are probably other theoretical frameworks that could be utilised to understand the Repertory Grid results.

Merits and advocates

In spite of the shortcomings of the method there are many keen advocates for the Repertory Grid Technique, a typical example is Godfrey Mazhmdu :

"Many studies in clinical, management and educational settings indicate that the repertory grid is now a well-established diagnostic and research tool. Its idiographic nature encourages the interviewee to use his or her own words when discussing issues of personal importance… It also provides information as to an individual's perceptual field, consequently promoting detailed exploration of personal meaning with a public record compiled easily. The grid provides for the analysis of relationships between constructs and between elements and for analysis of change not only within the same individual but also between individuals over time Observer bias is reduced almost to zero and objectivity is maximized… The discipline involved in the application of the techniques ensures that each interview is structured and is truly constructive. The interviewers/observers are forced to keep quiet, thereby minimizing their input, while the rigour of the compare and contrasting techniques ensures that the interviewees elaborate at length their understanding of their perceptions. Additionally, the conversational format of the technique offers itself as a tool, which is simple and enjoyable for the interviewees and does not provoke anxiety in them, while being reassured that their own opinions are being sought, so that there are no right or wrong answers. The methodology itself is flexible, elicits both qualitative and quantitative data that are open to a variety of analyses, and its overall potential as an interpretative framework explains why it is generally regarded as a catalyst for change. On the basis of the above explanation, it seems clear that the repertory grid research technique offers a number of fundamental advantages to the researcher It is also evident that many of the limitations outlined can be overcome and therefore reasonable to suppose that, on balance, the repertory grid is a fruitful technique that should be widely adopted for research purposes throughout nurse education and practice". (Mazhmdu, 1992)

EXAMPLES OF STUDIES USING THE REPERTORY GRID TECHNIQUE

Assessing Creativity

One of the areas where Rep Grid was used very early was in the exploration of Design and Creativity. (Jerrard, 1998; Quinn, 1980) Two recent studies will show its utility.

In a large study about assessing creative development in Art education professor Lars Lindström tried to find criteria's or descriptions of general abilities used by teachers to assess creative work. (L. Lindström et al., 1999) After a thorough literature survey several experts, teachers but also artists and craftsmen, were interviewed with the Repertory Grid and other techniques. Elements in the RGT-interview process were artefacts of fine metal craft. With the help of elicited constructs, laddering and deep interviews of the experts a list of important factors/criteria for the development of creativity was devised:

   Product criteria:

      1. Visibility of the intention/ Goal fulfilment

      2. Colour, form and composition/ Visual qualities

      3. Craftsmanship/ Technical skill

   Process criteria:

      4. Investigative work/ Persistence in the pursuit

      5. Inventiveness/ Imagination and risk-taking

      6. Ability to use models/ being able to learn from others

      7. Capacity for self-assessment/ knowing one's strengths/weaknesses

   Others:

      8. Overall judgement

Every criteria was described in four steps notifying a developmental, progressional change from the behaviour of a novice to that of an expert. The levels were

described in a narrative way, a rubric, to make it possible for a teacher to recognise the behaviour of a particular student.

The following rubrics was used for scoring Craftsmanship:

1. The pictures show little or no ability to use materials and techniques.

2. The pictures suggest a certain ability to use materials and techniques, but there are serious deficiencies in the execution.

3. The pictures show an ability to use materials and techniques to achieve the desired visual effects, but this is applied in a rather stereotyped way.

4. The pictures show a good and flexible mastery of materials and techniques and are consistently of high technical quality.

The following rubrics was used for scoring Capacity for self-assessment:

1. The student cannot point out the strengths and weaknesses of her own work or distinguish between works that are successful and those that are less successful. She has no opinions about her fellow students' pictures.

2. With some assistance, the student can point out the strengths and weaknesses of her own work and distinguish between works that are successful and those that are less successful. Opinions about her fellow students' pictures are confined to simple value judgements (good/bad, like/don't like).

3. The student is generally able to see merits and shortcomings in her work and can select sketches, drafts, and works which illuminate her own development. She can pass varied judgements on her fellow students' pictures.

4. The student can clearly see merits and shortcomings in her work and can select sketches, drafts, and works which illuminate her own development. She can also give reasons for her judgements and explain why things turned out as they did. She can pass varied judgements on her fellow students' pictures and is able to give constructive criticism.

There is an obvious difference between the criteria of excellence that were generated by this and following studies and those checklists that are often found in textbooks. The latter list components that should be present in a product or performance, while the interviewees in this study rather tried to define a set of

more general dispositions or key competencies. The typical textbook items are, at best, indicators of such "habits of mind". The interviewees' process criteria, in particular, add up to a culture of learning rather than a list of specific skills.(Lars Lindström, 2001)

Lindström found high agreement between class teachers and co-assessors in ratings of both the students' visual results (product criteria) and their approach to work (process criteria). In almost 3,100 comparisons between class teachers and the co-assessors from another school, there was 78 per cent agreement (= 2 steps on a twelve-grade scale). Given that other discrepancies between the two assessors were small and indicate an approximately normal distribution, this may be regarded as a satisfactory result. (L. Lindström et al., 1999)

Another study tried to capture Design Space From a User Perspective:
"The design of an artefact (e.g. software system, household appliance) requires a multitude of decisions. In the course of narrowing down the design process, "good ideas" have to be divided from "bad ideas". To accomplish this, user perceptions and evaluations are of great value. The individual way people perceive and evaluate a set of prototypes designed in parallel may shed light on their general needs and concerns. The authors assume that the personal constructs (and the underlying topics) generated as a reaction to a set of artefacts mark the artefacts' design space from a user's perspective and that this information may be helpful in separating valuable ideas from the not so valuable… In general, the Repertory Grid Technique proved to be a valuable tool in exploring a set of artefact's design space from a user's perspective." (Hassenzahl & Wessler, 2000)

Educational research

Course evaluations, learning outcome, teachers practice and conceptual change are areas where RepGrid also has been used extensively. (Hoogveld, Paas, Jochems, & Van Merrienboer, 2002; Karppinen, 2000; Pill, 2005; Smith, Hartley, & Steward, 1978) A typical example of this is a study probing students' unique view of energy; Need for revision of the concept of an average student; Information on the extent to which school science ideas about energy had been translated into students' everyday working knowledge; Constructs elicited as basis for interview. (Fetherstonhaugh, 1994)

Tacit knowledge, business and management

Ever since the Journal of European industrial Training devoted a full issue to Repertory Grid (Mark Easterby-Smith, 1980) there have been a multitude of studies and uses of the technique in management and business. (Chao, Salvendy, & Lightner, 1999; Crowther, Hartnett, & Williams, ; De Leon & Guild, 2003; Mark Easterby-Smith, Thorpe, & Holman, 1996)

Attitudes

Kelly's own area of research was in psychology with a special interest in personal attitudes and emotions. His method is still used to explore peoples feelings, prejudices and preferences (Honey, 2001; Parkinson & Lea, 1991)

A good example of this is an article, "Understanding public attitudes to technology", (Frewer, Howard, & Shepherd, 1998) where the authors states in the abstract; "The social context, which surrounds technology, is likely to be one of the most important determinants of its future development and application. The application of repertory grid techniques in conjunction with generalized Procrustes analysis identified important psychological constructs which determine attitude. A larger survey study examined the reliability and predictive capacity of these items in quantifying attitudes to technology. Factor analysis identified two subscales, which appeared to assess perceptions of technological risk and benefit… An inverse relationship between perceived risk and benefit was found, consistent with previous research in risk perception… A major problem in using researcher generated characteristics in scale development is that it is possible that some key determinants of public attitudes are not recognized by the researcher, and so no attempt is made to incorporate them into questionnaire design. Against this, the researcher may decide that particular elements are important in attitude formation when they are not. Even if items are not highly salient to people, they will still produce ratings which will then be incorporated into the subsequent model. What is required is a method where respondents generate their own descriptions of concerns associated with a particular 'target' (for example, a technology), which will avoid some of the problems linked to experimenter generated characteristics… The use of the repertory grid method permits responses to be focused within the hazard domain without imposing external experimenter determined risk characteristics on data generation." (Frewer et al., 1998)

CONCLUDING WORDS

Repertory Grid Technique is an interview technique that utilises individual's ability to compare elements to elicit attitudes, category making, assessing criterias and probably some personal tacit knowledge. It is a qualitative method in which statistical methods may be used to enhance analysis. As in most qualitative methods questions of relevance, reliability and validity must be addressed, usually with complementary interview and data sampling methods. The method is sensitive to the design of the interview but so are many alternative methods e.g. the bias that the researchers often impose on an interviewee in a traditional interview is reducedin RGT. The RGT is a fruitful technique that could be widely adopted for research and development purposes throughout design & technology education and practice.

REFERENCES/BIBLIOGRAPHY

Caputi, P., & Reddy, P. (1999). A comparison of triadic and dyadic methods of personal construct elicitation. *Journal of Constructivist Psychology, 12*, 253-264.

Chao, C.-J., Salvendy, G., & Lightner, N. J. (1999). Development of a methodology for optimizing elicited knowledge. *Behaviour & Information Technology, 18*(6), 413-430.

Cohen, L., & Manion, L. (1994). *Research methods in education* (4. ed.). London: Routledge.

Cronin, M. A. (2004). A Model of Knowledge Activation and Insight in Problem Solving. *COMPLEXITY, 9*(5), 17-24.

Crowther, P., Hartnett, J., & Williams, R. *Teaching Repertory Grid Concepts for Knowledge Acquisition in Expert Systems:*

An Interactive Approach.Unpublished manuscript, Department of Applied Computing and Mathematics University of Tasmania.

De Leon, E. D., & Guild, P. D. (2003). Using repertory grid to identify intangibles in business plans. *VENTURE CAPITAL, 5*(2), 135-160.

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over Machine*. Oxford: Basil Blackwell Ltd.

Easterby-Smith, M. (1980). How to Use Repertory Grids in HRD. *Journal of European Industrial Training, 4*(2), 2-32.

Easterby-Smith, M., Thorpe, R., & Holman, D. (1996). Using repertory grids in management. *Journal of European Industrial Training, 20*(3), 3-30.

Education, D. o. (2000, 20030515). *The Swedish Curriculum for Technology Education*, from http://www.skolverket.se/pdf/english/compsyll.pdf

Epstein, S., Lipson, A., Holstein, C., & Huh, E. (1992). Irrational Reactions to Negative Outcomes: Evidence for Two Conceptual Systems. *Journal of Personality and Social Psychology, 62*(2), 328-339.

Ericsson, A. K., & Charness, N. (1997). Cognitive and Developmental Factors in Expert Performance. In P. J. Feltovich, K. M. Ford & R. R. Hoffman (Eds.), *Expertise in Context* (pp. 3-41). Menlo Park: AAAI Press / The MIT Press.

Fetherstonhaugh, T. (1994). Using the repertorygrid to probe students' ideas about energy. *Research in Science & Technological Education, 12*(2), 117-128.

Fransella, F. (2003). *International handbook of personal construct psychology*. Chichester, West Sussex, England: J. Wiley & Sons.

Fransella, F., & Bannister, D. (1977). *A manual for repertory grid technique*. London: Academic P.

Frewer, L. J., Howard, C., & Shepherd, R. (1998). Understanding public attitudes to technology. *Journal of Risk Research, 1*(3), 221-235.

Gaines, B. R., & Shaw, M. L. G. (2003). *Personal Construct Psychology and the Cognitive Revolution*, from http://pages.cpsc.ucalgary.ca/~gaines/reports/PSYCH/SIM/index.html

Gathercole, C. E., Bromley, E., & Ashcroft, J. B. (1970). The reliability of Repertory Grids. *Journal of Clinical Psychology, 26*(4), 513-516.

Hassenzahl, M., & Wessler, R. (2000). Capturing Design Space From a User Perspective:The Repertory Grid Technique Revisited. *International Journal of Human-Computer Interaction, 12*(3&4), 441-459.

Hillier, Y. (1998). Informal Practitioner Theory: Eliciting the Implicit. *Studies in the Education of Adults, 30*(1), 35-52.

Honey, D. (2001). *The Repertory Grid in action: how to use it to conduct an attitude survey*

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merrienboer, J. J. G. (2002). Exploring teachers' instructional design practices from a systems design perspective. *Instructional Science, 30*, 291-305.

Jankowicz, D. (2004). *The easy guide to repertory grids*. Chichester, West Sussex, England ; Hoboken, N.J.: Wiley.

Jankowicz, D., & Hisrich, R. D. (1987). Intuition in small business lending decisions. *Journal of Small Business Management, July*, 45-53.

Jerrard, R. (1998). Quantifying the Unquantifiable: An inquiry into the Design Process. *Design Issues, 14*(1), 42-53.

Karppinen, S. (2000). *Repertory Grid Technique in Early Childhood as a Tool for Reflective Conversations in Arts Education.* Paper presented at the 10th European Conference on Quality in Early Childhood Education, London.

Kelly, G. A. (1955). *The psychology of personal constructs*. New York: Routledge.

Kimbell, R. (2004). *Assessment in Design and Technology Education for the Department of Education & Skills, UK.* Paper presented at the 3rd Biennial International Conference on Technology Education Research, Brisbane.

Kimbell, R., Bain, J., Miller, S., Stables, K., Wheeler, T., & Wright, R. (2006). *Assessing design innovation*. London: Goldsmiths College, University of London.

Lieberman, M. D. (2000). Intuition: A Social Cognitive Neuroscience Approach. *Psychological Bulletin, 126*(1), 109-137.

Lindström, L. (2001). *Criteria for assessing students' creative skills*.Unpublished manuscript, Rotterdam 26-29 september.

Lindström, L. (2005). *Assessing Craft and Design: Conceptions of Expertise in Education and Work*.Unpublished manuscript, Stockholm.

Lindström, L., Ulriksson, L., & Elsner, C. (1999). *Portföljvärdering av elevers skapande i bild.(Portfolio Assessment of Students' Creative Skills in the Visual Arts)* (No. 99:488). Stockholm: Skolverket / Liber Distribution.

Mawson, B. (2003). Beyond 'The Design Process'; An Alternative Pedagogy for Technology Education. *International Journal of Technology and Design Education*(13), 117-128.

Mazhmdu, G. N. (1992). Using repertory grid research methodology in nurse education and practice: a critique. *Journal of Advanced Nursing*(17), 604-608.

Middleton, H. (2002). Complex problem solving in a workplace setting. *International Journal of Educational Research*(37), 67 –84.

Middleton, H. (2005). Creative Thinking, Values and Design and Technology Education. *International Journal of Technology and Design Education*(15), 61-71.

Neimeyer, G. J. (2002). Towards reflexive scrutiny in Repertory Grid methodology. *Journal of Constructivist Psychology*(15), 89-94.

Neimeyer, G. J., Bowman, J. Z., & Saferstein, J. (2005). The effects of elicitation techniques on Repertory Grid outcomes: Difference, opposite and contrast methods. *Journal of Constructivist Psychology, 18*, 237–252.

Nightingale, P. (1998). A cognitive model of innovation. *Research Policy*(27), 689–709.

Parkinson, B., & Lea, M. (1991). Investigating personal constructs of emotions. *British Journal of Psychology, 82*, 73-86.

Petroski, H. (1996). *Invention by Design*. Cambridge: Harvard University Press.

Pill, A. (2005). Models of professional development in
the education and practice of new
teachers in higher education. *Teaching in Higher Education, 10*(2), 175-188.

Polanyi, M. (1966). *The Tacit Dimension*. Gloucester,Mass.: Doubleday & Company, Inc.

Quinn, E. (1980). Creativity and Cognitive Complexity. *Social Behavior and Personality, 8*(2), 213-215.

Reber, A. S. (1989). Implicit Learning and Tacit Knowledge. *Journal of Experimental Psychology: General, 118*(3), 219-235.

REEVE, J., OWENS, R. G., & NEIMEYER, G. J. (2002). Using examples in repertory Grids: The influence of construct elicitation. *Journal of Constructivist Psychology*(15), 121-126.

Schon, D. A. (1987). *The Reflective Practitioner*. London: Temple Smith.

Sloman, S. A. (1996). The Empirical Case for Two Systems of Reasoning. *Psychological Bulletin, 119*(1), 3-22.

Smith, M., Hartley, J., & Steward, B. (1978). A case study of repertory grids used in vocational guidance. *J. occup. Psychology.*(51).

Stevenson, J. (2003). Expertise for the workplace. In J. Stevenson (Ed.), *Developing vocational expertise* (pp. 3-25). Rows Nest Australia: Allen & Unwin.

Sun, R., Slusarz, P., & Terry, C. (2005). The Interaction of the Explicit and the Implicit in Skill Learning:A Dual-Process Approach. *Psychological Review, 112*(1), 159-192.

Williams, P. J. (2000). Design: The Only Methodology of Technology. *Journal of Technology Education, 11*(2), 48-60.

Yorke, M. (2001). Bipolarity … or not? Some Conceptual Problems Relating to Bipolar Rating Scales. *British Educational Research Journal, 27*(2), 171-185.

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