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Chapter 25

Constructive Alternativism: George Kelly's Personal Construct Theory

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Abstract

George Kelly's professional focus was on supporting people who were struggling with the stresses of their lives. Finding that the Freudian ideas he had been offered as tools in his own professional training offered little in working towards change with many of his clients, Kelly developed his own approach based upon a constructivist perspective of learning (which he called constructive alternativism) centred on the core metaphor of person–as–scientist. People, like good scientists, should always be open to exploring new data and considering alternative explanations and conceptions, rather than becoming fixed in established ways of thinking. Kelly's work developed into a recognised approach in psychology, and became very influential in at least one school of thought in science education. Kelly did not only offer a theory that could support clinical practice for therapists, but also offered a methodology for exploring a learner's developing thinking. In his own educational work, he found that his approach offered insights into teachers' classroom difficulties. This chapter considers the core ideas of Kelly's theory in comparison with other constructivist perspectives employed in science education. The chapter also discusses how Kelly's personal construct theory can inform classroom teaching and reflects on an approach that explicitly expects people to behave scientifically as a perspective on science teaching and learning.

Keywords: the method of triads; repertory grid; personal constructs; constructivism; children's science; alternative conceptions; person-as-scientist; falsificationism; accumulative fragmentalism; systems of constructs; building one's own maze; construct repertory test; conceptual change; triads as a teaching tool

Introduction

George Kelly proposed a perspective that he called constructive alternativism, and from within this developed Personnel Construct Theory (PCT). This chapter offers an introduction to PCT and its relevance for practice and research in education. Kelly's background and motivation for developing his ideas are briefly considered, and then the grounds for considering PCT as a theoretical framework in education are discussed. The nature of PCT as a constructivist theory is discussed, highlighting its similarities and points of difference with other constructivist theories that are commonly adopted in education. Kelly developed practical tools to apply his theory - the method of triads and repertory grid. The potential of these tools to those working in education is considered.

George Kelly (1905-1967)

George Kelly was something of a polymath, a renaissance man in a time of specialists. For his undergraduate degree he studied physics and mathematics. For his master's degree he chose sociology. He became interested in education, and so went back to college to read for a first degree in that subject. He then took both a masters, and then a doctoral degree, in psychology, before taking up work as a therapist. In a critical review of the dominance of constructivist thinking in science education, Joan Solomon (1994, p. 7) described Kelly as "a psychologist who studied patients locked away in the solitary world of the schizophrenic".

Kelly himself had been trained in the therapeutic methods of Freudian psychoanalysis. The Freudian perspective posits a structure to the mind and mechanisms by which early life experience could lead to various neuroses. Kelly found the system unsatisfactory as a basis for offering practical support for his clients. Kelly was dealing with people who often were deeply distressed in terms of how they understood their lives and he judged that Freud's theory did not offer him tools that were useful in helping his clients. He therefore came to a new way of thinking about patients' problems that he considered had more potential to be productive. He codified his system as PCT, which he included in a technical book to support other therapists who might want to adopt his methods. The account of the theory was then later republished as 'A Theory of Personality: The psychology of personal constructs' (Kelly, 1963).

Constructive alternativism

Kelly came to "a philosophical position" that he labelled "constructive alternativism" (Kelly, 1958/1969a, p. 64): "the notion that one does not have to disprove one proposition before entertaining one of its alternatives" (p.55). Kelly was arguing that given that there is generally some uncertainty about our existing understandings, we should be open to considering other options, alternative conceptualisations, even when they seem inconsistent with aspects of our current thinking.

This reflected Kelly's work with his clients, many of whom had developed ways of making sense of their worlds - their relationships, their lives, their role in the workplace - which were unproductive and impacting on them in negative ways. Kelly thought that "no one needs to paint themselves into a corner; no one needs to be completely hemmed in by circumstances; no one needs to be the victim of his or her biography" (Kelly, 1963, p. 15). [1]

Personal construct theory

Kelly set out his theory as a set of principles or tenets, described as a basic postulate and a series of corollaries (Kelly, 1963), reproduced in Table 25.1. Kelly's theory is constructivist in the way that it suggests that an individual person understands the world through developing a system of constructs that are personal to that individual, and which are the basis for interpreting experience. A construct had broad application as it was "an abstraction and, as such, can be picked up and laid down over many, many different events in order to bring them into focus and clothe them with personal meaning" (Kelly, 1958/1969b, p. 87). For Kelly such constructs encompassed the cognitive, affective and conative (Kelly, 1963, p. 130) and were bipolar continua. Examples might be 'large-small' or 'up-down' - that is dimensions which are each defined in terms of two poles that can be considered 'opposites' but which allow of intermediates. However, whereas we can all appreciate 'large-small' and 'up-down' as we all share similar meanings for the labels and all use such discriminations (Lakoff & Johnson, 1980), many personal constructs would be more idiosyncratic, and would not always have communicable labels that would be readily understood by others. Indeed, a key feature of many personal constructs is that as well as not having explicit labels, the

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[1] Because of the norms of the time he was writing, Kelly tended to use the male pronoun, referring to man, his, him, etc. This seems anachronistic, if not sexist, to a contemporary reader, and quotations are here updated to be gender neutral.

very construct itself may be tacit. That is, we may be applying discriminations without even being aware of doing so - personal constructs may be part of our implicit cognition. This links with work in science education on the role of implicit knowledge elements in cognition (Brock, 2015; diSessa, 1993; Taber, 2014a – see also Chapter 26), and more widely with the idea of two complementary systems of thought (Evans, 2008) acting within human cognition: faster-intuitive (preconscious) and slower-deliberative (conscious).

Principle label	Principle posits
The basic postulate	A person's processes are psychologically channelised by the ways in which he or she anticipates events.
The construction corollary:	We conservatively construct anticipation based on past experiences.
The experience corollary:	When things do not happen as expected, we change our constructs. This changes our future expectations.
The dichotomy corollary:	We store experience as [bipolar] constructs, and then look at the world through them.
The organisational corollary:	Constructs are connected to one another in hierarchies and networks of relationships. These relationships may be loose or tight.
The range corollary:	Constructs are useful only in limited ranges of situations. Some ranges are broad, others narrow.
The modulation corollary:	Some construct ranges can be 'modulated' to accommodate new ideas. Others are 'impermeable'.
The choice corollary:	We can choose to gain new experiences to expand our constructs or stay in the safe but limiting zone of current constructs.
The individuality corollary:	As everyone's experience is different, their constructs are different.
The commonality corollary:	Many of our experiences are similar and/or shared, leading to similarity of constructs with others. Discussing constructs also helps to build shared
The fragmentation corollary:	Many of our constructs conflict with one another. These may be dictated by different contexts and roles.
The sociality corollary:	We interact with others through understanding of their constructs

Table 25.1: The key tenets of Kelly's PCT (based on Kelly, 1963)

It is worth recalling that Kelly's theory was first presented in the 1950s, as much of it now seems mainstream given the widespread influence of constructivist thinking in education. As one example, Kelly's notion of looking at the world through one's constructs is reflected in constructivist work using the metaphor of people putting on different glasses to see the world (Pope & Watts, 1988). Kelly shares with such constructivist thinkers as Piaget (see Chapter 10) and Vygotsky (see Chapter 19) an assumption that frameworks for thought are developed iteratively over time such that each individual builds up a personal apparatus for modelling the world. Kelly's conception of constructs suggests somewhat discrete highly focused elements, where Piaget's theory (1970/1972) was based around the construction of domain-general structures of cognition that are largely under developmental control (albeit dependent upon opportunities to engage in, and derive feedback from, action in the environment). Like Vygotsky (1934/1986), however, Kelly's system did not posit completely independent elements (peas in a pod, in Vygotsky's simile), but a *system of* constructs (the organisational corollary - see Table 25.1).

In terms of social conditions, Kelly's theory makes an interesting complement to Piaget and Vygotsky. Piaget acknowledges social influences (see, for example, Piaget, 1959/2002, Chapter VI), but has been widely criticised for seeming to underplay them in much of his writing, whereas for Vygotsky (1978) the social context is critical as development of higher psychological functions relies on the modelling available from others. Kelly seems to stand in a somewhat intermediate position. Most of his principles (see Table 25.1) can be read as concerning how the individual interprets experience to produce a system for making sense of the world, and so anticipating the future. However, discussion and intersubjectivity also put in appearances (the commonality and sociality corollaries): suggesting that for Kelly social interaction was one aspect of a more general process by which constructs are derived. Moreover, in Kelly's theory there is no substantive distinction between constructs based on interaction with the physical environment and constructs deriving from enculturation, nor between those which are open to explicit reflection and those that channel tacit cognition (distinctions which are important in Vygotsky's theory).

Kelly's theory offers a good fit with many of the results of the research into what was called children's science or the alternative conception movement (Taber, 2009). This work highlighted the wide range of – sometimes idiosyncratic – alternative conceptions students presented that were alternative to the target concepts presented in the school curriculum. Piaget's theory explained in general terms why building the canonical (often abstract) concepts of formal science was challenging for students, and Vygotsky's theory explained why cultural mechanisms for reproducing knowledge were compromised by spontaneous thinking, but both of these approaches could be seen as deficit models: failures of logic or failures of cultural transmission – or indeed in some (judged to be) less developed social contexts, a society collectively lacking the resources for higher cognitive development (Luria, 1976).

Some researchers in science education wanted a theoretical base more in keeping with an ethnographic frame for exploring learners' ideas: that is for seeking to characterise and understand the nature and internal logic (i.e., derivation) of alternative conceptions, rather than simply their failure to match up to formal scientific concepts.[2] Kelly's theory, which did not posit personal constructs as essentially limited or flawed, fitted this stance. In this regard Kelly's theory has much in common with Glasersfeld's (1993) 'radical constructivism' where a person's understanding of the world is seen as a construction of reality based on that person's current interpretation of experience – with its necessarily limited access to the external world (see Chapter 24). Glasersfeld's constructivism suggests that we can never have unmediated access to an objective reality, but – to the extent that new experiences can offer opportunities to better understand the world – we can refine our constructions. From the perspective of PCT, personal constructs are not second-class versions of canonical ways of thinking, but rather all human conceptualisation occurs in terms of individuals' systems of personal constructs. So, the ideas of Darwin, Einstein, Freud, de Beauvoir, Keynes, Marx - and so forth - are as much products of personal construing as those of any science undergraduate, school pupil, or toddler.

Kelly's system also linked well with the motivations of those exploring the nature of students' ideas. Much of the importance attached to alternative conceptions by science educators was in their potential to be impediments to learning of canonical ideas. There were active debates about whether learners' conceptions were theory-like (coherent principles applied consistently) or not, stable or not, readily discarded when challenged or not, commonly held or idiosyncratic (Taber, 2009). The evidence available, or certainly the published interpretations of it, supported different views. It seems more obvious now that such debates were over-simplistic as people's ideas vary

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[2] It is sometimes useful to distinguish the conceptualisations of individuals (as conceptions) with the canonical conceptual structures of academic science (concepts) - then personal constructs relate to conceptions rather than concepts. However, a concept is empty unless it is applied by someone (and so is their conception), suggesting that this distinction uses 'concept' as a referent for an ideal with which real conceptions could (in principle) be contrasted (see Taber, 2013c).

along such dimensions (Taber, 2014b), and so more useful research questions asked about the particular conditions *when* student ideas seemed to be theory-like or not, and so forth.

Kelly's theory can encompass the range of empirical findings from research into learners' ideas. Constructs could be more or less tightly arranged into hierarchies (organisational corollary); could have limited or more extensive ranges of application (range corollary), and could be more or less coherent (fragmentation corollary); could be more or less readily modified (modulation corollary); could be more or less like those of their peers (individuality and commonality corollaries). Of course, such an inclusive theory has limited predictive power unless it explores *when* (under what conditions) constructs have particular qualities - but this framework provides a suitable language for discussing the phenomena of learners' ideas in science. In terms of Lakatos' (1970) model of scientific research programmes, PCT (a) offers a hard core of commitments (i.e., table 25.1) for a research programme and (b) suggests a positive heuristic for developing a belt of auxiliary theory to provide tools for diagnostic assessment and to develop teaching approaches (Taber, 2009). One of the most influential science education research groups in the 1970-1980s, the Personal Construction of Knowledge Group based at Surrey University (UK), adopted this perspective (Pope, 1982).

Kelly's own professional concern was in the extent to which people could change the way they construed their own realities, by positing, testing, and adopting alternative constructions. This clearly has parallels with the key focus in science education on conceptual change. It might be argued that a difference is that in science education the teacher wants to shift thinking towards a canonical target, where in therapy the aim was to help the individual see the world in a way that they themselves could be more comfortable with: however in both cases the outside agent is supporting a client in making changes that the client themselves might in principle somewhat desire (assuming they have entered therapy or class voluntarily) yet might resist because such changes may seem threatening or nonviable. Interestingly, one of the most influential general books produced by those researching student ideas, Driver's (1983) '*Pupil as Scientist?*' reflects Kelly's key metaphor for the person construing their world.

People as (informal) scientists

Driver (1983, Preface) wrote that "pupils, like scientists, view the world through the spectacles of their own preconceptions, and may have difficulty in making the journey from their own intuitions to the ideas presented in science lessons". Driver's title was posed as a question: a question Kelly had also posed. Kelly asked if it was possible to apply more universally (to people generally) his notion of being a scientist, one who:

> observes, becomes intimate with the problem, forms hypotheses inductively and deductively, makes test runs, relates data to predictions, controls experiments so that he or she knows what leads to what, generalises cautiously, and revises thinking in the light of experimental outcomes…our model of a person is that of person-the-scientist and our questions will revolve about the issue of whether a person can be understood in this manner, both in the floodlight of history and in the dark of his or her closet (Kelly, 1958/1969a, pp. 62-63).

According to the widely discussed falsificationist model of science championed by Karl Popper (1989), experimental outcomes can falsify the hypothesis being tested and then a good scientist should happily acknowledge that the hypothesis has been refuted and seek an alternative. Huxley (1870) had famously described 'the slaying of a beautiful hypothesis by an ugly fact' as 'the great tragedy of science'. However, taking a view that fits with more recent descriptions of 'science in action' (Latour, 1987) or 'science-in-the-making' (Shapin, 1992), Kelly recognised that the scientist had various options available. These included changing the predictions (perhaps revisiting what should be anticipated on the basis of a current construction); or the grounds for making predictions (perhaps switching to other constructs in the personal system); or the operational pattern of the constructs being used (which might be considered parallel to rejecting the instrumental theory rather than the substantive one: as when Galileo's contemporaries refused to admit what he saw through the telescope and justified this by rejecting that such a device could offer a valid image of the heavens); adopting a new construct to make sense of the findings - or even rejecting the results: the scientist "may refuse to accept the verdicts given by the data and ignore them, distort the perception of them, or manipulate them in such a way that they will appear to confirm the hypothesis" (Kelly, 1961/1969, pp. 110-111). Some of these options may seem illogical, unprofessional, or counterproductive, but (notwithstanding Huxley and Popper), in practice, scientists can adopt a wide range of strategies to avoid letting some inconvenient datum spoil an elegant theory. Indeed, the philosopher Lakatos argued that a naive adherence to falsificationism was not even logically justifiable. Often, the most rational thing for a scientist to do with an apparently uncooperative result produced in an otherwise productive research programme is to 'quarantine' (Lakatos, 1970) it as a puzzle to return to later, and then to, for the time being at least, carry on regardless.

Science as a process of knowledge construction

Kelly posited two models of how science might be imagined to proceed. One he described as 'accumulative fragmentalism', which saw science as analogous to a collective endeavour to complete a vast jig-saw puzzle, where each piece in turn needed to be found and carefully verified and fitted into its right place, before moving on to the next piece. This matched a commonly held image (perhaps even caricature) of the work of science, but Kelly preferred a different description, indeed a 'philosophical position', that he called 'constructive alternativism'. This perspective:

> is a constructive one. We understand our world by placing constructions on it. And that is the way we alter it too. There is no finite end to the alternative constructions we may employ; only our imagination sets the limits. Still, some constructions serve better than others, and the task of science is to come up with better and better ones. Moreover, we have some handy criteria for selecting better ones; at least we think we have, and they, too, are subject to reconstruction. (Kelly, 1964/1969, p. 125).

In this model, there is no sense that we might soon finish the jigsaw picture of nature, as an "ultimate correspondence" between our constructions and reality was "an infinitely long way off" (Kelly, 1961/1969, p. 96). Kelly thought "that reality is subject to many alternative constructions, some of which may prove more fruitful than others" and that progress comprised of inventing new constructions that would seem useful for a while, but would ultimately be found unsatisfactory, and so come to be replaced.

For Kelly, science was not an inevitable march of progress to a realistically achievable end, but rather a process we could have reasonable confidence was, on the whole, shifting in "in the right direction" (Kelly, 1961/1969, p. 96). This view again seems to reflect a contemporary perspective of the nature of science as offering 'reliable knowledge' (Ziman, 1978/1991), if not absolute truth corresponding to an objective external reality. This then was a constructivist notion of how science proceeds, and indeed for how people should proceed more generally. A person "develops his ways of anticipating events by construing - by scratching out his channels of thought" (Kelly, 1958/1969b). This can therefore offer a perspective for thinking about how individual learners may slowly modify their constructs within science classes in response to the experiences provided for them to construe. If nothing else, Kelly's insights can be valuable in both warning science teachers to be prepared for students to sometimes be slow in shifting from their alternative conceptions, but also reassuring them that in time such shifts can be achieved. A student trying to make sense of the implications of Newton's first law of motion, or seeking to come to terms with the immense timescale over which life on earth has evolved, needs time to 'scratch out' new channels of thought.

The construct system as a framework

The importance of considering a person's constructs as forming a system is that in a well-integrated system a single component cannot be changed as if in isolation from the rest of the system. Kelly described the hierarchical system as "a network of constructs" reflecting the relational model of concepts (Gilbert & Watts, 1983) that considers each concept to sit in a multi-dimensional net of linked concepts – the 'content' of a concept is "the full range of meanings due to its associations within the wider web or net of concepts" (Taber, 2019, p.31). [3] If our understanding of one concept changes, this has potential repercussions for all those other concepts that are linked to it - and so through a 'conceptual inductive effect' (Taber, 2015) to those linked *indirectly* through those other concepts. The term alternative conceptual 'framework' is sometimes used to label those closely related student conceptions which have been organised into extensive structures based on some key alternative conception. For example, the common misconception that chemical change is motivated by atoms seeking full shells can be at the core of an extensive network of ideas (some more canonical, many contrary to scientific principles) about chemical stability, chemical reactions, chemical bonding, ionisation energies, and so forth (Taber, 2013a).

Kelly used the metaphor of a person building their own 'maze', or 'labyrinth' – an ongoing building project where the structure was subject to perpetual revision, but where "the complex interdependent relationships between constructs in the system often makes it precarious for the person to revise one construct without taking into account the disruptive effect upon major segments of the system" (Kelly, 1958/1969b). This seems reminiscent of Thomas Khun's (1996)

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[3] Although this is certainly not the only way in which concepts may be understood, this conceptualisation seems to underpin (deliberately or inadvertently) the common use of tools such as concept maps to elicit and represent conceptual structures.

notion of scientists generally working within the framework of a particular familiar, indeed encultured, disciplinary matrix with its associated paradigm channelling thought. However, in this sense, Kelly's views better aligned with Popper (1994) who rejected what he called the 'myth' of the framework: that a person's current commitment need act as a kind of thought-prison. With Popper, Kelly thought that people build their own mazes (prisons) and so could ultimately deconstruct them. Kelly did, however, realise that this might be difficult work - which was where the therapist could hopefully help. Similarly, in a science classroom, the teacher can support a student in breaking out of the 'prison' of a tenacious conceptual framework that has come to be habitually used to make sense of a whole class of events – such as identifying a force with the direction of motion; or considering chemical change to occur so that atoms can fill their shells with electrons; or assuming that biological species are fixed types.

Kelly did apply his work in education. He described how in working with teachers,

> …the teacher's complaint [about a pupil] was not necessarily something to be verified or disproved by the facts of the case, but was, rather a construction of events in a way that, within the limits and constructions of her or his personal construction system, made the most sense to her or him at the moment. (Kelly, 1958/1969b, p. 76).

So, for example, Kelly found that teachers' complaints of 'lazy' students usually referred to pupils who needed more support to cope with classroom demands, and Kelly worked at 'reorientation' of the teacher's perception of the situation as "it usually happened that there was more to be done with [the teacher] than the child…Complaints about motivation told us much more about the complainants than it did about their pupils" (Kelly, 1958/1969b, p. 77).

A methodology for PCT

The therapist would however need tools, and in particular would need to help the client make explicit their current ways of construing the world as a first step to appreciating that other alternative construals could be viable. The parallel with science education is clear here, with the recommendations in constructivist literature that teachers must elicit students' alternative conceptions to understand students' current ways of thinking, as part of the process of developing teaching to shift learners' thinking towards the scientific models represented in the curriculum (Driver & Oldham, 1986; Russell & Osborne, 1993). [4]

From the perspective of educational research, this means that Kelly's work offers a system that includes both a theory offering metaphysical commitments, and associated methodology. Kelly tells us constructs are like this (ontology) - in particular, that they often act through implicit thought without being open to immediate conscious inspection - and this means there are certain challenges in identifying them (epistemology); and he then proposes an approach to proceed accordingly (methodology). Kelly offered two related tools that have since found widespread use: the construct repertory test (CRT) and the repertory grid (Fransella & Bannister, 1977).

The construct repertory test: the method of triads

The basis of Kelly's CRT, also known as the method of triads, is to provide an activity where the person is asked to make discriminations (i.e., to construe the world) without necessarily having to explicitly apply criteria. This means that implicit constructs may be used, whereas a task that relies on a reflective activity (such as giving a verbal description) cannot directly tap intuitive thought. Kelly considered that, as his system concerns bipolar constructs, the simplest approach was to present three elements to be discriminated and to ask the client "to think of some important way in which you regard two of them as similar to each other but in contrast to the third" (Kelly, 1961/1969, p. 106) - in effect, which two fit together best; and which is the odd one out?

Kelly would prepare a deck of cards for this activity, from which various triads could be selected for presentation. He would first ask his clients to tell him about significant people in his life so the cards would have the names or roles of parents, siblings, spouse, boss, colleagues, neighbours, or whoever. This version of the approach is known as the Role CRT. The method of triads therefore elicited some of the ways a person made discriminations, and therefore drew upon the constructs the person used (whether aware of them of not) to interpret the world. A verbal label could be put at one pole of the elicited construct ('kind', 'hurtful', 'loving', 'bossy', 'cold', etc.). The implicit pole might be given a label if the person readily offered one, or might just be an unnamed contrast.

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[4] 'Represented' in the curriculum, because it is assumed that the target knowledge in school science is a curriculum model which often simplifies the actual scientific model to provide a realistic target for teaching/learning that offers the essence of the scientific model – that is, an 'intellectually honest' (Bruner, 1960) simplification.

Kelly's method can be applied widely. The 'elements' (as Kelly called what was presented, such as names of people or roles) need not be about people: indeed, in published research objects or images of various kinds have been presented - for example the names of museums and art galleries, or planets, or pictures of different designs of writing pens. An example from science education asked students to make discriminations among triads of cards showing representations of submicroscopic structures such as atoms, ions and molecules (Taber, 1994). Of course, in Kelly's original work, the elements were selected to be of significance for the client so the act of making discriminations had ecological validity - it linked to a client's own concerns.

In such therapeutic work the practice is ideographic, concerned with the nature of the individual (Taber, 2013b). Kelly's method can be used in more nomothetic research looking to test a population in their response to a common set of elements. If those being tested have no strong interest in the elements presented then the method loses some of its essential nature. One precaution to avoid asking for meaningless discriminations is to precede the presentation of triads by a screening stage. So, for example, if people were to be presented with triads of the names or images of famous scientists, the researcher could first go through the pack and ask the study participant to sort the elements into those they did or did not recognise as scientists. The test would then proceed with only the scientists recognised by that participant included in the bespoke deck.

Element presented: Elicited constructs:	Vygotsky	Piaget	Kelly	Ausubel	Glasersfeld	Kuhn	Popper	…
focus on social	✓	✗	✓					
natural scientist	✗	✓	✓					
psychologist		✓		✓		✗		
focus on stability					✗	✓	✗	
admits relativism					✓	✓	✗	
…								

Figure 25.1: The form of the outcome of the construct repertory test

For many purposes, the CRT can suffice as a method for exploring student conceptions. The researcher can gain insights into student thinking by exploring the choices a person makes and how they describe their constructions. The results of applying the method can be a grid of the form shown in figure 25.1. Such a grid may have diagnostic value in science teaching if discriminations are made which seem contrary to conventional science, and it can offer insights into the imaginative and idiosyncratic thinking of an individual.

The repertory grid

The repertory grid moves beyond the CRT. Having elicited labels for personal constructs, the participant is asked to then rate each element on each construct on a numerical (e.g., 5 or 7 point) scale. The outcome of this would be a grid with an entry in each cell (such as in the hypothetical case shown in figure 25.2). The strength of this type of data is that it allows a systematic analysis, to reflect aspects of the structure of a person's constructs (cf. the organisational corollary, table 25.1).

Element presented: Elicited constructs:	Vygotsky	Piaget	Kelly	Ausubel	Glasersfeld	Kuhn	Popper	…	
focus on social	7	2	5	4	2	7	2	…	focus on individual
natural scientist	3	6	6	4	4	7	7	…	[no label given]
psychologist	7	7	7	7	5	1	1	…	not psychologist
focus on stability	2	4	2	4	5	6	3	…	focus on change
admits relativism	2	4	6	4	6	5	1	…	denies relativism
…	…	…	…	…	…	…	…	…	…

Figure 25.2: The form of the repertory grid

The quantitative data generated allows tree diagrams to be constructed similar to those used in cladistics to show the relationships among different species: these can both reflect the degrees of perceived similarity among the elements and also the degrees of similarity among the elicited constructs applied. It is important (given the apparent precision of numbers) to recognise that any representation of the construct system produced is a model subject to the limitations of the methodology (Taber, 2013c). Any particular administration of the CRT is sampling from a vast repertoire of potential triads that could be presented. Moreover, the discriminations made in relation to a particular triad need not exhaust possible discriminations based upon available constructs. Just as the same interview questions could potentially access different responses from the same person, construct elicitations and ratings of elements should not be considered definitive. However, the analysis can offer a basis for identifying significant shifts between administrations potentially due to conceptual change.

Classroom application

Whilst the repertory grid is mainly a technique for research or detailed work with individual clients, the CRT has much potential to be used both in science education research and teaching. The elicitation can take the form of a research interview mediated by the use of triads as a focus for discussion - avoiding the formality of a psychometric test (Taber & Student, 2003). The process of selecting triads can be used for real-time hypothesis-testing as the researcher seeks to interpret the participant's thinking, and PCT offers a complement to approaches such as interview-about-instances (White & Gunstone, 1992).

There is also potential for the method of triads to be used as a teaching activity to initiate group discussion among students. Even quite young students can engage in choosing the 'odd one out'. Despite the strong links between Kelly's ideas and thinking about both the nature of science and students' science learning, there has been limited application of CRT to science teaching. Teachers could have multiple packs of 'elements' (which might be names / images / symbols for different organisms / habitats / organs / cell types / compounds / circuit components, etc.) which could be used in classroom starter or review activities. The approach can also be used in conjunction with other techniques. For example, students producing a revision concept map of a topic could be given a set of relevant cards and told that at any point where they feel they have exhausted their ideas they should pause and spend a few minutes playing the odd-one-out game (i.e., the method of triads) in pairs. This 'oblique strategy' is likely to help bring other features to mind.

The technique can also be used to encourage creative thinking in science. Despite imagination being an essential complement to logic in scientific work (Taber, 2011), this is often not sufficiently emphasised in school science. All scientific discoveries begin as imagined possibilities that are then empirically tested, and some of the most significant discoveries have involved imagining possibilities not entertained by scientific peers at that time. It has been suggested that later science learning is supported by early rich conceptualisation – that is that the ability to think up many possibilities is more valuable than coming up with canonical ideas (Adbo & Taber, 2014). Kelly's triads are intended to explore the manifold nature of a person's conceptual system, and so multiple responses are encouraged.

For example, students could be given a pack of elements showing the names/images of a range of types of animal. How many ways, for example, can the triad elephant / ant / dolphin, or the triad bat / snail / seahorse, be construed? There are clearly a great many possibilities. The activity would likely not only engage diverse biological knowledge (habitat, diet, geographical range, reproduction…), making it a suitable occasional activity for reviewing prior learning, but would, as well as revealing alternative conceptions, likely elicit conjectures that were uncertain that could motivate new learning. Similarly, if students were asked to construe a triad of elements [sic, elements as the triad elements!] – say, sulphur / magnesium / uranium – there are a great many potential responses. Too often science is taught as a very close-ended activity – where there is a right answer, a right way of thinking – which does not fully reflect the practice of science itself, yet when students are asked to be imaginative in a context where idiosyncratic responses are not subject to censor, they can respond with creativity and enthusiasm (Taber, 2016). The method of triads offers an accessible, flexible, and engaging classroom activity, yet underpinned by a substantive psychological theory.

Further reading

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