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Learning in the Liminal Space: A Semiotic Approach to Threshold Concepts

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Abstract:	The Threshold Concepts approach to student learning and curriculum design now informs an empirical research base comprising over 170 disciplinary and professional contexts. It draws extensively on the notion of troublesomeness in a 'liminal' space of learning. The latter is a transformative state in the process of learning in which there is a reformulation of the learner's meaning frame and an accompanying shift in the learner's ontology or subjectivity. Within the extensive literature on threshold concepts, however, the notion of liminal space, has remained relatively ill-defined. This paper explores this spatial metaphor to help clarify the difficulties that some teachers observe in the classroom in regard to their students' understanding. It employs a novel and distinctive approach drawn from semiotic theory to to provide some explanatory insight into learning within the liminal space and render it more open to analysis. The paper develops its argument through four distinct phases. Firstly it explores the spatial metaphor of liminality to gain further purchase on the nature of this transformative space. The second section introduces semiotic theory and indicates how this will be used through a series of graphical and visual devices to render the liminal space more open to analysis. The third section then employs semiotic analysis to nine dimensions of pedagogical content knowledge to gain further insight into what may characterise student conceptual difficulty within the liminal state. The fourth and concluding section emphasises the role of context in conceptual discrimination before advocating a transactional curriculum inquiry approach to future research in this field.
Response to Reviewers:	We have made reference to and cited the Baillie et al work 'Heteropia: Alternative pathways to social justice'. We did not include additional material relating to the individual subjectivities and underlying epsistemologies of authors as, with three authors, we felt this would be cumbersome, would adversely affect the tone and coherence of the piece and would not substantially add to the argument. We have corrected and standardised references as requested in keeping with the house style.

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> The only real voyage of discovery consists not in seeing new landscapes, but in having new eyes, in seeing the universe with the eyes of another.
>
> Marcel Proust, 1900

Introduction – Threshold Concepts

The Threshold Concepts approach to student learning and curriculum design now draws from an empirical research base comprising hundreds of academic papers from over 120 disciplinary and professional contexts, and from authors in the higher education sectors of many countries (Flanagan 2013).   This approach has advocated the idea that certain concepts, practices or forms of learning experience can act in the manner of a portal, or learning threshold, through which a new perspective opens up for the learner. The latter enters new conceptual terrain in which things formerly not perceived come into view. This permits new and previously inaccessible ways of thinking and practising. Meyer and Land (2005) characterise such conceptual gateways as transformative (occasioning a significant shift in the perception of a subject), integrative (requiring the integration of a new understanding or way of thinking and practising) and usually irreversible (unlikely to be forgotten, or unlearned only through considerable effort). A further significant characteristic, Meyer and Land indicate, is related to the discursive aspect of such thresholds. These conceptual gateways are often the points at which students experience difficulty and are often troublesome as they require a letting go of customary ways of seeing things, of prior familiar views. They provoke a state of 'liminality' – a space of transformation in which the transition from an earlier understanding (or practice) to that which is required is effected. This transformation state entails a reformulation of the learner's meaning frame and an accompanying shift in the learner's ontology or subjectivity. The latter tends to be uncomfortable or troublesome for, in many respects, we are what we know. As Dewey observed eighty years ago, 'The path of least resistance and least trouble is a mental rut already made. It requires troublesome work to undertake the alteration of old beliefs.' (Dewey 1933, cited in HLGMHE 2013 p.3).

Within the extensive literature on threshold concepts, however, the notion of liminal space as remased relatively ill-defined. This paper explores this spatial metaphor to help clarify the difficulties that some teachers observe in the classroom in regard to their students' understanding. It employs a novel and distinctive approach drawn from semiotic theory to to provide some explanatory insight into learning within the liminal space and render it more open to analysis.

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1   Characteristics of the Liminal Space

Thresholds theory draws extensively from the notion of troublesomeness in the liminal space. The latter is conceived as a transformative state in the process of learning in which there is a reformulation of the learner's meaning frame (Schwartzman 2009) and an accompanying shift in the learner's subjectivity. Hence it entails both a conceptual and an ontological shift. The notion of liminal space, however, has remained relatively ill-defined, something of a 'black box' within the conceptual framework of Threshold Concepts. The liminal state can be seen to perform a progressive function which begins with the encountering and integration of something new. This subsequently entails a recognition of shortcomings in the learner's existing view of the phenomenon in question and an eventual letting go of the older prevailing view. At the same time this requires a letting go of the learner's earlier mode of subjectivity. There then follows an envisaging (and ultimate accepting) of the

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alternative version of self which is contemplated through the threshold space. This involves a 're-authoring' of self as Ross (2011) terms it, or 'undoing the script'. Learning in the liminal space further entails the acquisition and use of new forms of written and spoken discourse and the internalising of these. Meyer and Land writing in this Journal in 2005 characterised liminality as 'a "liquid" space, simultaneously transforming and being transformed by the learner as he or she moves through it' (Meyer & Land 2005 p.380). These authors have characterised liminality as a transformative state that engages existing certainties and renders them problematic and fluid. It is also a suspended state in which understanding can approximate to a kind of mimicry or lack of authenticity. Liminality, they argue, can be experienced as unsettling, experienced often as a sense of loss, as prevailing earlier conceptual views, and earlier states of subjectivity, are relinquished. 'The condition of liminality' they observe, 'may be transformative in function; there may be a change of state or function' (Meyer & Land 2006 p.22). In keeping with anthropological accounts of liminal experience, learning within the liminal state is sometimes experienced as oscillative, as the changed perspective slips in out of focus and eludes the learner's grasp.

> Q. Did you feel the same as student 1?
>
> Second student: Yeah. I felt lost.
>
> Q. In lecture times as well?
>
> Second student: You know, I understood the concept for about let's say 10 seconds, yes yes, I got that and then suddenly, no no, I didn't get that, you know, suddenly, like this.
>
> (M. Orsini-Jones 2006)

The discursive shift that takes place as part of the liminal transformation has also been noted. There seems an indissoluble interrelatedness of the learner's identity with thinking and language (reading, writing, listening, talking). As Becker et al (2005p.421) point out, referring to the shifting discourse of medical students:

> ...students acquire a point of view and terminology of a technical kind, which allow them to talk and think about patients and diseases in a way quite different from the layman. They look upon death and disabling disease, not with the horror and sense of tragedy the layman finds appropriate, but as problems in medical responsibility.

Others emphasise the creative potential of the liminal space:

> No, I think you're misunderstanding me... we're not talking here about our students coming out of this liminal space..this liminality, whatever . We're saying we want them to stay in it. We want them to stay precisely in that fluid state. That complexity ... that emergence, because in that way their ideas won't become crystallised, they won't harden and get stylised. Their ideas will stay emergent ...provisional, exploratory ... Still with lots of unexplored possibilities. Fresh. That's what we want. Keeping that way of seeing . We want them – and their ideas – to stay held in that tension. That's the creative space.
>
> (Lecturer, Art School –personal communication)

Baillie et al (2012 p.2) in their application of threshold concept theory to issues of social justice, emphasise the non-linear and recursive nature of liminal space. They view it as a 'heterotopic' space in which to encourage counter-hegemonic thinking – thinking otherwise.

> ... the kinds of transitions we are considering are not linear, not the learning of simple isolated concepts, they are messy, abstract transformations. The space, which describes the learning journey we speak of, as well as its destination, is more like a 'heterotopia.' Heterotopias are places and spaces,

described by Michel Foucault in the text 'Of Other spaces' as 'non-hegemonic.' ... a place where alternatives are considered, 'common sense' is questioned and business as usual stops for a moment.

The notion of transformation itself has been subject to critique. In Ross' view, 'transformation has to be understood as a matter of shifting subjectivity, not as deep changes to an essential selfhood. Subjectivity is best understood as always in process, and so shifts are commonplace, part of the negotiations that take place as a result of the discursive nature of subjectivity ' (Ross 2011 p. 226). Ross' view here chimes with Dewey's earlier observation that 'The moment we recognise that the self is not something ready-made, but something in continuous formation through choice of action, the whole situation clears up' (Dewey 1916 p.235). Channelling shifts in subjectivity in this way, Ross argues, is a principle purpose of reflection in the educative process, 'a purpose that may still be complex and contestable, but which at least has the benefit of being open to analysis'. Subjectivity might also be considered as a discursive or narrative effect, 'a character in a story as much as the "author" of the story', according to Usher, Bryant, & Johnson, (2002 p.88) It is never 'a once-and-for-all construction', and the experience of meaning is never something permanently fixed. 'Subjectivity', they conclude, 'is therefore always shifting and uncertain and has to be continually "re-formed"'. (ibid)

It might be tempting to deem certain aspects of the liminal state as merely 'incorrigible' (Ayer 1956) – in that in principle they are inaccessible and 'unverifiable because they are matters of self-knowledge' (Gomm 2004). This paper seeks to explore this spatial metaphor further and the extent to which the liminal state might be rendered, in Ross' phrase, 'open to analysis'. It seeks to gain further purchase on why certain learners are better able to negotiate the liminal space and others find difficulty in doing so. It aims to identify likely determinants of successful liminal transition through the application of semiotic analysis, a perspective not formerly applied to threshold concept theory. This semiotic and visual (diagrammatic) analysis of the conceptual dimensions of liminal space is based on the work of Vivian (2012) and is intended to help clarify and simplify representation of what might be typical student learning experiences. It examines how the learner's experience of signification in the acquisition of new knowledge can lead to intended meanings, erroneous conception, partial understanding or confusion.

2   Signification - Liminality as semiotic space

Any encounter with troublesome knowledge in the liminal space will have a discursive characteristic. It will involve encounters with new signification and attempts to derive meaning from symbolic representation, linguistic, mathematical or graphical. This section of the paper attempts to gain further insight into the experience of liminal space from such a semiotic perspective. To facilitate the illustration of this section the Saussurean symbolism for the semiotic sign (Saussure 1916), which is composed of both a signifier (Sr) and a signified (Sd) has been further developed as shown in figure 1.
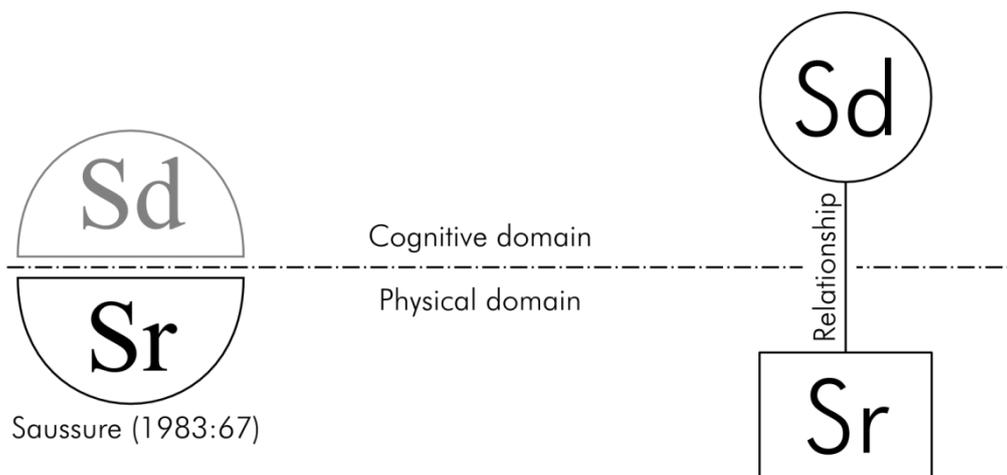

Figure 1: Proposed symbolism for the semiotic sign

The sign is now shown to consist of three parts not two:

- A rectangle denoting the signifier and representing the physical manifestation of the sign.

- A circle denoting the signified and symbolizing the intangible nature of thought.

- A line connecting the two denoting the relationship between the signifier and signified.

Threshold, portal, gateway, doorway are all metaphors that have been used for describing the nature of transformative concepts in the thresholds literature. For the purposes of illustration the metaphor of a tunnel is used here, which has certain advantages that will, it is hoped, become apparent as this section of the discussion develops. (See Figure 2.)

It is recognised that attempting to capture investigative notions such as threshold concepts, liminality and troublesome knowledge diagrammatically is potentially problematic. By fitting such interpretive notions into a schematic frame we do not wish to portray them in any essentialist fashion, as if they constitute predictable moments in a learner's trajectory. We acknowledge that such entities are best seen as fluid, and, as will be discussed below, that these forms of understanding and knowledge vary considerably according to context. We hope however that the following visual representation can act as a heuristic device which, used judiciously, may provide a useful means for teachers to discuss issues of troublesome knowledge with their students.
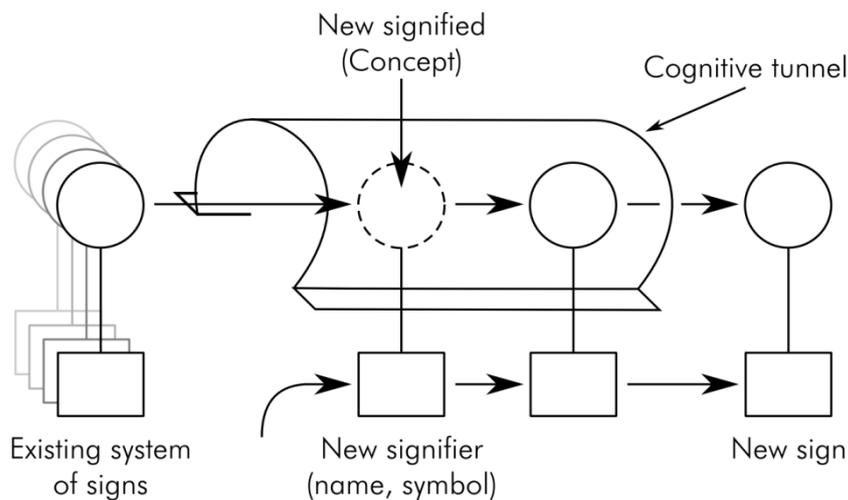
Figure 2: Introducing a new concept

The learner has a cognitive stock of existing concepts and their labels i.e. signs. When introducing a new concept, it is common practice to create a new signifier thus adding a new sign to the learner's stock. It takes time to learn this sign and when the learner emerges from the liminal 'tunnel', their ability and willingness to use the signifier will depend on their understanding of the signified and their feelings about the learning process.

Creating new names and graphic symbols can be problematic and so often, as is the case with everyday speech, the learner must be taught a new meaning for an existing signifier. In this situation, the learner must disregard an existing understanding of the signifier in favour of a new one for the new context. The learner may have to remember that the old understanding may still be appropriate in other contexts. See figure 3.
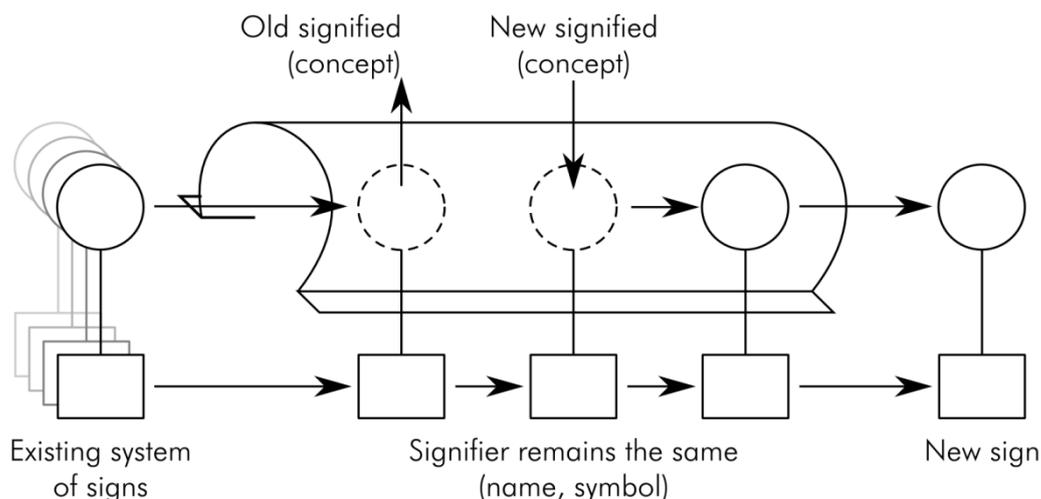
Figure 3: Introducing a new meaning

Conceptually this can be highly challenging. If unsuccessful, the learner will emerge with a different understanding from that of the teacher (i.e. the learner retains the old sign) and this will have repercussions for the efficacy of further communication in which the learner and teacher will be happy to use the same signifiers but have different perceptions of their signification.

The tunnel metaphor also includes the physical aspects of a tunnel. It is dark and foreboding. If long, the sense of direction and progress can become obscured and the light at the end may be dim or even non-existent. These properties are metaphors for the state of liminality that exists as the new concept is acquired. The new learner may not wish to enter the tunnel, or, being obliged to enter by the demands of the learning programme, may want to escape as quickly as possible. They may even give up and return to the entrance, seeking to find another less daunting route. These are metaphors for the willingness on the part of the new learner to engage in the conceptual struggle. (These affective dimensions of liminal experience will be considered in greater depth in the following section). It should be noted that the tunnel is drawn in the conceptual domain, which is internal to the individual learners and tutors involved. Communication between these individuals is in the physical domain where the oral, textual and graphic signifiers play their part.

3   Liminality and Pedagogical Content Knowledge

In any given episode or context of learning the way that the teacher draws on his or her knowledge of likely variation of signifieds in the pre-liminal state is, in our view, a characteristic of what Shulman (1987) has termed 'pedagogical content knowledge' (PCK). A teacher draws on PCK when putting him or herself in the position of the learner.

> Pedagogical content knowledge identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue. (Shulman, 1987, p. 4).

Land et al (2005:57-61) have identified nine implications of a threshold concepts approach that they feel are important in curriculum design and evaluation. Each of these implications can be construed as a factor within pedagogical content knowledge and we shall now consider each of these implications through a semiotic lens.

a)   Jewels in the curriculum

Threshold concepts are described as jewels because of the opportunity they provide for learners to gain crucial understandings and for teachers to gauge the conceptual development of their learners. Concepts inevitably tend to be explained in terms of other concepts, and even so-called elementary concepts have to be understood in terms of other concepts, albeit via metaphor. It is inevitable that signifiers (words, symbols, images) are accumulated by learners sequentially but – problematically – their signifieds (concepts) do not have to obey the same logical sequence. For example concept A could be understood in terms of concept B and concept B in terms of concept A, but one has to be learned first. It is therefore inevitable that when confronted with a concept the learners' understanding of some of the signs required for understanding that concept may be deficient in some way. For example, here is a student of Marine Biology:

> Osmosis is counter-intuitive, it goes the opposite way. When does it click? When you study marine fish in 2nd or 3rd year, you see what would happen; it's in a relevant situation. In first year you do mechanisms in blocks and there's no relevance. (Taylor 2008, p. 191)

This is represented diagrammatically in figure 4.
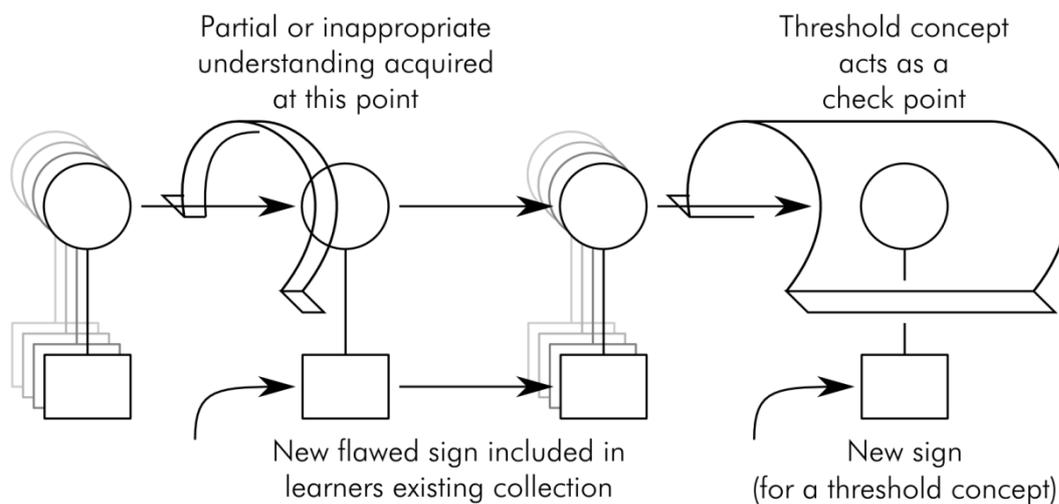
Figure 4: Threshold concepts as check points for progress

Any concept has to be described or represented using already familiar signs, and if any of these are poorly understood then the description or representation will be misunderstood. Perhaps the threshold concept is so troublesome not necessarily because the concept is so difficult but because it challenges the learner's understanding of its component concepts and this is why it acts as a check point for the learner's progress.

b) The importance of engagement

Studies have shown that learners need to engage with and manipulate conceptual materials i.e. the physical means of describing, discussing and exploring concepts. These are the signifiers in the physical domain and for academic subjects this inevitably includes forms of graphic communication. The teacher creates a framework of engagement by setting tasks designed to motivate the learner to engage with the conceptual nature (the signifieds) by transforming the signifiers from one context to another. The teacher can then infer understanding on the part of the learner by comparing the learner's transformation with their own. See figure 5.
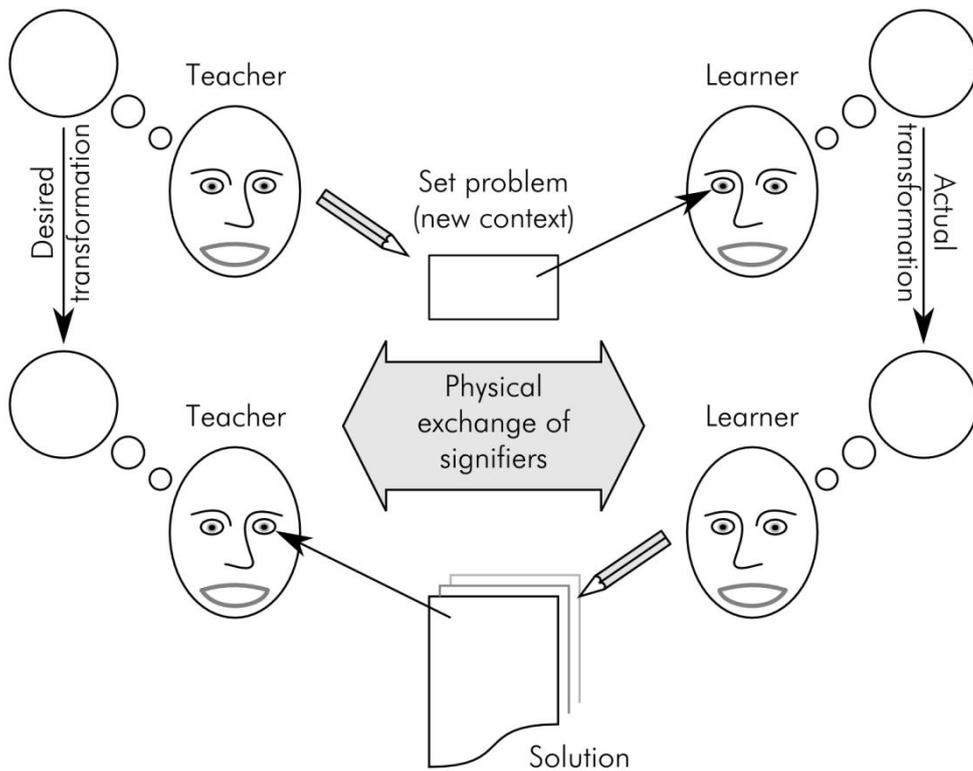
Figure 5: Creating and assessing conceptual engagement

Hence the communication between teacher and learner is in the physical domain and its efficacy depends to a considerable extent on the figurative capability of the graphic system being used.

Furthermore, specialised schematic graphic systems of communication can facilitate this process because they lack the ambiguity of realistic depiction and speech-based description systems, which make it more difficult for the learner to use signifiers without real understanding of their signifieds, and they possess graphic duality, which make it easier for the teacher to identify shortcomings in understanding.

c)   **Listening for understanding**

The transformative and integrative effects of threshold concepts cause the meanings of the existing signs in the learner's collection to change insofar as the signifieds change but the signifiers stay the same. See figure 6.
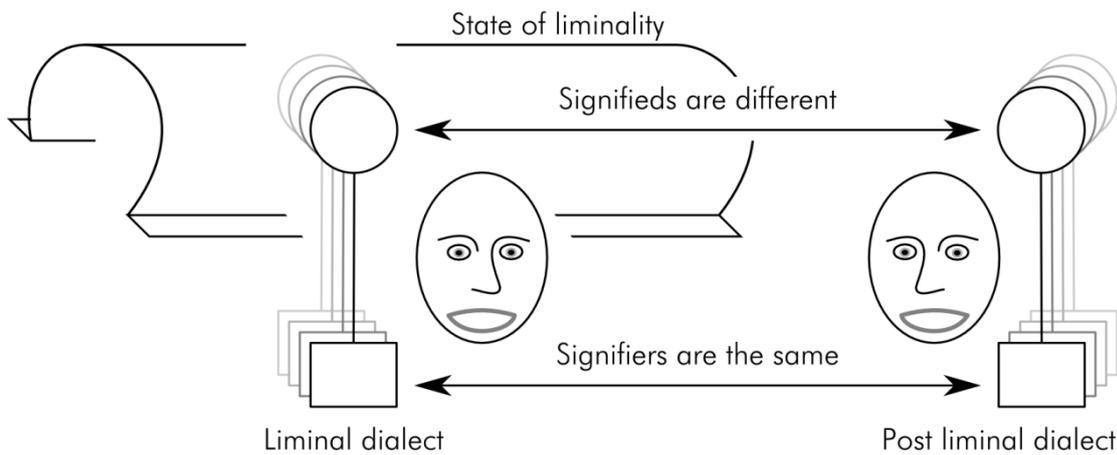
Figure 6: Unnoticed 'dialect'

In effect, there is now a new collection of signs – a new 'dialect'. Generally speaking, different dialects can be recognised because there are changes in the signifiers but in this case the signifiers stay the same and so the altered understandings are not self-evident. The specialised use, say, of the term 'culture' in Anthropology, or 'cost' in Accounting, would be examples. The change in dialect goes unnoticed.

Somehow, the teacher needs to put him or herself in the position of the learner but the transformative nature of threshold concepts cause old meanings to be forgotten since they are no longer appropriate. At the time of acquiring the appropriate understanding, the teacher as learner may not be consciously aware of the process nor have a need to remember it. Only later, when trying to pass on this understanding to others will the need to remember an earlier way of seeing become apparent. Time can also affect the teacher's memory of their personal liminal state. Liminal states can vary with the learner anyway and so the teacher must somehow be aware of the nature of the individual learner's liminal state.

d)   Reconstitution of self

It is perhaps difficult to comprehend how the acquisition of a single concept, however significant, can change the learner's perception of their self. It sounds more like a spiritual or religious experience. James (1902 p.206) categorizes such conversions as either 'volitional' or 'type by self-surrender'. The volitional type is of interest here in that it consists of a series of step changes, 'jerks and starts', that are accumulated over a period of time and this is more akin to the experience of an educational programme.

The addition of a new concept to a learner's collection can also affect the understanding of other concepts in that collection with the result that over time the whole collection develops and changes. This is depicted in figure 7.
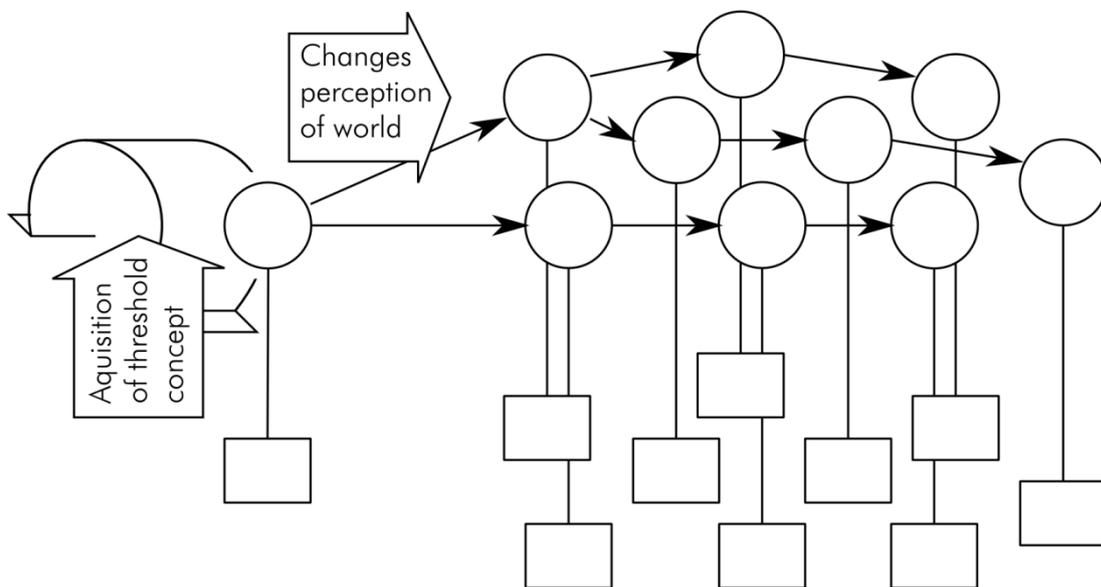

Figure 7: Shifting subjectivity: changing the self

Changing the signified changes our perception of the signifier and can cause us to identify new signifiers for the concept in different domains i.e. the integrative effect. This effect is accumulative and gradually affects our perception of the whole world around us and hence how we fit in that world. The experiences of encountering theories of gender, evolution, or the practice of deconstruction may all have such effects. The threshold concept

may be in the nature of a conceptual straw that breaks the camel's back – a piece in a jigsaw of concepts that causes them to coalesce and produce a step change in perception.

e)   Tolerating uncertainty

New signs have to be acquired sequentially but, significantly, concepts are not designed to be understood in a sequential manner and the world operates as an integrated whole. A certain amount of holistic understanding is always required. This inevitably means that there is a (liminal) period of uncertainty in the curriculum in which the reason for introducing the concept and perhaps the concept itself are not understood. As Dewey (1933 p. 26) observed:

> Reflective thinking is always more or less troublesome because it involves overcoming the inertia that inclines one to accept suggestions at their face value; it involves willingness to endure a condition of mental unrest and disturbance. Reflective thinking, in short, means judgement suspended during further inquiry; and suspense is likely to be somewhat painful.

Pedagogically it is a challenge for the course designer to minimise these periods and threshold concepts are required to integrate these concepts at regular intervals otherwise the course remains conceptually fragmented. The signifiers are acquired but the learner's understanding has to be delayed whilst waiting for more concepts to be introduced. (See Scheja 2006 for a detailed discussion of delayed understanding and 'staying in phase'). This is shown in figure 8.
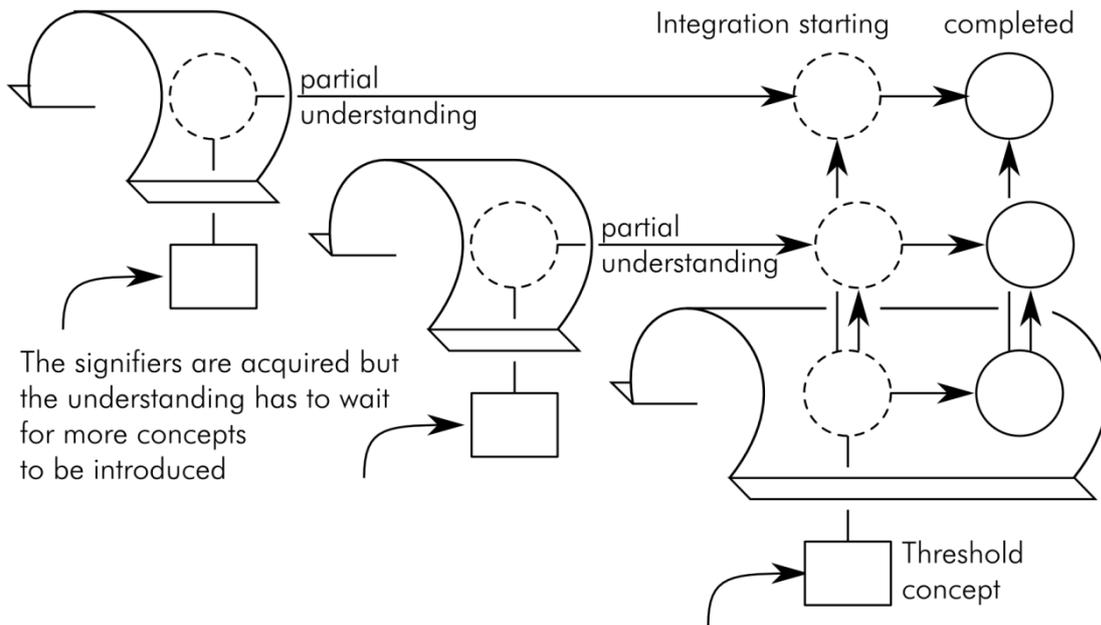

Figure 8: Periods of conceptual uncertainty and delayed understanding

It helps if the learners are aware of their incomplete understanding and understand the nature of their thought processes. This enables them to be patient, persevere and not to leave the tunnel of liminality too soon (see section following for discussion of the need for learner resilience). Even so, there is a natural tendency for learners to settle for particular understandings before the conceptual whole is revealed, which means that they need to be prepared to revaluate their conceptions at a later date.

f)   Recursiveness and excursiveness

The physical learning of signs is sequential in that most processes of learning are sequential by nature i.e. reading, listening, writing, and thinking etc. This does not preclude repetition (recursiveness) or digression (excursiveness). Take, for example, a concept (A) that is theoretically required to be understood before concept B, as in figure 9.
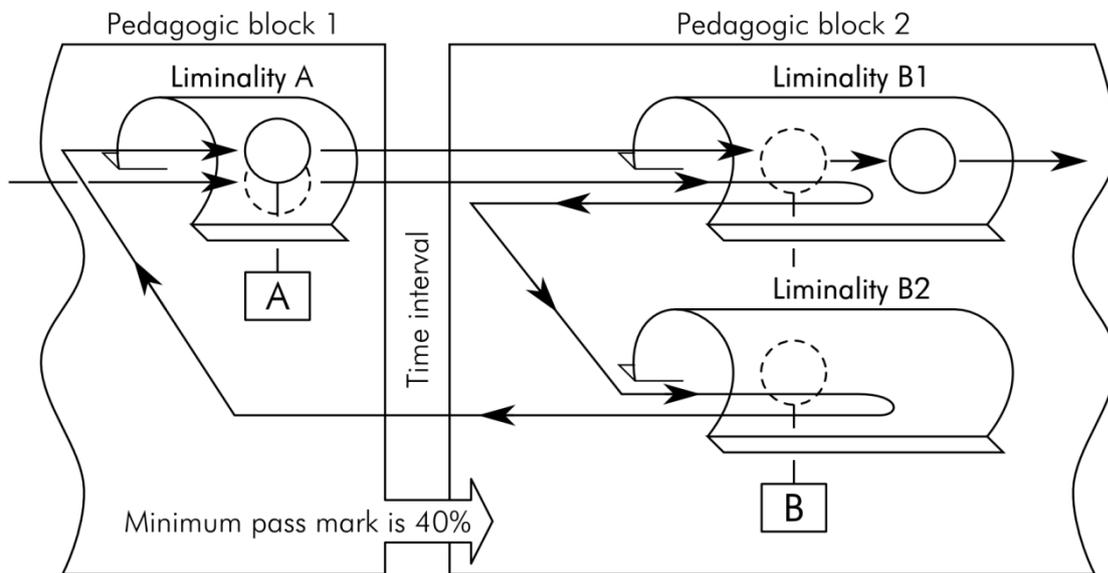

Figure 9: Repetition and digression

The learner will study concept A and then go on to concept B. Let us assume that the processing of learning B using strategy B1 is not successful and so the learner attempts to learn B using strategy B2 (i.e. digression). Let us assume that this fails also but now the learner is aware that she has shortcomings in her understanding of concept A and goes back to study that concept (i.e. repetition). Having reviewed concept A, she goes on to study concept B using the original strategy B1 (i.e. repetition) and this time believes that she is successful. As far as the learner is concerned this whole process is sequential.

This pattern of learning does not necessarily negate the idea of learning outcomes, though in practice, with minimum pass marks of 40% it is likely that many learners will move from one block to another with shortfalls in their understanding. Such blocks are created by the definition of courses, years, semesters, modules and even assignments. There is then the logistical problem of whether or not the learner can go back to, and re-experience, previous states of liminality even if they are willing to do so.

g) **Pre-liminal variation**

A group of learners being introduced to a new concept may typically be assumed by the teacher to possess a common understanding of the component concepts. Actually, what they share is a common collection of signifiers in the physical domain, that is, the words and symbols used to label the component concepts. As a group they will be subject to a common physical pedagogic process which again is a manipulation of linguistic signs. All this occurs in the physical domain. It is impossible to know the extent of that common understanding. See figure 10 which also serves to emphasise that the act of learning is a personal cognitive process.
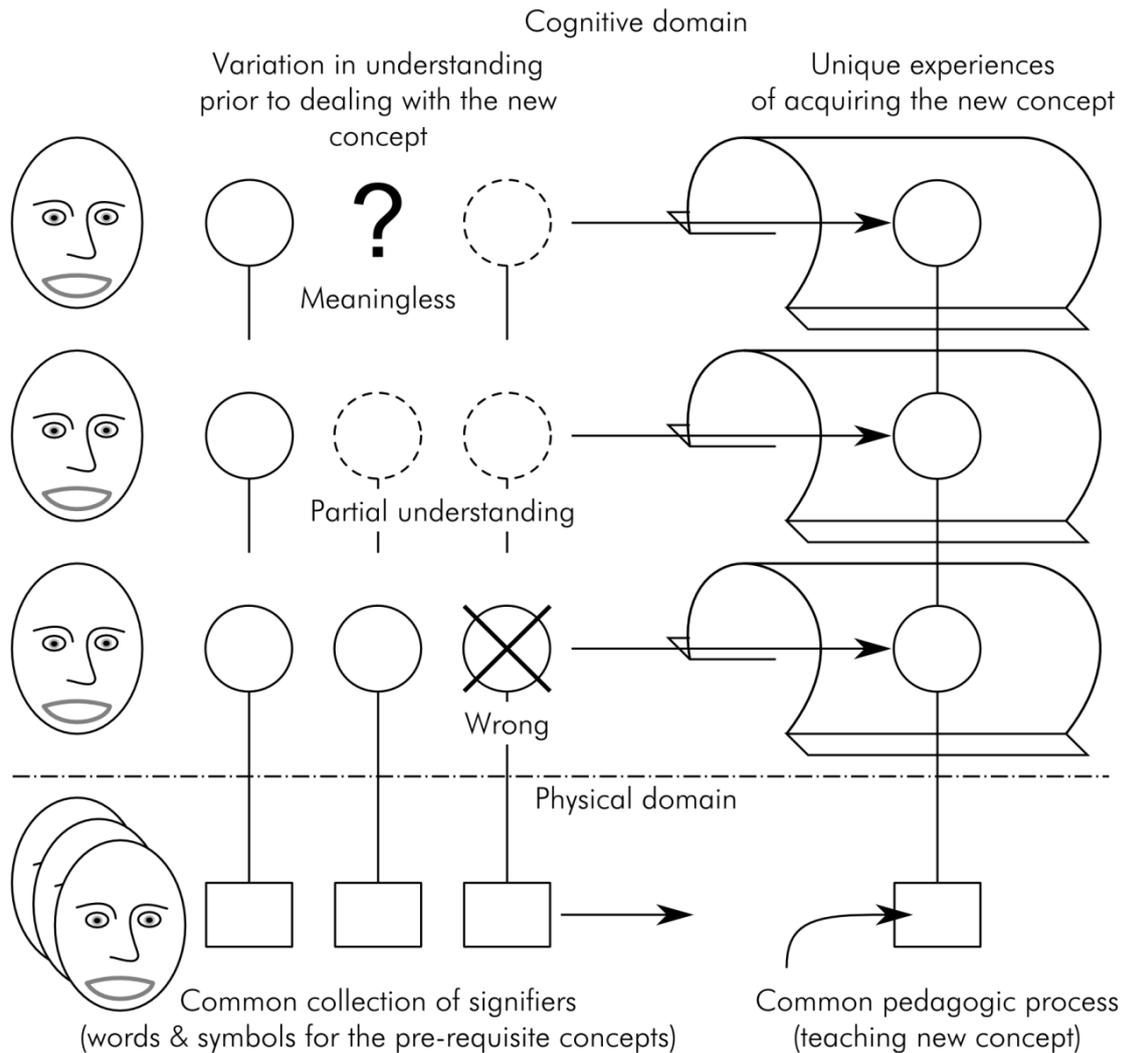
Figure 10: Pre-liminal variation

Figure 10 identifies four arbitrary states of understanding – 'complete', 'partial', 'wrong' and 'meaningless'. Some learners will no doubt understand some of the concepts, some will have partial understanding and some may have incorrect understanding. There may be signifiers which the learner recognises but are meaningless to them. These 'empty signifiers' are particularly interesting as they are then susceptible to unfortunate affective connotations such as anxiety and can lead to demotivation.

Now with just three component concepts and four states there are forty-eight possible permutations. When one considers that partial understanding is measured on a continuous scale between no understanding and complete understanding, and that the number of component concepts (and their components in turn) can be much greater than three, the potential variation is enormous albeit some combinations are likely to be more prevalent than others. It therefore follows that variation in conceptual understanding within a group prior to being taught a new concept is inevitable.

This pre-liminal variation is not restricted to the learners, for it is also possible in complex areas of study that the teacher also does not have complete understanding of the new concept and its components. It is possible for the student to acquire a deeper understanding than the teacher, and since learning must be derived from the physical signs provided by the teacher, it follows that the same signs could be more meaningful to the learner than the teacher.

Linguistic signs are, of course, mere labels – by themselves they do not convey any meaning. Meaning is derived when they are combined with other signs. Combination creates relationships and these relationships are defined by the syntax of any set of signs. For example, it is our shared understanding of the concept of metaphor and the use of adjectives that enables the word 'threshold' to give meaning to the word 'concept'. So another aspect of pre-liminal variation is the understanding of language being used. The teacher's use of language, signs and syntax may fail to communicate meaning because of the learner's inability to handle that usage. This is one possible reason why learners are able to grasp concepts from their peers when mediated through peer discussion, which were meaningless when supplied by their teachers. Another reason might be the recursive and excursive natures of the peer support process.

h) Unintended consequences of generic 'good pedagogy'

Learning is as much about unlearning old misconceptions as it is about acquiring new ideas. Unfortunately, previous pedagogy can introduce and/or reinforce ideas that later need to be abandoned, as indicated in figure 11.
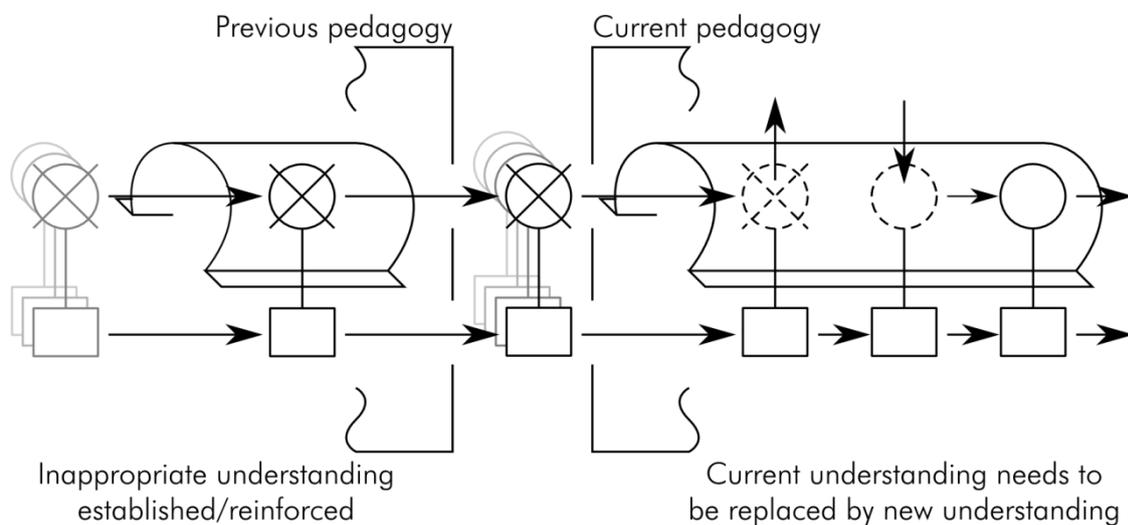

Figure 11: Reinforcing and then unlearning understandings

Two examples of traditional good pedagogic practice are identified by Land et al (2005) as possible creators of inappropriate understandings – 'simplification' and 'relating learning to everyday phenomena'. Both of these would be issues in a subject such as Elementary Mechanics, where a huge need to simplify is created by the use of Mathematics. Most learners new to Mechanics are also learning Mathematics and it is that which restricts their ability to deal with realistic scenarios. For many, the introduction to Mechanics is through the subject of Applied Mathematics where the focus is on the Mathematics rather than the Mechanics. Regarding the wisdom of relating to everyday phenomena, Land et al refer, by way of illustration, to the Accounting concept of depreciation. Depreciation , especially with its relation to the concept of profit, is an artificial construct which is not encountered in everyday life and any identified relationship will need to be figurative, containing analogy and metaphor. In contrast, Mechanics is literally related to everyday phenomena. Sometimes that relationship is counter-intuitive but even this can be used effectively to convey the nature of the concepts. Ironically, it is the simplification created by the need for Mathematics that weakens the link with reality.

We might select the concept of acceleration in Mechanics as a good example of this issue. In everyday life, acceleration is associated with increasing speed e.g. 'to begin to move more quickly' (Oxford English Dictionary 2013). Typically acceleration is introduced to learners as a kinematic concept in the context of linear motion which reinforces the relationship between acceleration and speed i.e.

- v = u + at. This is one of the 'suvat' equations that are derived from the geometric interpretation of the speed-time graph. Acceleration is treated as a constant, though it can be negative

- a = dv/dt. This differential relationship is conventionally illustrated as the slope of the speed-time graph. Acceleration can now be treated as a variable having a known algebraic relationship with time, which can produce a negative magnitude.

Both of these approaches reinforce the notion that acceleration is related to and dependent on speed and completely ignore the influence of direction. The negative value is often identified as 'retardation' – a different signifier that further reinforces the concept that acceleration denotes an increase in speed.

When introduced to vector mechanics, learners have to acquire the notion that that there is no causal influence on acceleration by speed and that it is only dependent on force. Direction as well as magnitude has to be taken into account and the differentiation of velocity cannot be illustrated using a speed-time graph. The hodograph was introduced to illustrate the relationship between velocity and acceleration but does not appear to have gained the same universal acceptance as the speed-time graph.

Conceptually acceleration does not necessarily involve a change in speed. For example, are you aware that as you read this page, you are actually accelerating whilst sitting still! Actually you are sitting on the surface of a large rotating object (i.e. the Earth) and moving at very high speed in relation to the centre of that object. However, everything else around you is also moving at the same speed and direction, so you are stationary relative to them. A force is keeping you on the surface (i.e. gravity) and is accelerating you towards the axis of rotation. In effect you are falling. If this explanation is meaningless or makes no sense to you then the threshold nature of acceleration has just been revealed to you.

i) The 'underlying game' (Episteme)

The teacher's leaving 'tacit' of components of knowledge crucial to student understanding, has been found to be a frequent source of 'conceptual bottlenecks' for students (Pace et al. 2012). Perkins (2006) has commented on the way that experts have access to a rich epistemic base, a facility or repertoire which they can draw upon at will in a versatile fashion to address a problem in hand. He has also referred to this episteme as an 'underlying game', characterising it as:

> '…a system of ideas or way of understanding that allows us to establish knowledge. ..the importance of students understanding the structure of the disciplines they are studying. 'Ways of knowing' is another phrase in the same spirit. As used here, epistemes are manners of justifying, explaining, solving problems, conducting enquiries, and designing and validating various kinds of products or outcomes.' (Perkins 2006 p.42)

Such epistemic fluency is usually not available to undergraduate students. Whereas an expert teacher might know that a concept may underpin a number of signs, it does not necessarily (or usually) follow that the concept is included in the learner's sign collection. The concept may have been introduced to the learner beforehand, who had failed to grasp its relevance to the subsequent collection, or its existence may be presumed by the teacher, and left as an example of 'tacit knowledge'. Without a signifier, there is no reminder in the physical domain that the concept exists. If that concept is not understood appropriately, then this lack of understanding will have a deleterious impact on the signification of the sign collection, as illustrated in figure 12.
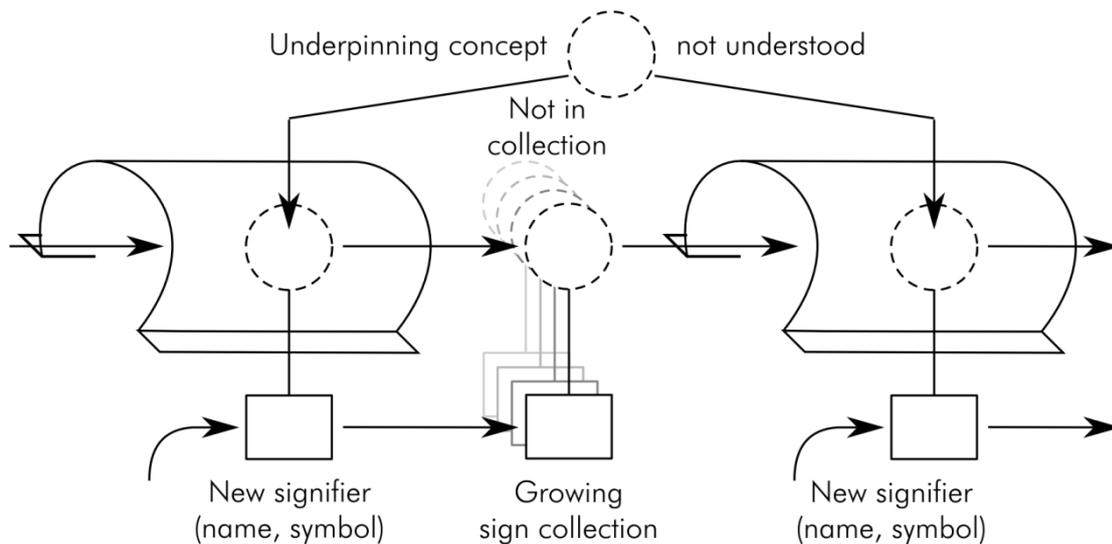
Figure 12: Presumed understanding

For example a learner of vector algebra could be in this situation. The algebraic construction relies on the use of a line as metaphoric reification of a vector concept. The orientation of the line denotes direction and the length denotes magnitude. Early textbooks used the line in their illustrations but the practice has all but disappeared in the second half of the twentieth century, being replaced by an arrow. The arrow is used in UK society to denote direction but its length is never used to denote magnitude. As a result, the metaphoric basis of vector algebra is no longer visibly evident in the sign collection, and therefore unavailable to the student's understanding. It is presumed, but not present.

Conclusion: the role of context

We saw in Figure 5 above how the teacher can create a framework of engagement by setting tasks designed to motivate the learner to engage with the conceptual nature of what is being learned (ie the signifieds) by transforming the signifiers from one context to another. In this way, it was stated, the teacher can then infer understanding on the student's part, by comparing the learner's transformation with their own. This could be construed as another form of 'listening for understanding'.

The troublesome transition from one signified to another can incur significant affective 'noise' for students in a liminal state, particularly when they are stuck, or their understanding falls into any of the 'partial', 'wrong' or 'meaningless' categories discussed earlier. There is an established corpus of research which has drawn attention to the need for teachers to take heed of such affective issues (Baxter Magolda 1999, Kerdeman 2003, Kloss 1992 and Lucas 2008). These authors point to the acknowledged difficulties and discomforts of supporting students as they change their epistemological beliefs.

This body of work also emphasises that understanding and knowledge vary according to *context*. Figure 11, earlier, made reference to the problematic dimension of 'unlearning' or letting go of a prevailing view. In a contextual view of knowledge, however, it might be the case that students do not necessarily have to 'unlearn' prior understandings and conceptions so much as learn to recognise that, *in different contexts* the signified, but not the signifier, may change. In the disciplinary context of accounting, for example, Lucas (2000, p.501) acknowledges the contribution of Linder (1993):

> Given the stubborn resistance to change of these students' alternative conceptions of accounting, it may be of value to view learning not as a change in a person's understanding of a phenomenon or a particular aspect of reality (Johansson et al., 1985) but as a change in a person's relationship with a context (Linder, 1993). Linder, in considering student learning, does not consider the everyday conceptions that students possess to be a problem. Nor is he concerned with students' resistance to

changing their conceptions. "Because it would appear natural for a person to construct a variety of conceptions of phenomena, what would then seem to be important is the ability to recognize a context and, in terms of this recognition, evoke an appropriate conception. So, instead of depicting meaningful learning in terms of conceptual change we should consider depicting it in terms of conceptual appreciation" (p. 295).

Such contextual recognition, we would argue, constitutes a further dimension of pedagogical content knowledge. It presents an opportunity, along with the other aspects of pedagogical content knowledge discussed earlier, for the disciplinary specialist in university teaching to open up a dialogue with his or her students, and to pursue routes of inquiry into the nature of their understanding of particular phenomena in specific contexts. It affords a space for what Cousin (2008) has termed 'forms of transactional curriculum inquiry'. She maintains (pp 269-270) that the search for threshold concepts has the potential to open up discussions and co-inquiry among subject experts, students and educational researchers, creating between these three key parties a 'pursuit of shared understandings of difficulties and shared ways of mastering them' and an approach 'which becomes neither student-centred nor teacher-centred but something more active, dynamic and in-between' (p.270). This suggests a promising future way to investigate learning within the liminal space.

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