Threshold concepts and spatial awareness in transport and product design

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**THRESHOLD CONCEPTS AND SPATIAL AWARENESS IN
TRANSPORT AND PRODUCT DESIGN**

INTRODUCTION

> The second assessment was more that you had to design something and that
> is when I struggled. And surprisingly – even though it is a design course –
> maybe I am more suited to a modelling background. (1st year Transport and
> Product Design student)

In 2005, Coventry University was successful in obtaining funding from the Higher
Education Funding Council for England for the Centre of Excellence for Transport
and Product Design (CETPD) under the CETL initiative. The CETL initiative has
two main aims: to reward excellent teaching practice, and to invest further in that
practice so that the funding delivers substantial benefits to students, teachers and
institutions. The pedagogical research activity undertaken within the CETPD has
three inter-related strands of enquiry: threshold concepts in design, the nature of
spatial awareness and internationalisation of the design curriculum. In terms of
threshold concepts in design, the pedagogical research programme is investigating
ways in which students, like the student quoted at the outset, acquire, or face
difficulty in acquiring, transformative threshold design concepts that are crucial for
the levels of design practice required by the global transport design community.
The research draws upon the continuing work of Meyer and Land (2003; 2005;
2006) into threshold concepts and troublesome knowledge.

Transport and Product Design at Coventry University is acknowledged as a
centre of national excellence with claims to international prominence. The
underlying philosophy of the course at Coventry is to bring students to a point
where they are eligible to enter the transport design and other international product
design industries. This philosophy is informed by a conceptual framework of
learning drawing on notions of situated cognition and the theory of communities of
practice (Wenger, 1998). Because learning within a community of practice
transforms who a student is, and what a student can do, teaching staff consider
participation within the programme as an experience of identity formation. The
course offers more than the accumulation of skills and information, and is viewed
as a process of becoming – in this case becoming a certain kind of creative and
critically minded design practitioner. Through this transformative practice a
professional identity is formed, and, through the desire to become accepted within

the community of creative design practitioners, learning can become a source of motivation, meaningfulness and personal and social energy. At the heart of this process is the development of spatial awareness and access to a set of knowledge practices that are necessary to visual design.

USING THRESHOLD CONCEPTS AS AN ANALYTICAL FRAMEWORK

Outcome-led approaches, in which student learning is expressed in terms of measurable cognitive outcomes, have dominated curriculum design in recent years. Davies (2003, p.2), however, considers that the creative arts are challenging with respect to outcome-led learning because 'we work with rather more ambiguous terms such as 'creativity', 'imagination', 'originality''. Creative art subjects have long been regarded as somewhat problematic in this regard, and particularly in terms of assessment, as they contain what Gordon calls the 'wow' factor' – 'creativity, originality, inventiveness, inspiration, ingenuity, freshness and vision' (2004, p.61).

Approaches to teaching used by the Transport and Product Design staff at Coventry are underpinned, in the words of one respondent, by a tacit 'underlying agenda of things the students need to have'. A large proportion of the work the students are involved in is carried out in studio conditions. As such, the working environment tends to resemble the *atelier* method of teaching which 'involves a group of students…working with one or two tutors…through a year-long cycle of design.' (Caddick and O'Reilly, 2002, p.190). Further, members of staff feel that the environment the students become part of is important in terms of feeling comfortable. This is facilitated through the enthusiasm of the staff who pass on their knowledge in the manner of an 'apprenticeship' coupled with 'respect for the creative mind' (Design Tutor).

Within the context of the Transport and Product Design course, we chose to apply the threshold concepts framework (Meyer and Land, 2006) as a lens for identifying or surfacing this 'underlying agenda of things the students need to have'. Through clarification of the knowledge practices that students must acquire, our longer term aim is then to identify pedagogic strategies for enhancing the student learning experience. Given the difficulties in expressing measurable outcomes of learning within the discipline, and the comparatively lesser degree of consensus on what constitutes the working body of knowledge, it was recognised that identifying threshold concepts could be difficult. However, according to Meyer and Land (2003, p.11), even 'where there is not such a clearly identified body of knowledge it might still be the case that what [we]have come to encapsulate in the term *ways of thinking and practising (WTP)* also constitutes a crucial threshold function in leading to a transformed understanding.'

Given the salience of spatial awareness in the process of becoming a creative and critically minded design practitioner, the CETPD research team decided to investigate perceptions of spatial understanding with both staff and students. This enabled us to open up these ways of thinking and practising in Transport and Product Design, and, through the analysis of empirical data, to help identify threshold concepts that lead to a transformed understanding. Staff and student

perceptions of what constitutes the development of spatial awareness were explored through interviews with staff and ten first-year Transport and Product Design students together with a questionnaire circulated to the whole first year intake.

SPATIAL UNDERSTANDING

A search of the literature revealed that the concept of spatial awareness has long been debated, and a number of terms are offered, including Spatial Awareness (Karnath et al. 2001), Spatial Functioning (Temple and Carney, 1995), Spatial Ability (Garg et al. 1999), Spatial Orientation (Bodner and Guay, 1997), Spatial Visualisation Ability (McGee, 1979 cited in Alias et al., 2002) and Spatial Intelligence (Eliot 2002; Gardner 1983; Shearer 2004). In this instance, we draw on Gardner:

> Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one's initial perceptions, and to be able to re-create aspects of one's visual experience, even in the absence of relevant physical stimuli …spatial intelligence emerges as an amalgam of abilities. The most elementary operation, upon which other aspects of spatial intelligence rest, is the ability to perceive a form or an object …appreciating how it will be apprehended for another viewing angle, or how it would look (or feel) were it turned around …Such tasks of transformation can be demanding. The ability to solve these problems efficiently is special. (Gardner, 1983, pp.173-174).

Staff perceptions

It soon became apparent that a definitive staff view of the meaning of the term 'spatial awareness' had not yet emerged even within the context of the course. This debate over meaning was reflected during a meeting with all members of the teaching staff present, and during individual staff interviews. It was possible to group indicative responses into the following categories:

Category	Indicative response
All around awareness	'I don't think there is any area of conscious thought about anything that the design business doesn't touch on in a way that few others do: it is this business of this incredible all-round awareness.' 'Holistic approach: cloud of information with polarised areas.' 'I think spatial awareness is one of the mechanisms of this wider consciousness that people need to tap

	into to become a designer.' 'Awareness of where things are - boundaries where you cut off your understanding.' 'Holistic integrity.'
Co-ordination	'Hand/eye/brain co-ordination.'
Design sensitivity	'Sensitivity: being able to 'see' design; some see it as a picture, others see it as presenting and manipulating information.' 'Seeing things as a whole, but having an instinct to knowing which bit to highlight to achieve certain purposes.' 'Aesthetic understanding.'
Space	'Displacement of space.' 'Relationship between form and spaces.' 'Form-space-intelligence.'
'Intuitive/6th sense.'	'Intuitive/6th sense.'
Looking at an object from the outside	'I think it really has to be looking at an object.' 'Awareness of an object at a distance.' Looking at an object from the outside rather than being in an object.'
Mental rotation	'2D to 3D translation.' 'Looking at an object at a distance, but able to perceive it in the round in detail.' 'Read views and put together in their heads.' 'Manipulation and holding things in their head.'
Positioning system	'Is about navigation and urban environments.' 'An awareness of space from what is occupying that space already.' 'Associated with moving through space, retaining a memory of navigation?' 'Mental markers of space that allow you to judge big or smaller spaces.' 'Spatial positioning system working on several planes.' 'Natural navigation.' 'Dead reckoning: awareness of where we are in relation to things.'

	'I see it as a kind of navigational positioning where you are relative to other things…like a positioning system.'
Time	'Relates to time especially when orienting through large spaces.'
Visualisation	'Somebody being able to sit in a chair and visualise what the space around them is and look at that on drawings and have a concept of what that means.' 'Understand what that means in terms of space around a product, car, phone etc.' 'Looking at space required around or within something.'
Volume	'Relates to the ability to transform volume.'

Table1. Staff perceptions of spatial awareness

Student perceptions

This lack of clarity regarding the characteristics of spatial awareness was similarly reflected during ten one-to-one interviews with students which took place in their first term. It became clear that student responses were relatively untheorised and that students did not use a disciplinary language to describe the concept. Responses to a question asking about their understanding of the term 'spatial awareness' ranged from total lack of knowledge:

– 'I can't say I do. I would like to guess but I might be wrong.'
– 'Never heard of it before.'
– 'Not a lot really.'

to a recognition of the phrase:

– 'No, I have heard the term but I am not aware of it.'
– 'I've heard of it before…'

to an approximate guess:

– 'Like distance from things and if something will fit into a certain space or if it doesn't?'
– 'In what sense – when you walk into a room and feel a lot of space?'

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- – 'It depends on what context you mean it in: driving a car - do you know where the other cars are or being able to rotate things in your head.'
- – 'Being aware of people and things around you – taking careful look at things and understanding them.'

During the second term, a questionnaire was circulated which included a question about spatial awareness. From the noticeably more sophisticated responses to this question it appeared that the students had made some progress in their understanding:

Category	Indicative response
User needs	Being aware of design for the needs of others
Scale	Building of scale models accurately
Perspective	Helps understand dimensions and perspective for any angle
Relation of object to space	How well a product looks within the space its placed, e.g. you wouldn't put a dolls chair in a concert hall because it would be unnoticeable
Proportion	I like to look at an object and realise the proportions and why they are like that
Design sensibility	Making something look 'right' transitional form helped me with this
Observation	Noticing and constantly analysing objects around you. Shoe project - analyzed the 'make-up'
Use of space	Spatial awareness - designing the space around you
3D awareness	Spatial awareness is your ability to perceive and interpret 3D objects
Visualisation	Spatial awareness: could be described as the ability to 'imagine' how your proposed design would look, before actually representing it on paper
Ability to design from 2D into 3D	The ability to translate two dimensional sketches into three dimensional forms, i.e. models

Fit	The layout of my work - making each piece flow and work together
Drawing techniques	Through lectures, I have learnt how to draw an object from different angles from the same position
Relation of object to environment	Understanding the space around you on a particular environment and designing and modifying the components in that environment. This awareness is important when dividing perspective models

Table 2. Student perceptions of spatial awareness

More research is to be undertaken, in particular the piloting of a test to assess students' skills in this area as they enter the course. It is hoped that findings from this test will allow the development of skills to be benchmarked and possibly to enable a greater degree of consensus on spatial awareness to be reached as it relates to this context. If this greater consensus can be reached it has been suggested that a new phrase be coined to distinguish the meaning of visual-spatial understanding in the design context when compared to phrases used by other disciplines. Suggestions have included 'Generative 3D ability', '3D creativity', 'Form-space intelligence'.

IDENTIFICATION OF THRESHOLD CONCEPTS WITHIN THE PROGRAMME

Through the discussions surrounding the notion of spatial awareness, some possible components were identified by the staff, which could be considered as threshold concepts (see below). These, it could be argued, underpin the tacit 'underlying agenda of things the students need to have':

Possible threshold concept /practice	Students need to be able to:	Threshold Concept Characteristic(s)
Confidence to challenge/expand design clichés	inculcate design conventions and expand upon them using information from a variety of sources and experiences	Transformative Irreversible Troublesome
Empathy	to think outside of themselves and think of other people	Transformative Irreversible Troublesome
Group work	accept that designing is a team effort	Transformative Irreversible Troublesome
Language of design/designer identity	communicate using the recognised language of the design community of practice	Irreversible
Touching	understand the link between the physicality of the subject - feeling, touching, stroking, arms and bodies moving; clay, paper, resistance,	Transformative

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Table 3. An articulation of candidate threshold concepts in Transport & Product Design

Some of these components were explored during the student interviews and the most troublesome appeared to be the confidence to challenge/expand design clichés. This related to the first module to be assessed, in particular to a task called the 'Thought Receptacle'. This was a reflective exercise which involved producing a diary-like item that outlined designs and objects that the students particularly liked, backed up by information as to why that was so. The task is designed to develop students' confidence to challenge existing style and practice and to foster a degree of conceptual transgression. Several students failed this task and had to re-submit. Their typical comments in relation to staff feedback included: 'really thought I had understood [the thought receptacle] – but from the feedback I hadn't. Apparently it was too planned'. Another reflected that: '[the thought receptacle] should reflect your personality and music I liked and sometimes poems and wrote down a lot of … but it wasn't much so then later on [the lecturer] said relate to design as well…the creative thing wasn't really set in.'. This was echoed by staff comments in relation to this assessment, which identified a 'limited sense of personal point of view, …distance from being a designer, lack of confidence.' As well as the fact that there was 'not much personal stuff coming through.' On the other hand one felt there was evidence of a 'Good mix of work, confident, having a go, not afraid to go into areas where she hasn't been before, confident in herself or staff to play, will find a niche eventually.'

Empathy was a problem for some of the students, particularly during the ergonomic module, which puts a high emphasis on the link between design and user needs. Some students had difficulty seeing the link. One said 'I enjoy the designing side of things but some of the other bits they are getting us to do I really don't understand the relevance of it.' Another commented: 'I came in mind to do auto design and I think the first year was designing landscapes and development plans – not only with me but I guess with most of the students. It [the assignment] should have a bit of car in it. I suppose it might make sense later.'

Group work also proved troublesome, with some of students expressing their frustration when group members didn't turn up or pull their weight. One complained that 'we have had a lot of trouble with our first group work assignment. We were all given a user to focus on in the group work but when the day of the assessment came, two of the user groups did not turn up to set up their stuff in the morning. So out of the five user groups we only had three displays for three user groups.' Another said of a fellow group member 'when we needed the assessment in he never turned up and I had rung him and texted him and all things like that and after our assessment was over – later in the day he sent me a text saying who was this even though he knew perfectly well who it was, so that made me very cross.' One expressed dislike of the group process as a whole:'I don't really like working as a group – I don't like relying on other people – because I don't work like most others and people don't work like me and you end up with clashes.'

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On the other hand, some students found that they unexpectedly enjoyed their group work: 'We had a really good group – one of the best groups I have worked in over the course of the year and everyone sort of clicked. There would be   some who wouldn't turn up to the group meetings but we left them to their own devices. We bonded together and got everything sorted – actually had fun in that module'. Another, in similar vein, commented That ' the group work I enjoyed. We had a group discussion, worked out our strengths and what we felt we did best – and we went off and did   that. I enjoyed that. Not everyone turned up but we did the best that we could and passed it. We just kind of discussed it [who would do what in the group] and it seemed like the best thing to do.'

The most significant progression in the students was evidenced in the development of a language of design. In order to ascertain this, the students were asked if they had to explain themselves when discussing the course with people who were not part of it:

- 'Another thing about the design language – we use it because it is a lot easier to use than – we say rendering rather than saying we did our drawing and then coloured it in, because it is a lot easier to say rendering.'
- 'It's funny you should say that because I tell people I am on the auto and product course and some people don't know what automotive is…I don't think many people would understand rendering – drawing maybe but not rendering.'
- 'I do yes…often when I am talking to my brothers about what I am doing I talk about rendering, ellipses and they are like what? I am picking it up as I go along.'
- 'Yes, people do ask me to explain – if I am talking to people who I have gone to school with and done technology with they do know what I am talking about – but say my parents or my sisters or something they don't really know what I am talking about sometimes. It was always like that but it has got worse since I have been on the course.'
- 'Yes, they do all the time. When I am talking to my family I sometimes wander into the design world and maybe name an artist or piece of work, and I tell them about a particular technique and they are like are you speaking alien? It is really hard work to try and explain what you are projecting onto someone who doesn't understand it.'

THE UNDERLYING EPISTEME AND CONCEPTUAL GAMES

From the staff responses in relation to the concept of spatial awareness it became clear that the skills and knowledge practices that staff impart to the students in order for them to complete the course and become successful designers remain, in the main, relatively untheorised and tacit. The lack of clarity in relation to a definitive meaning of spatial understanding in this context is perhaps because spatial awareness is, in the words of one teacher on the programme, 'Not

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something that designers acknowledge or talk about because it is the natural world they inhabit.' Another commented that 'it is an intuitive skill you develop, especially through experience.' Significantly the staff felt that '*is not a single threshold concept: there are components that result in this*.' This was possibly attributed to the fact that the course does 'not explicitly explore spatial awareness'.

These latter responses provide an interesting illustration of the important distinction David Perkins has made between threshold *concept* and underlying *episteme*. He points out that 'Although some of what is troublesome about knowledge squarely concerns the categorical function of concepts, much concerns the larger conceptual games around them' (2006, p.41). He cites as an example the difference a history student might experience between coming to understand, on a conceptual level, the notion of bias when examining historical sources, and actually having to consult and use historical sources whilst keeping her critical antennae alert to the possibility of bias, and making appropriate allowance for the effects of bias when it is encountered. The former might remain at the level of inert knowledge whilst the latter most definitely would constitute an active knowledge practice. 'As with inert knowledge,' he argues, 'so with ritual, conceptually difficult, foreign, and tacit knowledge – these troubles have as much to do with the activity systems that animate concepts as they do with concepts in their basic categorical functions' (p.41). Besides recognising what he terms 'the games of enquiry we play' with particular concepts, it is, he argues, important to look beyond the particular. 'The disciplines', he states, 'are more than bundles of concepts. They have their own characteristic *epistemes*.' (Perkins, 2006, pp.41-42)

Perkins provides a helpful definition of an episteme as:

> a system of ideas or way of understanding that allows us to establish knowledge. Schwab (1978) and Bruner (1973) among others have emphasised 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)

Each discipline brings with it its own distinctive episteme and distinctive form of validation. Perkins points out that in various sub-disciplines of Engineering, for example, 'effective designs find their validation in not just sets of principles but practical performance from prototypes to wide-scale field tests' (p.42).The design tutors we interviewed often indicated their sense that what design students required to enter the design community of practice, and to think and practice like a designer, was 'not a single threshold concept' but 'components that result in this'. What characterises the 'this' that is referred to seems to be primarily a nexus of attributes that are *integrated*. 'It is this business of this incredible all-round awareness' one respondent remarked. Another felt it was a 'holistic approach', a 'cloud of information with polarised areas.' Yet another felt the designer needed a capacity for 'holistic integrity.' Spatial awareness, some tutors felt, was an important 'component' – 'Awareness of where things are, boundaries where you cut off your understanding.' – but only one component of this broader epistemic fluency. 'I

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think spatial awareness is one of the mechanisms of this wider consciousness that people need to tap into to become a designer.' This underlying episteme of design appears to be a powerful and ever-present determinant of subjectivity: 'I don't think there is any area of conscious thought about anything that the design business doesn't touch on in a way that few others do'. This, too, resonates with Perkins' (2006) observation that 'threshold concepts certainly include more than particularly tough conceptual nuts in the content of a discipline. There are threshold epistemes that shape one's sense of entire disciplines' (p.44).

The empirical data from our interviews with Design staff and students highlighted the troublesome nature of *tacit* understandings in the teaching of spatial awareness in design contexts. This seems to concur with Perkins' own findings.

> Perhaps tacit knowledge is the most pervasive trouble with epistemes. Many teachers play the epistemic games of their professional disciplines fluently and automatically, and successful students ultimately need to do so as well. The problem is, many students never get the hang of it, or only slowly, because the epistemes receive little direct attention. For [students], surfacing the game through analytic discussion and deliberative practice could make a big difference. (2006, p.43)

Davies (2006), researching into the learning of Economics, comes to similar conclusions. He points out that a threshold concept is very likely to be troublesome because 'it not only operates at a deep integrating way in a subject, but it is also taken for granted by practitioners in a subject and therefore rarely made explicit' (p.74). He, too, rejects the reductivist notion that the knowledge practices of a disciplinary community can be represented in terms of a skill set or 'bundle of concepts' in Perkins' phrase. He cites Mitchell (2001) who emphasises 'ideologies' as they relate to disciplinary thinking:

> It is the way in which such concepts are related, the deep-level structure of the subject which gives it coherence and creates a shared way of perceiving that can be left unspoken. This shared way of perceiving is the ideology of a subject, 'the invisible structures and beliefs by which we operate and which appear as natural unchallengeable ways of doing things' (Mitchell, 2001, p. 2, cited in Davies, 2006 p.71).

So in addition to their categorical functions, threshold concepts seem to be entangled with a much wider pattern of practice and enquiry, a set of games that are played with the concepts, and which in turn can provide a further source of troublesomeness for the novitiate. Within transport and product design, students seem to be required, *inter alia*, to gain sophisticated three-dimensional spatial understanding, and to nest this within a streetwise and sophisticated cultural sensitivity to prevailing taste, style and fashion. At the same time their designs draw on these spatial understandings and cultural antennae, they must also on the one hand conform to the material, cost, efficiency, environmental and safety constraint,of the industry (referred to within the community's discourse as 'packaging') *and* surprise and pleasantly shock their tutors through a degree of conceptual transgression which ensures that their creative work does not replicate

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the styles and norms of the older generation of their tutors. Where the expected or permissible boundaries of such transgression lie remains tacit and implicit. The shock of the new, yes, but they still need to pass. And the examiners are the older generation. This is something of a tall order and entails a complex process of enculturation if the students are to eventually make it in the design world. These necessary disciplinary understandings and attributes might be presented diagrammatically as follows:
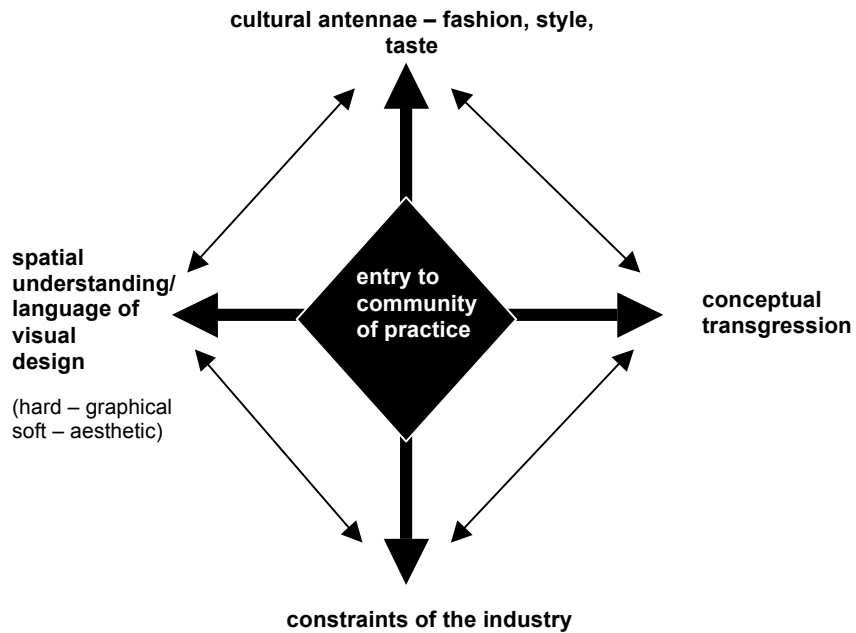

Figure 1. A conceptualisation of the transport & product design student's disciplinary enculturation.

ENTERING THE COMMUNITY OF DESIGN

So how might design students gain sufficient understanding of the 'underlying agenda of things the students need to have'? The Coventry programme draws these students into a state of 'liminality' (Meyer and Land, 2005), an in-between state of uncertainty and insecurity in which they do not enjoy full community membership status and struggle both to make sense of the underlying episteme and also to find their own creative identities as design practitioners. Perkins draws attention to 'the toolkit fallacy' which maintains that 'providing the students with the toolkit of explicit heuristics would enable their effective use'. He argues that this is insufficient:

instead, it was found that students also needed a self-management strategy to monitor their deployment of heuristics and their progress. Moreover, it was not enough for teachers to work model problems, they had to comment directly on the heuristics as they were deployed so students gained a situated sense of their utility. The combination of a self management strategy and explicit modelling yielded a dramatic improvement in students' ... problem solving. (2006, p.43)

The threshold concepts framework (Meyer and Land, 2006) also emphasises that the act of learning is an act of identity formation, and that entrance to a particular discourse community and the ways of thinking and practising particular to that community involves integrated transformations in language, identity and conceptual structure. But as Davies maintains, immersion in the ways of the community is necessary but insufficient.

> A student can accumulate knowledge about a community and the ideas that are commonly accepted in that community, but this falls short of acquiring the way in which members of that community see the world. When asked to explain a given theory, or to cite extracts from a body of received knowledge, they may be able to do this perfectly well. But when asked to look around them they do not see the world as viewed by a member of a subject community. (Davies, 2006, p.71)

Seeing the world as viewed by a member of a subject community also requires an affective transformation, or the gaining of what Cousin (2006) has termed 'emotional capital'. The liminal state encountered within the Transport and Product Design programme provides space for the development of a self-management strategy in the terms Perkins speaks of. The liminal state, a place of transition, uncertainty and hybridity, can also be a space for resistance and the assertion of difference (Bhabha 1998). In terms of identifying threshold concepts, it is possible that the problem with the thought receptacle task discussed earlier, which relates to the possible threshold concept of 'confidence to challenge' (conceptual transgression), was that the students were not yet confident in their own abilities and had not yet reached the stage where they felt confident in expressing their own ideas. One member of staff identified students who 'reach the point where being creative is not possible, can't think beyond the box'. This proved troublesome for one student who performed well in the first assignment but not in the second, and expressed her uncertainty about carrying on with the course because:

> the second assessment was more you had to design something and that is when I struggled. And surprisingly – even though it is a design course – maybe I am more suited to a modelling background. (1st year design student)

Here the conceptual barrier prevents access to an identity that is desired by the student (designer) and brings into view an alternative subjectivity which seems less desired and less satisfying (modelling). It is also possible that the problem with the group work was that the students who did not turn up for their meetings were not willing to accept that designing is a team effort, and therefore had not reached the

possible threshold concept stage of the maturity (emotional capital) to accept such a constraint. In both instances, the troubled transition to a particular conceptual structure inhibits transformation to a more developed identity and access to the community of practice. What is particularly troublesome in these instances is that the underlying episteme necessary for these students to move on does not even come into view. This argues strongly for a mode of pedagogy which can render these less accessible knowledge practices more visible and explicit so that they can become the focus of discussion and exploration between deign students and their tutors. 'Without this openness' suggests Davies, 'the interaction between teachers and learners is shrouded in a mystery that ultimately deprives many learners of an opportunity to experience the way of thinking and practising that is apparently being offered to them. They just cannot see it' (Davies, 2006 p.71).

CONCLUSION

Using the threshold concept framework has enabled the research team to open up a dialogue with teaching staff in a discipline that appears, in the main, to be relatively undertheorised. The usefulness of this dialogue was evidenced – during the whole-staff meeting and in individual interviews – by the enthusiasm of staff to participate. The Design tutors, as reported earlier, felt that there was an underlying agenda of things the students needed to experience before they could become successful designers, but our initial investigations found that this underlying agenda had previously not been articulated clearly. This could speak to the nature of the subject, in that creative arts subjects are not easily quantifiable, with regard to learning outcomes and especially in assessment terms.

   In addressing the original research question relating to spatial awareness, the first year of research by the CETPD team has found considerable variation in first year Design students' understanding of spatial issues.   As the course progressed, the students were beginning to formulate more sophisticated understandings of spatial matters, but the variation in their understanding at this stage did not appear to be particularly influenced by age, gender or culture. Further research to address patterns of variation will take place in the form of a longitudinal study following the original group of ten student interviewees through their four-year programme. A research methodology is planned that intends to gain insights into variation in the pre-liminal, liminal, post-liminal and sub-liminal (epistemic) dimensions of their development of spatial awareness in line with the model proposed by Meyer, Land and Davies (2006). Throughout this continuing study the research will focus on the following issues:

   –   what is the student understanding of spatial awareness (and other relevant
       threshold concepts) in the first year of entry?
   –   how might factors such as age, gender and culture influence this
       understanding?
   –   what patterns of variation in the development of conceptual understanding
       relating to spatial design issues are discernible across subsequent years of
       the programme?

Findings from the data analysis will be used to explore, with the Design staff, the relative advantages and limitations of the *atelier* method as a learning environment for the development of spatial awareness and other related concepts necessary for the successful education of automotive design practitioners.

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