

The threshold concept journey in design: from identification to application

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Published version deposited in CURVE May 2011

Original citation & hyperlink:

Osmond, J. and Turner, A. (2010) 'The threshold concept journey in design: from identification to application' in Jan H.F. Meyer and Ray Land and Caroline Baillie (Eds). Threshold Concepts and Transformational Learning (pp: 347-364). Rotterdam: Sense Publishers.

https://www.sensepublishers.com/product_info.php?cPath=&products_id=1038&osCsid=1a7

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THE THRESHOLD CONCEPT JOURNEY: FROM IDENTIFICATION TO APPLICATION

INTRODUCTION

This chapter builds upon previous research (Osmond and Turner 2007) outlined in Land and Meyer's *Threshold Concepts within the Disciplines* published in 2007. Specifically, it outlines the use of threshold concepts as a research framework within the transport and product design course at Coventry University, and then considers the journey from seeking to identify a threshold concept to a consideration of its potential impact on teaching and learning.

BACKGROUND

The research began in 2005 within the Centre of Excellence for Product and Automotive Design (CEPAD), established from a successful bid to the Higher Education Funding Council for England (HEFCE), as part of the CETL initiative. Pedagogical research has been a key activity within CEPAD with three inter-related strands of enquiry: identifying threshold concepts in design, examining the development of spatial awareness and investigating the internationalisation of the design curriculum. This chapter focuses on the research relating to the identification of threshold concepts in design.

As previously reported by Osmond and Turner (2007), at the outset of the research it was soon evident that in relation to pedagogical theory, the Transport and Product Design discipline was relatively untheorised, and approaches to teaching used by the Transport and Product Design staff were underpinned by a 'tacit underlying agenda of things that students need to have' (IBID). A similar observation by Buchanan in relation to design research is that within the design community there has been relatively little consideration of the nature of design research and its value, and questions about whether there is 'design knowledge that merits serious attention.' (1999: 3). This is echoed by Dorst (2008), who argues that most research into design has focused on the *process* of design at the expense of the development of the designer, and Rogers: 'In this respect, design research is a relatively young discipline and does not possess a well established knowledge base when we compare it to the likes of the sciences, humanities and other more established scholarly disciplines [4].

Further, a pilot study using an existing research methodology (ELTQ 2002) based on phenomenographic research was found to have little relevance to this context. The pilot used the Experiences of Teaching and Learning Questionnaire (ELTQ 2002), developed from the ESRC-TLRP project "Enhancing Teaching-Learning Environments in Undergraduate Courses", but notions of deep and surface learning were found not to be particularly applicable to the course, with the questionnaire itself found to be both too atomistic and generic a tool. Similarly, the notions and characteristics of deep and surface learning had little resonance with staff and students in relation to the nature of learning or student engagement, perhaps reflecting the increasing debate around the notion of deep/surface learning exemplified by Beattie et al (1997) and Haggis (2003).

The research therefore focused on the notion of threshold concepts (Meyer and Land), which were introduced to characterise the idea that in certain disciplines there are concepts that:

...represent a transformed way of understanding or interpreting, or viewing something without which the learner cannot progress. (2003)

Since the initial definition, the notion of threshold concepts has been further developed (Meyer and Land, 2005) and threshold concepts have been identified across disciplines as diverse as health, accounting, languages, communication studies and online spaces (Clouder, 2005; Lucas and Mladenovic, 2006; Orsini-Jones 2008, Cousin, 2006, Savin-Baden, 2008). The applicability and relevance of the notion of threshold concepts across disciplines is also reflected in an increasing body of literature and events focusing on threshold concepts both generally and within disciplines.

Within this context, the threshold concept framework was applied as a lens to research the Transport and Product Design Course in order to identify key concepts that students need to acquire in their development as designers and enable them to enter both national and international transport and product design industries. The concept provided a very useful starting point for opening up a research dialogue with both students and staff of the courses. Staff in particular engaged enthusiastically with the pedagogical research team in both interviews and whole-staff meetings and found the thresholds approach accessible in terms of a theoretical concept and the language (Osmond et al., 2007, 2007a). From the perspective of the pedagogical research team, threshold concepts provided a 'way in' to conducting pedagogical research with staff who may have had little or no engagement or knowledge of existing pedagogical research or theory.

Initially, to help identify potential threshold concepts in this area, and bearing in mind that staff saw possessing and developing spatial awareness as a crucial aspect of the student journey, a research question was posed: 'Is spatial awareness a threshold concept for the Transport and Product Design

course?'. A concomitant research aim was to develop a discipline specific tool to measure the student journey in terms of spatial awareness from entry to the end of the first year.

Interviews with staff were carried out using the above research question as a baseline and a key finding was that there was no common definition of the meaning of spatial awareness as it related to the Transport and Product Design course. Staff responses ranged from 'all round awareness' to 'design sensitivity'. In addition, student responses were gathered through a mixture of qualitative interviews and questionnaires and these responses were categorised as 'having no knowledge', 'little knowledge' and 'guessing' (see Table 1 below).





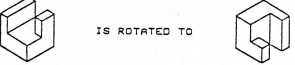


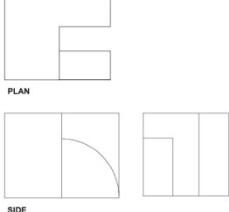

Table 1: Staff and student perceptions of the term 'spatial awareness' (Osmond et al. 2007)

Category	Indicative response: staff
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.
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.
Space	Displacement of space.
	'Relationship between form and spaces.'
'Intuitive/6 th sense.'	Intuitive/6 th 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.
Mental rotation	2D to 3D translation.
	Looking at an object at a distance, but able to perceive it in the round in detail.
Positioning system	Spatial positioning system working on several planes.
	Is about navigation and urban environments.
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...
Volume	Relates to the ability to transform volume.
Category	Indicative response: students
No knowledge	I can't say I do. I would like to guess but I might be wrong.
	Never heard of it before.

Some knowledge	No, I have heard the term but I am not aware of it.
	I've heard of it before...
	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?

However, although no common definition of spatial awareness was reached, a number of possible threshold concepts did emerge from the data, some of which were used to inform the development of a pilot spatial awareness measurement tool (©TPD Test) which was implemented with 114 first-year students alongside an existing spatial awareness test (PVRT¹), the latter specifically designed as the basis for evaluating courses developed to enhance students' spatial skills. (Figure1)

Figure 1: ©TPD Test (Osmond 2007) and existing spatial awareness test

©TPD Test		Example questions from the Purdue Visualization of Rotations Test (PVRT), Bodner and Guay 1997	
<p>Task</p> <p>Draw a simple cube at a size you feel comfortable with (5 minutes)</p> <p>Draw the object (boxes or bin) in front of you from the angle you can see (5 minutes)</p>		<p>11</p>  <p>IS ROTATED TO</p> <p>AS</p>  <p>IS ROTATED TO</p> <p>A B C D E</p> 	<p>12</p>  <p>IS ROTATED TO</p> <p>AS</p>  <p>IS ROTATED TO</p> <p>A B C D E</p> 
<p>Draw this object in 3D from the orthographic views. (5 minutes)</p>	 <p>PLAN</p> <p>SIDE</p>		
<p>Draw the unseen side of the chair in front of you. (5 Minutes)</p>			

¹ The Purdue Visualization of Rotations Test

Analysis of the PVRT test results were undertaken and the mean score was comparable to previously published scores for this test carried out by Purdue University; in addition the TPD Test results correlated with the PVRT results indicating that the tests were assessing similar aspects of spatial awareness². The results were then compared with students' end of year assessment results, with a specific comparison undertaken with a 2D and 3D representational module, but no correlation was found. In other words, scoring well or not so well in both tests did not correlate with how the students performed in their assessment results, and therefore whether they passed their first year of study.

Due to the lack of common definition of spatial awareness amongst staff and students and the lack of correlation between the tests and end of year assessment results, the research team concluded that spatial awareness, as represented in the tests, was not a threshold concept in the first year of study. This led to a reconsideration of the meanings inherent in the term 'spatial awareness' and how relevant it was to the Transport and Product Design course. Current work focusing on the term 'visual creativity' is currently under investigation. Meanwhile, whilst spatial awareness was not seen as a threshold concept, a number of possible threshold concepts did emerge, with the notion of 'confidence to challenge' tentatively identified as a threshold concept within the first year of the course. (see Osmond et al. 2007a)

DEFINING THE THRESHOLD CONCEPT

As described above, the research tentatively identified 'confidence to challenge' as a first year threshold concept, defined by an Industrial Design tutor as:

the ability to inculcate design conventions and expand upon them using information from a variety of sources and experiences.

This 'confidence to challenge' allows students to tackle what Buchanan calls 'wicked problems', which

...have incomplete, contradictory, and changing requirements; and solutions to them are often difficult to recognize as such because of complex interdependencies.' (1992)

Without this confidence students can remain in a liminal state, constantly 'surfacing around' in search of a solution, and this seemed to present even more difficulties to those international students who are used to a more prescribed style of teaching and curriculum:

² Statistical analysis of the results was conducted using SPSS™ statistical software (version 14.0). Data were checked for normality before the calculation of mean scores. Correlations were carried out using Pearson and Spearman Rank tests as appropriate (Ho, 2006).

I think during the very beginning I really struggled to really know what I should do in my projects - you really spend a lot of time to think about it but the result is not really that good as you expected because you keep surfacing around, you can't really make decisions about doing ... that's one of the most negative feelings because you don't know what to do sometimes - I mean I understand you do projects it is not really satisfying teachers, you learn during the process, but still you want to know what they really want. (first year international student)

A search of the design literature reveals that the 'surfacing around' described by the student quote above, chimes with Tovey's (1984) notion of an 'incubation period' that designers tend to experience:

It is possible that the incubation periods, that time of apparent inactivity during which the designer's brain furiously grapples with the problem, is simply the period during which the two halves of the brain are out of touch or unable to agree. But contrast the moment when they do suddenly come into alignment would be the classic 'eureka' point.' (226)

This is also described by Cross as the attention of the designer oscillating between the problem and the solution, epitomised by this quote from Archer (1979):

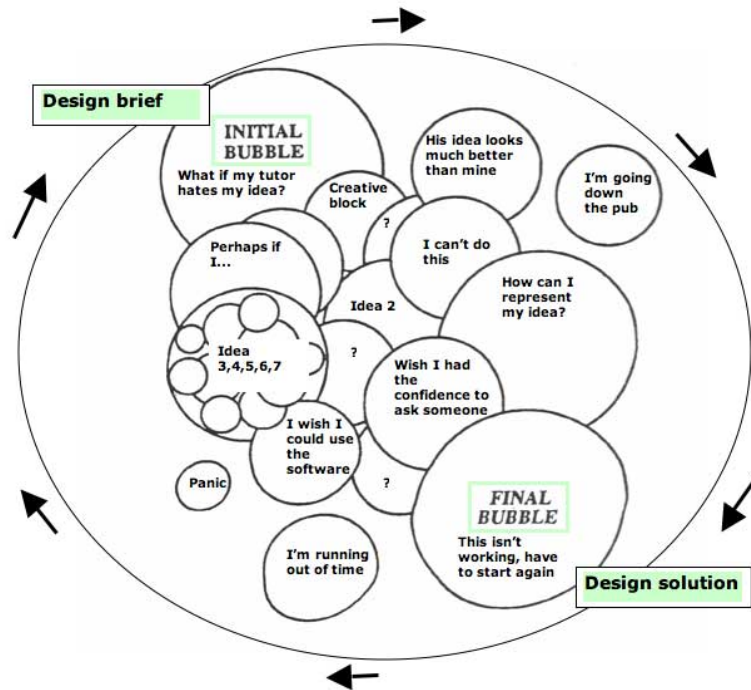
The design activity is commutative, the designer's attention oscillating between the emerging requirement ideas and the developing provision ideas, as he illuminates obscurity on both sides and reduces misfit between them.' (quoted in Cross 1992: 5)

Whereas Dorst likens this uncertainty to 'tightrope walking' in that designers can work on a design for indefinable lengths of time, not knowing whether the design will be successful or reach a 'satisfying conclusion.' (2003:97).

This incubation period can also be likened to Wallace's concept of a 'bubble' (Figure 2), which he describes as:

Progress through many simultaneous tasks involves solving hundreds of individual problems...To solve a particular design task, the complete set of problem bubbles associated with the task must be solved; but many, many bubbles not directly related to the task will be entered between starting and finishing the task...' (1992:81)

Figure 2: Stuck in the Bubble (adapted from Wallace 1992)



Wallace therefore marks out the terrain a designer routinely enters when first approaching a design, which one member of staff described as 'the explosion in the head which actually makes them better designers', and is a sentiment echoed by Cross when he states that a good designer '...is someone who has no limitations in having odd and strange ideas in that early stage of the concept phase.' (IBID:13)

Further, Dorst and Lawson's (2008) 'Levels of Design Expertise' model (based on a model originally developed by Drefus) and outlines six levels of expertise in relation to a designer's development. A fledgling designer will begin in the 'naive' category, where the student has not yet realised that 'design is a series of activities'. The student then moves to the 'novice' category where rule-based design is the norm. The next stage is to 'advanced beginner' which involves situation-based design, followed by the 'competent' design stage where the focus is on strategy-based design. The student then moves into the expert category where pattern based design is used, and finally to the 'visionary' category where designers incorporate all the previous categories and strive 'to extend the domain in which they work...new ways things could be, defines the issues, opens new worlds and creates new domains.' (2008:9). Therefore, it appears that the students can be characterised as being as the 'naïve' stage, where they do not yet realise that 'design is a series of activities'

and the surfacing around and/or incubation period experience is perhaps the initial stage on the journey to becoming a 'visionary' designer.

The period of uncertainty or being 'stuck in the bubble' when looking for solutions and considering alternatives for solutions has also been identified as an important part of the process of the 'creative thinking' process. Although the terms and context vary, the principle and importance of a period of uncertainty is well recognised. For example, Kleinman talks about 'Creativity-as-process':

Creativity-as-process is conceptualised [and] conceived as leading to implicit or intangible outcomes and...as not linked to any outcome. While the latter may appear illogical, in that all processes must lead to some form of outcome, and seems perhaps counter-intuitive, it recognises that creativity sometimes requires an acceptance of a lack of structure and direction, e.g. 'playing for the sake of playing'. (2008)

DeBono (1995) in describing his six 'thinking hats' system refers to the importance of creating time and space for creative thinking. The coloured hats are used as a tool to allow time and space for creativity, with the different coloured hats denoting a particular type of thinking. There is no set order to 'wearing' the hats but ideas such as thinking for 'ideas and proposals' and 'evaluating the alternatives' clearly resonate with the ideas of 'surfacing around' for solutions identified in this research. In addition, DeBono identifies 'provocations' to achieve 'movement' to come up with new solutions, defining movement as a mental operation requiring 'confidence and practice'. Amabile (1983 in Vidal 2009) in defining the creative person describes how 'creative thinking skills determine how flexibly and imaginatively people approach problems and tasks. It demands courage to be creative because you will be changing the status quo', and Baille (2003) focuses on fostering students' creative thinking skills in particular through a series of case studies entitled *The Travelling Case*. Other publications that identify the importance of creativity in problem solving include Vidal (2009); Kotzé & Purgathofer (2007) and Dekker (1995).

It is likely then that some first year students, when faced with a design brief for the first time, can get 'stuck' in Wallace's bubble, perhaps lacking 'the ability to entertain ambiguity and complexity' (Wylant 2008), and subsequently may panic as they search for solutions. In practice then, they may be afraid of admitting that they don't understand the brief or can't get past a creative block and constantly enter and re-enter the bubble as they struggle for inspiration, and, at this stage, lack the 'confidence to challenge'.

INVESTIGATING THE THRESHOLD CONCEPT

The notion of 'confidence to challenge' as a threshold concept was explored further during the third year of this research through a whole-staff meeting

and one-to-one interviews with five third year students (including one international student) who were originally interviewed as first year students.

The aim was to establish evidence of progression through the threshold concept, perhaps identifying critical points (such as key experiences and assessments) which enabled this and to this end each student was presented with a picture of a piece of assessed first year work and asked to describe how they would approach such a brief from their 3rd year perspective. Two students were quite taken aback to be presented with a piece of work that they hadn't seen for over two years:

Hmm, 40% didn't do very well, I don't think I read the brief properly - I think that was what - my drawing skills don't look fantastic either.

I look at my first year work now and I think I shouldn't really be here. Yeah, at the time I knew for example some of the things could have been better, but compared to what I can do it is like I am looking at myself 10 years ago thinking what were you doing - quite shocking.

They all recognised that there was a real difference in how they would approach the same brief and talked about how they felt they had progressed quite significantly since their first year, typified by this comment from one of the students:

I can approach things in a more homogenous way...a holistic approach now. I can actually look at things and think well it looks good - works well. First year I felt like I approached things from separate angles and hoped that they would collide in the middle and I would have something that looked good and worked well, but now I find that I can merge things together while I am doing it, it is more controlled.

Interestingly, three students felt that their actual thought process had not changed since the first year, rather, that they had been given the tools to underpin and express the process in improved designs:

...it is kind of an emotional/emotive thing that goes on in your head - as you progress along the year, you do learn new skills and new ways of handling/tackling a project or handling different stages, but in the thought processes - I would say that the actual rigid structure of thinking in the way to tackle the project hasn't changed that much...you just improve on what you have got, rather than a total overhaul of your thinking processes

I still think my thought processes are quite similar to the way I used to think compared to the way I used to think in the first year or second year

I think there is a natural thought process that you actually do compose as the project goes along

However, the students did confirm that the sense of being stuck in the bubble when faced with a new brief was still present in their third year:

It has happened to all of us at one point or another, when you have had that soul crushing moment when you think I can't do it or something has gone wrong and you haven't got time.

Oh yes there are still some briefs that you do have to rack your brain over and think what is going on here

This difference between the first and third year appeared to be that the students had inculcated and used coping strategies:

If [it] happens in the 1st year I don't think you would be equipped to deal with it, but in the 2nd and 3rd you have learnt the skills to get round that problem.

I have actually found that I am quite good at pressing the reset button and getting everything back together.

I think actually understanding of the briefs you really need to know what you are talking about and be able to understand it right from the beginning and make sure your understanding of it is the right one - because if you think you completely understand and it comes to the end of the assessment, and yeah but I understood the brief, they are like no you didn't understand it in the correct way so you have to make sure you understand right from the very beginning- I think that is definitely something that I need to make sure is happening,

It seems then that by their third year of study, the students were still getting stuck in the bubble, but had developed strategies to deal with it by accepting that this is part of the design process:

Pressure - you are up against the wire and you have got a few hours left and you think to yourself...what am I going to do? It is that pressure that forces you to condense your skills into something useful - I feel that's when I have learnt most - when I have been up against the wire.

The result is an increased confidence in not only drawing on different strategies to cope, but also translates to presenting and defending their actual design work. All the students mentioned that the work they carried out as part of a group in their third year, aided by an assignment that required them to present designs to companies who agreed to pose as 'clients', boosted their confidence:

Yes, I was able to stand in front of the editor of [...] today and wing the presentation when the video wasn't working and he really liked it. I felt that I can do that a lot more effectively now, you have the practice of defending everything you have done.

To explain why you have done something and why you think it is good I feel that I have got a lot more confidence

I think [my confidence] has definitely improved - I am still not 100%...the group work we were doing a lot of in the studio in front of everyone else

- I had to be confident with my work and I was proud of it in the end, I would be drawing something and this doesn't look quite right and someone else would tell me if there was something wrong with it that they could see or they would say it was really good.

It appears then that during the first three years of the course, the students undergo a series of transitional moments that enhance their ability to progress through the bubble when faced with a design brief, which is underpinned by the development of an inquisitive attitude/hunger for knowledge; a 'playfulness' that facilitates the stretching of boundaries; a lateral and logical approach to tackling problems and an ability to evolve, change and refine ideas. Further, tutors feel that releasing students' creativity comes to the fore during the process of design; '...through problem solving, direct modelling, sketch modelling...experiencing it where it really takes place.' (Osmond and Bull 2007). Previous research (Osmond et al., 2007) observed that this facilitation of creativity is underpinned by the provision of a studio environment that favours a teaching approach akin to the atelier principal of teaching, defined by Craddick and O'Reilly (2002) as involving a group of students...working with one or two tutors...through a year-long cycle of design.' facilitated by a staff who cultivate a 'respect for the creative mind' (Design Tutor). In this, the teaching method resembles the apprenticeship model, in which effective teaching, according to Pratt is

...a process of socializing students into new behavioural norms and professional ways of working. Effective teachers are highly skilled practitioners of what they teach. Whether they are in classrooms or in clinical settings, effective teachers are recognized for their professional knowledge and expertise. (2005)

TRANSITION POINTS

For the first year students, one member of staff talked about how the result of the first assessment was an important transitional moment, almost like a reassurance that the students 'had the right' to be on the course:

...something about having gone through the process and being reassured...[they feel] am I still here? Can I stay? Now can I actually call myself a designer?

With second year students a seminal moment occurs when the students use clay for the first time. This experience brings a number of concepts together, in particular, space - physically in terms of the actual studio environment, and conceptually, in terms of the brief which requires them to produce a 'clay head' based on their imagination (Figure 3), and an awareness of each other as a group:

Figure 3: Clay heads project



Somewhere towards the end of the 5-week clay head part – their own studio, freedom they are given – and their understanding all of a sudden of who they are in the group and working together in a sustained way, and achieving.

Just after the experience with the clay heads, the staff mentioned an increase in confidence in terms of students approaching them:

Another gateway is just after the clays, because I tend never to see any students come to tutorials until they are in year 2 and then we do the empowering ‘yes you can go and do this’.

Being mature enough to turn up and talk to us...We are perhaps changing their view from us being teachers to just people, to facilitators

A transition for third year students was mentioned in reference to being exposed to the ‘world of work’ either through a company placement or an in-house design placement:

Going out on a real placement or a placement alternative here, where you do need to get up for work and behave in a professional way - when they finish that, there is definite change from then on.

Another change noticed by staff is how the students use technology differently during their third year:

[in their second year, the students] get locked behind what is technically feasible, whereas we want the technology to enable their design rather than solve all the technology first - 2nd years seem to get locked behind that, whereas the third years don’t.

Other transitional moments discussed by staff as spanning the students’ journey through the course were group work and empathy. For the former, the key moment was when individual students realised that they had conceded that their design was perhaps not the design that should be pursued:

One of the big ones is working in groups – if their personal piece of work isn't the bit that gets chosen – a big one is to recognise is 'that idea is better than mine and I have to stop making that one work, and try and make this one work'.

For the latter - empathy - this relates to students having to expand their awareness to include the needs of other people, a particularly important transition for a designer:

...because what the students have to be able to do as a designer is not think like themselves, not got to design for themselves – and I think that is one of the most difficult - it is actually taking them out of themselves, and making them think like a 60 year old or like a child. I think that is one of the important breakthrough moments, when they stop doing that, when they stop thinking like a petrol-head. When they can think like an old lady trying get a bag onto a bus I think that is the breakthrough moment when they can achieve interesting design because it is that ability to think outside [of themselves]

The pedagogical design of the transport and product design course appears to be key in providing opportunities and experiences for key transitions in the student identity to occur and for the development of key design competencies. By the third year of study students are able to use learned competencies to negotiate the bubble - for example, knowing where to look for inspiration, tolerating a creative block until inspiration strikes, possessing relevant technological competencies, knowing how to use clay and not being afraid to approach peers and teachers for help. This progression is evidenced by the students' increased confidence in their own ideas and proposals, an example of which was discussed earlier when a third year brief involved the students presenting their ideas and proposals to real clients.

THE THRESHOLD CONCEPT

The key aspect identified in this research is the need for students to accept as an important and necessary part of design process, that period of uncertainty when they are searching and trying out different solutions or 'surfacing around'. We are therefore arguing that toleration of being stuck in the bubble - or Meyer and Land's liminal space - leads to the 'confidence to challenge', defined as inculcating design conventions and expanding upon them using information from a variety of sources and experiences. In other words, although the 'confidence to challenge' was originally identified as the threshold concept within this context, it is the *process* - the toleration of uncertainty - that brings about the transformation in the student, and this achievement of tolerance is linked to an increasing confidence in their own capability and identity as a designer to identify and propose design solutions. Using Meyer and Land's characteristics of threshold concepts, achieving toleration of being stuck in the bubble is *transformative* in that the students

accept that this is what a designer 'does' and thus they begin their journey to the designer identity. It is *irreversible* in that they would find it very difficult to 'un-think' themselves from a design identity. It is *integrative* in that that they realise that everything they know, learn and experience is a legitimate source of inspiration (for example accepting that those moments when they dance around the bubble thinking about subjects that are not directly related to their task may turn out to be the most important part of the process). And, most of all it is *troublesome* in that the students will constantly experience and re-experience the 'surfacing around' as they hunt for a solution, even when they attain the status of professional designer.

In other words, when students accept that part of the creative process is being stuck in the bubble - or they accept *the toleration of uncertainty* - while they search for inspiration, then they have achieved the confidence to play with both conventional ideas and challenge these with new thoughts, or perhaps develop the capability for what Perkins (2000) describes as 'breakthrough thinking' which leads to the 'kind of creativity that involves thinking outside the box.', or even 'thinking in a very different box.' (Wylant 2008).

IMPLICATIONS FOR TEACHING AND LEARNING

According to Davies and Mangan (2007) it is not enough to identify a threshold concept - for this activity to be useful, consideration of how this can affect the design of teaching and learning must be the next step. A characteristic of the assessments and activities associated with the transitional moments where students appear to progress through the threshold concept, appear to be problem-based, experiential, related to work and 'real-world' design activities and often involve group work; in other words there is a focus on 'doing as learning'. This reflects the growing interest evident in the literature in curriculum design incorporating work-related learning, the use of serious games and simulations using immersive virtual worlds (e.g. Savin-Baden and Wilkie, 2006, Gauntlett, 2007)

In contrast, development of the toleration of uncertainty seems to be implicit – almost an underlying agenda - in the teaching and learning process and to help first year students, in particular international students, perhaps explicitly surfacing this may enable them to develop suitable coping strategies during their first year on the course. In other words, by legitimising the 'stuck in the bubble moment', it is possible that students may feel more comfortable in this moment at an earlier stage.

However, surfacing the underlying agenda in a creative discipline such as this one could be problematic and surfacing 'the stuck in the bubble' moment may not enhance students' creative abilities. The course as it stands is very successful, and some members of staff would argue this is precisely because of the freedom the students are given to experiment and 'play' during the design

process and that 'the stuck in the bubble' moment, if described and explicitly surfaced, may hinder their progress, or as a member of staff comments:

Can't write it in a document. Sometimes to write things down kills them – you finally isolate it and nail it down and write it down it looks trite and stupid – it's not worth the paper it is written on – you can say it in the heartfelt way – it's meaningful – probably works as a quote – but it wouldn't work in text..'

Dorst echoes this when he talks about how existing models of the 'design process' exclude everything else that is happening when designers are in design mode and that 'it takes only an afternoon to explain one of the design process models to a group of design students. But knowing that model doesn't make these students designers at all...' (2008: 5)

Conversely, Perkins argues that by not surfacing the underlying agenda, or what he calls the episteme:

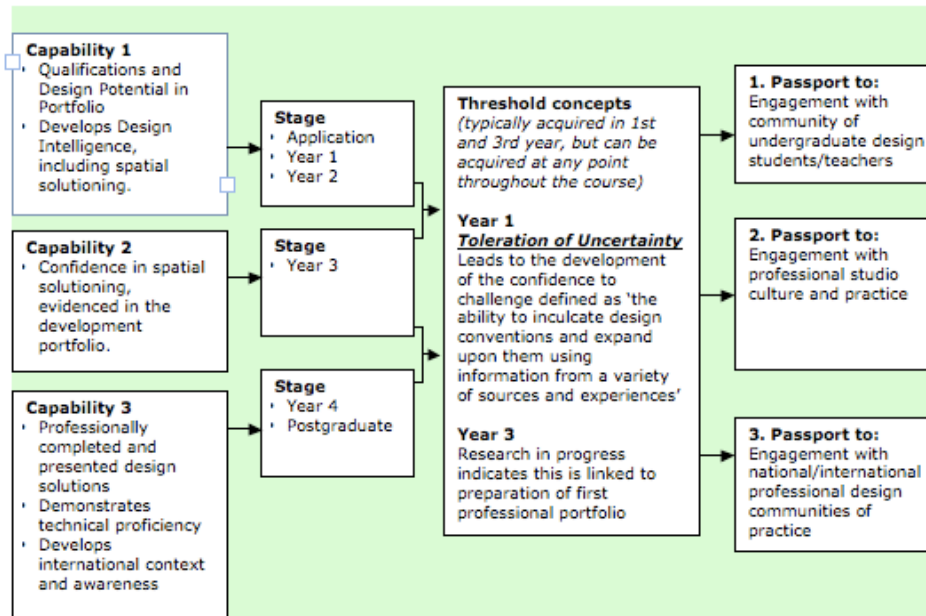
...many students never get the hang of it, or only slowly, because the epistemes receive little direct attention. For [students], surfacing the game through analytic discussion and deliberative practice could make a big difference. (2006: 43)

Wallace concurs when he states that design thinking is improved 'through being consciously aware of the design process' (1992:75) whilst at the same time 'hovering' above the bubbles.

Perhaps a way forward may well be to focus on the concept of negotiating the bubble as a way to assess gaps in student knowledge. If, in the first year, students were encouraged to articulate the reasons as to why they are stuck in the bubble - for example, 'I would like to produce a rotational 3D model on screen so I can play with it, but I don't know how to use the Alias software'; 'I can't seem to make this clay model work'; 'I am afraid of admitting that I don't understand the brief'; 'my mind is blank at the moment and I don't know how to get past it', then this feedback could facilitate appropriate interventions and support as well as legitimising their feelings of being unable to make a conceptual leap at this point in the course.

At this point in the research, having identified a first year threshold concept, the intention is to explore the notion of introducing teaching and learning interventions along the lines of the discussion above. Further, research in progress indicates another threshold concept during the third year of the course which is linked to engagement with professional practice and the preparations of early professional portfolios. Finally, work is currently taking place on the development of a representational model of the research outcomes (see Figure 4 for early model development) which has the potential to be of use within the design disciplines and similar both within and outside Coventry University.

Figure 4: Representation model of threshold concepts in Transport and Product Design (work in progress)



CONCLUSION

This paper has charted the identification of a threshold concept - the toleration of uncertainty. The research has also clearly identified nature and importance of the design of learning, teaching and assessment activities in facilitating the development of the identity of a designer- and has discussed some possible implications for teaching and learning for the transport and product design at Coventry University.

The researchers found that using threshold concepts enabled a useful and constructive dialogue with both staff and students within a relatively untheorised discipline. Although the research found that spatial awareness, considered as being at the heart of the course by staff was not a threshold concept but a design capability, it did allow the 'confidence to challenge' to emerge as a possible contender.

A search of design literature allowed the linking of the threshold concept to the work of Tovey's incubation period, Cross's oscillation between problem and solution, Dorst's tightrope walking, strategic thinking and visionary designer category; and, of particular interest, Wallace's idea of representing design tasks as a set of 'problem bubbles'. Links were also found in the

creativity literature, particularly in the work of Kleiman, De-Bono, Baillie and Amabile.

We have argued that it is only when students have mastered toleration of a period of uncertainty that they gain the 'confidence to challenge' and are ready or able to tackle design briefs that typically contain 'wicked problems'. Further investigation of the 'confidence to challenge' with third year students showed that between entry and the third year of study they have developed a tolerance of being in a period of uncertainty due to inculcating skills, capabilities and coping strategies delivered via an apprentice-like immersive method of teaching underpinned by an atelier, or studio-based, environment. Staff also identified particular moments during the course that moved the students on, including first year assessments, the use of clay in the second year, exposure to the professional community of practice during the third year, coupled with the ability to work in groups and the development of empathy.

As such, the threshold concept has been identified as *the toleration of uncertainty* which precedes the development of the 'confidence to challenge' and it adheres to Meyer and Land's threshold concept characteristics in terms of being transformative, irreversible, integrative and, most of all, troublesome.

Implications for teaching and learning of the identification of the threshold concept are still a focus for research, but may include the introduction of teaching and learning interventions such as a first year module that surfaces the process to allow the identification of 'gaps' in the students' knowledge. Finally, the development of a model of the process is planned, as is further investigation into possible a third year threshold concept linked to students' exposure and engagement with the profession design community of practice.

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