Multi-Disciplinary Interaction in Learning Led Design

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Abstract
The purpose of the study reported here was to investigate the iterative design development of an Academy for 11-18 year olds focusing on the following research question: *What are the features of the multi-disciplinary interactions and associated modelling techniques, which lead to the development of an Academy proposal which meets its Education Brief?*
A case study approach bounded by time and focus group was adopted (Cresswell, 1998). This approach was adopted in order to create a rich picture of the social setting and to illustrate the complexity of the process referred to as 'learning led design' from in depth analysis of the education brief, through iterative development in consultation with key stakeholders to the presentation of final proposals.

Findings illustrate that collaborative interactions are an important feature of effective design development with cross disciplinary creative collaboration being the key to the development of successful outcomes.

Key words
design, iterative development, interaction, collaboration, learning led design

Introduction

'Academies' are all-ability schools based in the United Kingdom which have been established by sponsors from business, faith, voluntary groups or other education establishments working in highly innovative partnerships with central Government and local education partners. The Department for Children, Schools and Families (DCSF) meet the capital and running costs for Academies in full and they are funded at a level comparable to other schools. A number of Academies are currently being re-designed and built as part of the Building Schools for the Future and Academies programme funded by the British Government.

The purpose of the study reported here was to investigate the iterative design development of an Academy for 11-18 year olds focusing on the following research question: *What are the features of the multi-disciplinary interactions and associated modelling techniques, which lead to the development of an Academy proposal which meets its Education Brief?*

As the complexity of the Education Brief in this context posed a challenge to the design team, it was vital that they worked collaboratively to develop an appropriate solution. According to John-Steiner (2000) "Generative ideas emerge from joint thinking…with the interdependence of thinking leading to the co-construction of knowledge" and "mutual appropriation of concepts" (John-Steiner, 2000).

This paper will be in four parts. First, it will review a breadth of literature related to design (Archer, 1984; Cross, 1982; Cross, 1989; French, 1971; Lawson, 1978; Lawson, 2004; Maver, 1970; Pahl and Beitz, 1988 and Pugh and Morley, 1988). Second, the paper will present and analyse the data. Third, the paper will discuss the significance of the results. In the conclusion suggestions will be made for further research to build on and extend the findings of this study.

Literature review

Literature on design – The nature of design activity

Design of the kind undertaken by professional designers could be considered one of the most intellectually demanding types of thinking as it involves both procedural knowledge, that is knowing how to do something, and declarative knowledge that is factual or conceptual knowledge (Lawson, 2004). In addition designers are required to understand a broad range of contexts and to be able to respond to problems in a creative manner. Cross (1982), coined the phrase "a designerly way of knowing", in reaction to the realisation that designers do indeed have a special way of knowing, one which has to be learned by doing. Designing in a professional context can be considered as an experiential process mediated by social interaction often in a collaborative environment.

The design process

Research into standardised design procedures has led many (Archer, 1984; Cross, 1989; French, 1971; Lawson, 1978; Maver, 1970; Pahl and Beitz, 1988 and Pugh and Morley, 1988) to question the validity of algorithmic versions of a so called 'design process', many of which omit the vital feedback loop which occurs during mental iteration. Mental iteration (Jin & Chusilp, 2006) is seen as a repetition of cognitive activities occurring in designers' thought processes. In other words as a designer develops their ideas they revisit previous concepts and build upon them in order to develop new insights. This has led some including myself to conclude that the concept of a design process is a misnomer which becomes a straight jacket of

conformity inhibiting the designers' creativity (McLellan & Nicholl, 2008; Spendlove, 2003; Trebell, 2008) by overlooking the heuristic nature of designing at the conceptual stage (Lawson, 2004).

Creativity in the design process

Creativity in the design process (Darke, 1979; Dorst and Cross, 2001) is often characterised by the occurrence of a significant event – the so called 'creative leap'. When researching designers and designing, many researchers have conducted 'think-aloud' protocol studies (Ericsson & Simon, 1993; Van Someren et al, 1994) where designers were asked to think aloud as they solved design problems thus giving the researcher an insight into inner thought processes. However, it should be born in mind that language is the social representation of thought but does not necessarily mirror thought processes in detail (Vygotsky, 1986), so that think aloud experiments are likely to be a poor representation of internal cognition and therefore not the most effective method to meet the stated aim.

Conceptual design, ideation and the prevalence/relevance of sketching

According to Cross, (1994); Guilford, (1970); Pugh, (1991) and Roozenburg & Eekels, (1995) conceptual design should contain two kinds of steps: divergent in which alternative concepts are generated, and convergent in which these are evaluated and selected. Ideation (Jonson, 2005), an important element of conceptual design, can be seen as the generation, development and communication of ideas, where the 'idea' is understood as a basic element of thought that can be either visual, concrete or abstract. As such it is an essential part of the design process, in education and professional practice. In this process, freehand sketching has traditionally been considered a core conceptual tool (Bilda & Demirkan, 2003; Cross, 1999; Garner, 1992; Goel, 1995; Schön, 1983; Suwa & Tversky, 1997; Tversky, 1999). Suwa and Tversky (1997) argue that 'designers attend to the very figural or formal properties of sketches as they make them and from this tend to 'read off' new ideas or as Schön (1983: 78) explains "designers have a conversation with the materials of the situation" through the generation and development of design ideas.

Bilda et al, (2006) and Jonson (2005) challenged the supremacy of sketching during design activity. Bilda et al (2006) encouraged architects to design without the use of sketching, by visualising the concept and articulating it verbally as part of a 'think aloud' protocol analysis. Jonson (2005) encouraged a number of students and professional designers to develop the notion of 'reflective practice' (Schön, 1983) by self reporting the nature of design tools used during the ideation phase of a given task. Tools recorded included sketching, words, sketch modelling and computing. Findings indicate that designers were not solely dependent on sketching as a means of generating, developing and communicating design ideas. Those deprived of sketching still managed to articulate their ideas effectively but it was acknowledged by Bilda et al (2006) that this was because the participants were experts in their field. As such they would have internalised external tools thus creating highly developed psychological tools (Vygotsky; 1978; 1981; 1986) which were called upon in this instance to support ideation. Bilda et al (2006) acknowledged that when interviewed, the architects stated clearly that they preferred to be able to use sketching as an aid to cognition and that being denied the opportunity to do so was frustrating because their mental processing functions were overloaded.

In summary designing in a professional context tends to manifest itself as a range of modelling techniques used throughout the process in order to communicate complex ideas. These have been usefully defined by Kimbell and Stables (2007) as:

- visual modelling where ideas are progressed through sketching;
- written modelling where ideas are progressed through annotation;
- verbal modelling where ideas are progressed through discussion;
- numerical modelling where ideas are progressed through the use of numerical calculations;
- material modelling where ideas are progressed through the development of three dimensional representations.

Ideas then are central to the concept of designing and these develop and change as a range of modelling processes are employed to inform thinking.

Design as a socially mediated process

Increasingly studies of designerly activity in a professional context have focused on social interaction as a key feature of designerly activity (Cross, 1996; Cross et al, 1996; Lawson, 1997 and Medway and Andrews, 1992). Taking place as they do in the naturalistic setting of the design studio, these studies have enabled researchers to analyse the place of language in the development of ideas and to conclude that the spoken word can act as an essential catalyst in the development of creative outcomes (Cross, 1996; Lawson, 2004).

Learning led design

> Space – whether physical or virtual can have an impact on learning. It can bring people together; it can encourage exploration, collaboration, and discussion. Or, space can carry an unspoken message of silence and disconnectedness.
>
> (Oblinger, 2006)

Education research currently favours an approach which values the co-construction of knowledge through interaction (Vygotsky, 1978, 1987; Wertsch, 1991; Wertsch, Tulviste, & Hagstrom 1993 and Zinchenko 1985), supported by information and communication technology. However, to date the design of learning spaces has not been sufficiently challenged to enable the development of spaces which fully support this paradigm.

This can be rectified by emphasising the principles of social constructivism. Spaces can be developed which convey co-learning and the co-construction of knowledge. From an architectural perspective this means thinking of the whole campus as a learning space rather than emphasising classrooms (Fielding Nare, 2009; Van Note Chism, 2006). Within any learning space it means avoiding the message that the room has a front or a 'privileged' space. Outside the classroom, it means providing ubiquitous places for discussion and study (Fielding Nare, 2007; Van Note Chism, 2006). It means that the flow of spaces – from library to faculty or administration to classroom and the corridors and outdoor passageways in between – must be rethought in terms of learning (Fielding Nare, 2007; Van Note Chism, 2006). Spaces should centre on learning not experts. However, it is important to acknowledge that space should be understood as including internal and external, formal and informal spaces because as Van Note Chism (2006) explains every space is potentially a learning space.

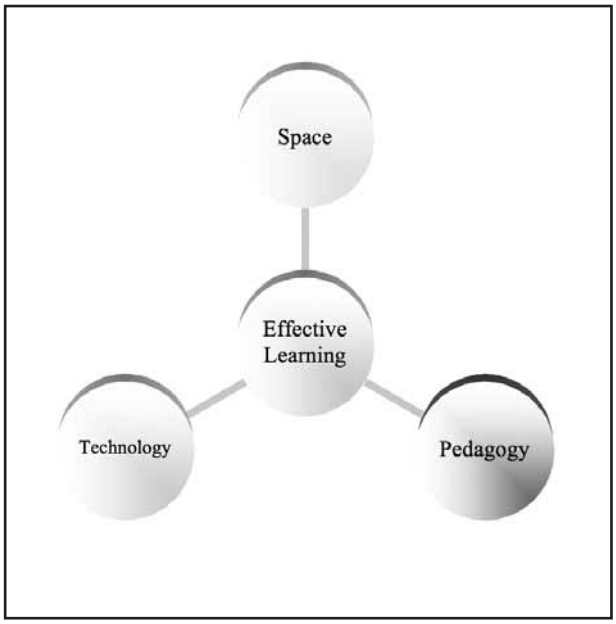

Figure 1. The synergistic relationship between space, technology and pedagogy in enabling effective learning

"Learning takes place everywhere on a college campus, in fact learning arguably happens everywhere – on city sidewalks, in airplanes, in restaurants, in bookstores and on playgrounds. Human beings wherever they are have the capacity to learn through their experiences and reflections".

Despite this there is a lack of "critical spatial and visual literacy" (New London Group, 1996; Burgin, 1996) of occupants within learning environments, and in the community at large (Thorn, 1999), which has led to little opportunity to challenge spatial practice in educational design.

However, with the British Government's Building Schools for the Future and Academy Programme, challenging designers to ensure that building design leads to transformational change in learning outcomes, there has been a development in what could be referred to as 'learning led design' where multi-disciplinary design teams work closely together to shape the spaces of the future. These teams typically consist of architects, engineers, educationalists, pre-construction teams and landscape architects.

Methodology

In order to study the features of the multi-disciplinary interactions and associated modelling methods, which lead to the development of an Academy proposal which meets its educational brief, a 'case study approach bounded by time and focus group' (Cresswell, 1998) was conducted. The research was undertaken between May and September 2009 and ran in parallel with the design development of the Academy. During the design development a multi-disciplinary team consisting of architects, educationalists, landscape architects, engineers and construction workers took part in an iterative design process which included consultation with a broad range of stakeholders including, students, teachers and planners in order to ensure that the solution developed met everyone's needs.

The educational context and sample

The site of the case study was an Academy in outer London specialising in Science and Technology with

Client team	Design development team
Academy representatives	An educationalist
Client architect who developed the reference scheme	A team of architects
The sponsor	A pre-construction bid team
The project manager	A landscape architect
Local authority representatives	An M&E engineer

Table 1. An overview of the client and design development teams

Business and Enterprise which aspires over time to have 1150 students on role with 250 in the sixth form. This Academy was chosen because the Executive Principal was a charismatic leader not previously involved in a design development project. An Academy with a sponsor was chosen as this adds an interesting dynamic.

During the process additional engagements were held with the following people:

- a number of students;
- members of the leadership team, the site manager and ICT manager;
- representatives of the Science and Technology department.

It should be noted that the consultations listed above took place during the invitation to tender (ITT) stage of the programme and that once the team were accepted as preferred bidder a much larger consultation process took place. Any consultation is limited at ITT stage as there are two bid teams working on the project at this point and sight of two schemes in the local area can become confusing.

Data gathering

In order to create a rich picture of the context, a range of data collection methods were used in order to enable the triangulation of data. These included scrutiny of the education brief, notes from client engagement meetings, concept sketches, sketch plans, detailed plans, concept sketches and detailed landscape plans.

Data were collected throughout the design development process and analysed against a range of categories drawn from the literature, supplemented by categories derived from the data.

	Education brief	Notes from client engagement meetings	Concept sketches, sketch plans, detailed plans and physical architectural models	Concept sketches and detailed landscape plans
Data set A – Collected prior to the design development process beginning	✔			
Data set B – Collected during client engagement meetings		✔		
Data set C – Produced for client engagement meetings			✔	
Data set D – Produced for client engagement meetings				✔

Table 2. Data gathering techniques

The data gathering techniques are summarised in Table 2.

Data presentation, analysis and discussion

One research question drove this study: What are the features of the multi-disciplinary interactions and associated modelling techniques, which lead to the development of an Academy proposal which meets, its' Education Brief?

In order to answer the question items from data sets A, B, C & D collected throughout the design development process will be presented, analysed and discussed.

Presentation and analysis of data

In order to explore the features of the multi-disciplinary interactions and associated modelling techniques which lead to the development of an Academy which meets its education brief, it will be important to understand the nature of the activities that take place during the design development process.

These can be represented as a pentagon with each corner of the pentagon representing a key activity in the design development process. It should be noted that each activity is joined to all of the other activities as a change in one area will have an impact on the others. This also begins to exemplify the iterative nature of design development, where a constant revisiting of earlier concepts and data inform design development throughout the process.

Deconstructing the educational brief

Prior to design development, it is essential that everyone on the design team reads the Education Brief and that the Education Consultant analyses the document and develops a list of questions which can be used to clarify key points at the first client engagement meeting. Table 3 is an example of the analysis of an element of the Education Brief against common themes (listed in the left hand column), questions designed to interrogate the brief further and the Executive Principals response. In this table it is clear that the general approach to the organisation of learning is well defined in the educational brief. However, the detail such as the approach to staff work bases, toilets, expression of space etc had yet to be clarified.

Detailed analysis of this kind is carried out in relation to a number of key issues including ethos and values, academy specialisms, teaching and learning, vocational education, support for learning, ICT and internal and external connectivity. Through analysis and interaction with the client, the educationalist de-constructed the education brief through questioning and verbal modelling and re-constructed it using written modelling in a way which represents a set of guiding principals for use by the design team. For example through discussions relating to ethos and values it became clear that the Academy was to be 'a life long learning hub for the entire community' which 'celebrated its' inclusive nature' through shared staff and student entrances, shared teacher/para-professional work bases and devolved learning support spaces. It also became clear that the client team were keen to explore the links between pedagogy and space and to re-define existing concepts such as the science department in order to meet current and future curriculum needs. This led to them requesting a range of spaces in this area including laboratories, science studios, a large demonstration space and a science garden rather than a fixed number of traditional laboratories all of which are equipped in exactly the same way and thus struggle to meet a broad range of pedagogic requirements.

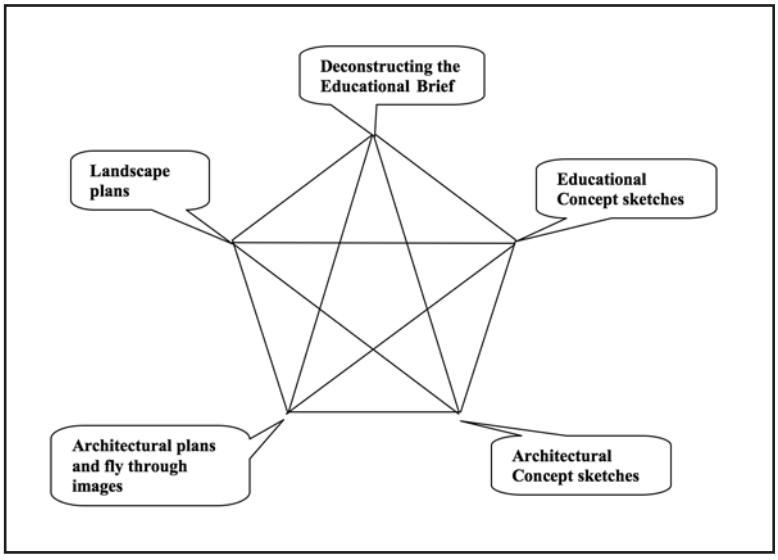

Figure 2. Key activities in the academy design development process

Educational concept sketches

Having interrogated the Educational Brief, it is possible using written modelling to produce a description of the core components essential within each of the learning zones as shown in Table 4. As you can see these begin to drive out key features which can be picked up by the architects, landscape designers and engineers such as the provision of studio classrooms to support kinaesthetic activity, external learning opportunities and a shared staff work base for use by both teachers and para-professionals.

RESEARCH

Education objective	Design implications	Executive principals comments
Organisation of learning		
Global communication learning zone (Year 7) English and Modern Foreign Languages	Would it be desirable to express a learning zones identity through the treatment of the spaces?	Yes definitely
	Understand generic make-up/ organisational structure.	There are learning zone leaders who are in charge of three subjects. The subjects all have subject leaders.
Science and technology learning zone (Year 8) Science and Technology	Gathering area within zone Staff work space – work and social?	
		In each zone there must be a small operational work base for 11-12 teachers and a number of para-professionals. Hot desking will be essential in these areas
World studies learning zone (Year 9) History; Geography; Religious Education and Citizenship/PSHCE	Office – Head of LZ or Head of Year Group Pastoral arrangements?	All staff in an area will share an office so no learning leader offices.
Logic and global enterprise learning zone (Year 10) Mathematics; Information and Communication Technology and Business	SEN small meeting room	One to one SEN or mentoring rooms across the scheme are essential
	Pupil lockers	Yes they want lockers but consider position carefully
The expressive and creative arts learning zone (Year 11) Music; Art; Drama and Physical Education	Pupil social space – ICT facilities	It would be good if there was designated external learning space for each zone
	Pupil and staff WCs – unisex, separate male and female, mixed staff and pupils? Curriculum storage outside classrooms – shared in zone	Shared staff and student toilets. This needs to be explored further as it is not the case in other Academies.

Table 3. Analysis of one element of the education brief

Written modelling of this kind summarising each of the five learning zones namely: global communications, science and technology, world studies, logic and global enterprise and expressive and creative arts were produced and shared with the design team and discussions held in order to ensure 'mutual appropriation' of the concepts being developed (John-Steiner, 2000)

However, it was important to be able to share this interpretation and understanding with both the wider design and client teams in an accessible format which would support ongoing interaction and become part of the language of design (Lawson, 2004) in this context. To this end the written modelling was developed into educational concept sketches using visual modelling techniques and

Global communication learning zone – Year 7 English and modern foreign languages
Give the spaces enhanced functionality by developing studio classrooms which have vinyl floors and sinks. Do this in perhaps two of the spaces which are dedicated to Year 7 use as this enhances opportunities to engage in kinaesthetic learning opportunities. We need to explore the use of acoustic screens in this area but must be mindful of cost. Access to breakout space in as central a spot as possible to enable those involved in activities to interact. I realise that this is a big challenge. If possible access to appropriate external spaces noting that Year 7 currently have their own play area. This should allow for a range of passive through to high energy activities. There should be a learning zone staff work area for teachers and para-professionals. This space will need to enable hot desking. This space will also house at least one member of the leadership team. A one to one space for SEN intervention activities, mentoring etc taken from nurturing space on the schedule. Sensible allocation of staff and student toilet facilities so that they are within easy reach of learning zones.

Table 4. Written modelling of educational concepts

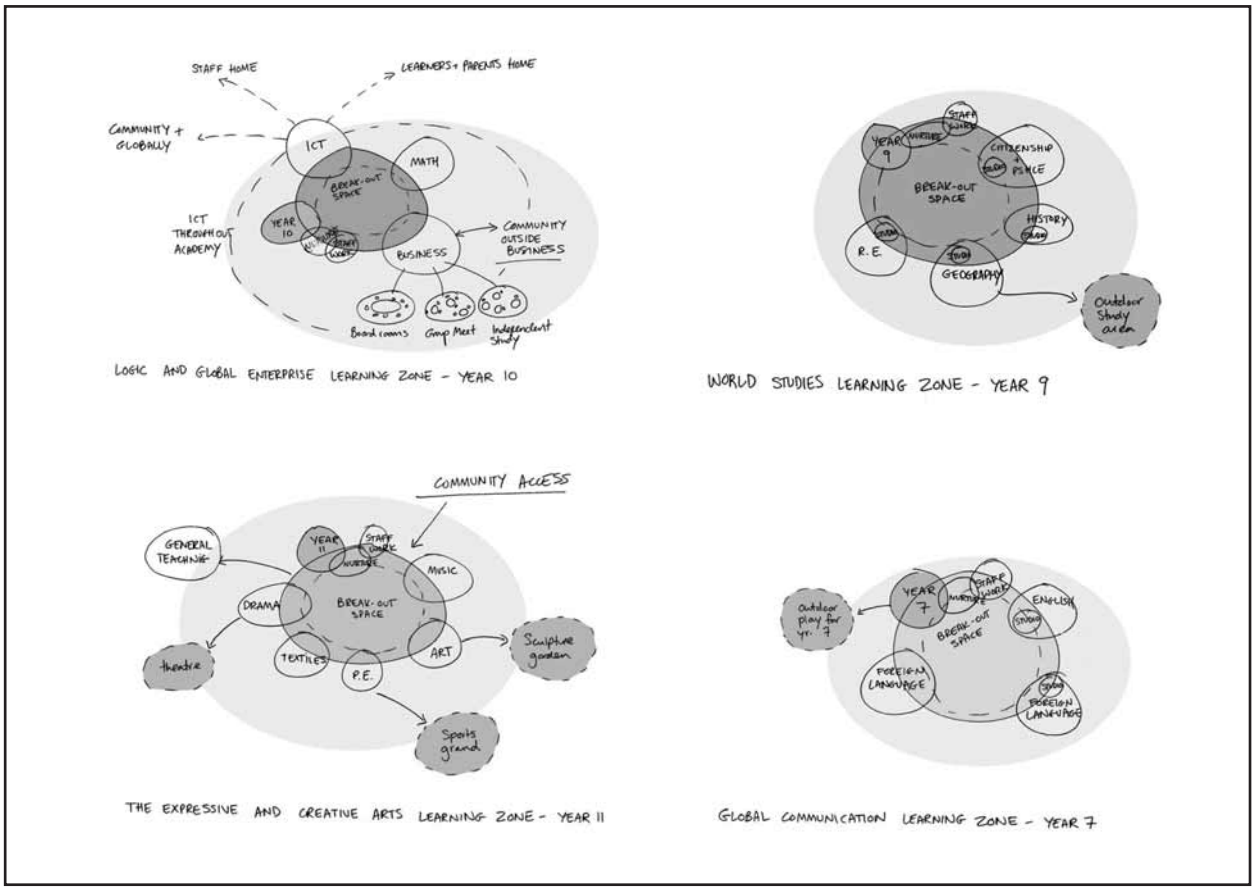

Figure 3. Educational concept sketches

shared with the design and client teams in order to ensure that the key educational drivers had been understood and would therefore be designed into the scheme. Examples of the educational concept sketches developed for this project are shown in Figure 3.

It should be noted that there are a number of core educational tenets embedded within the sketches. For example the Academy will be fully inclusive with nurture spaces developed in each learning zone. Learning zones will support a wide range of different types of learning allowing children to develop multiple intelligences rather than simply devouring subject knowledge. Studio spaces will be developed for project work, external spaces for sport, art, geography and science and relevant space such as ICT, sport and the well being centre will be community facing to enable community use.

The concept sketches have also been used to show important adjacencies such as food technology and dining developed in order to enable students to cater for functions. Other key features are the centrality of the demonstration space which will be a large re-configurable learning space accessible to all in the learning zone and the provision of CAD/CAM to enhance the realisation opportunities within Design and Technology.

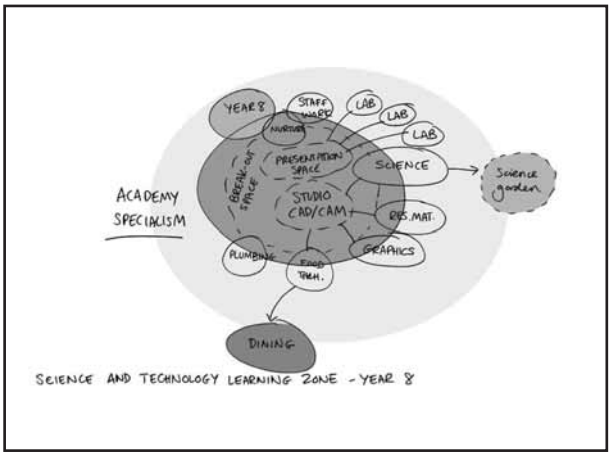

Figure 4. Educational concept sketch representing the science and technology learning zone

Architectural concept sketches

Another key feature of the Academy was the development of the heart or agora space which was a sponsor requirement. The agora space needed to be developed so that it supported the ethos and specialisms of the Academy. This was achieved by the team interacting by brainstorming potential uses and then playing these back through visual modelling in order to ensure that the teams' understanding of the space was accurate. An example of one of the sketches used is shown in Figure 5.

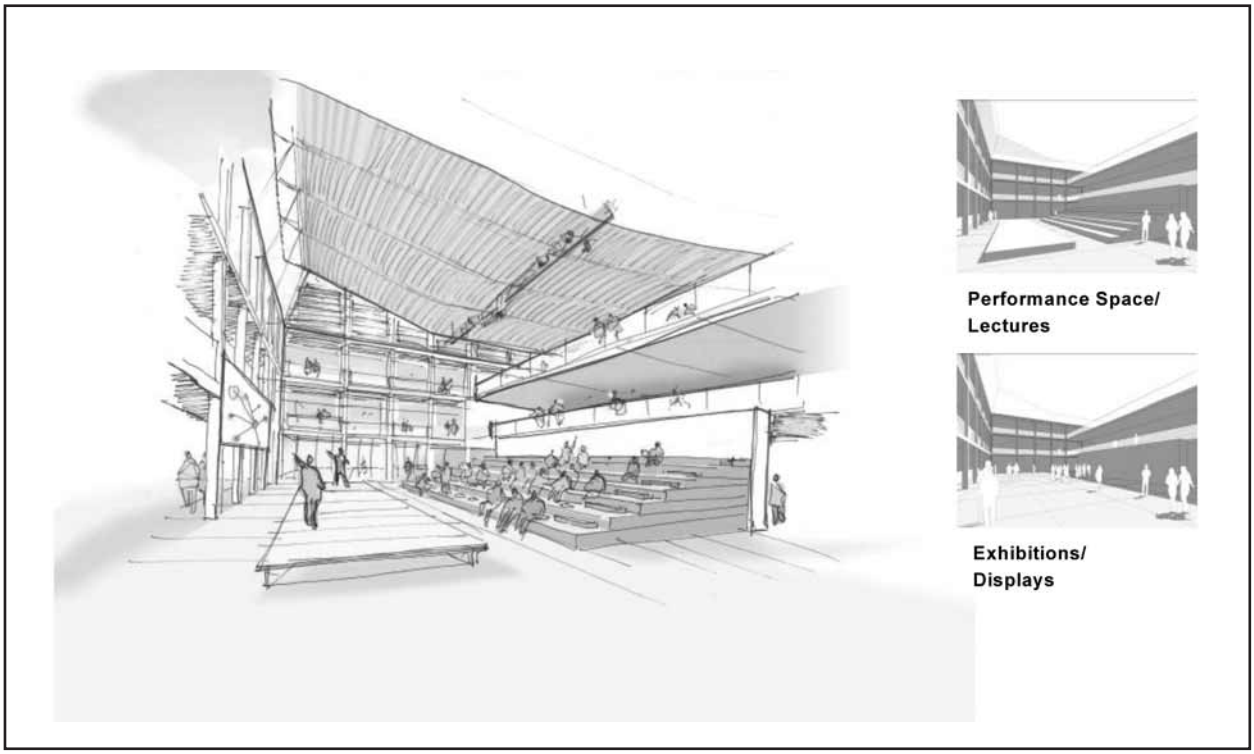

Figure 5. An image developed to 'sell' the potential use of the agora

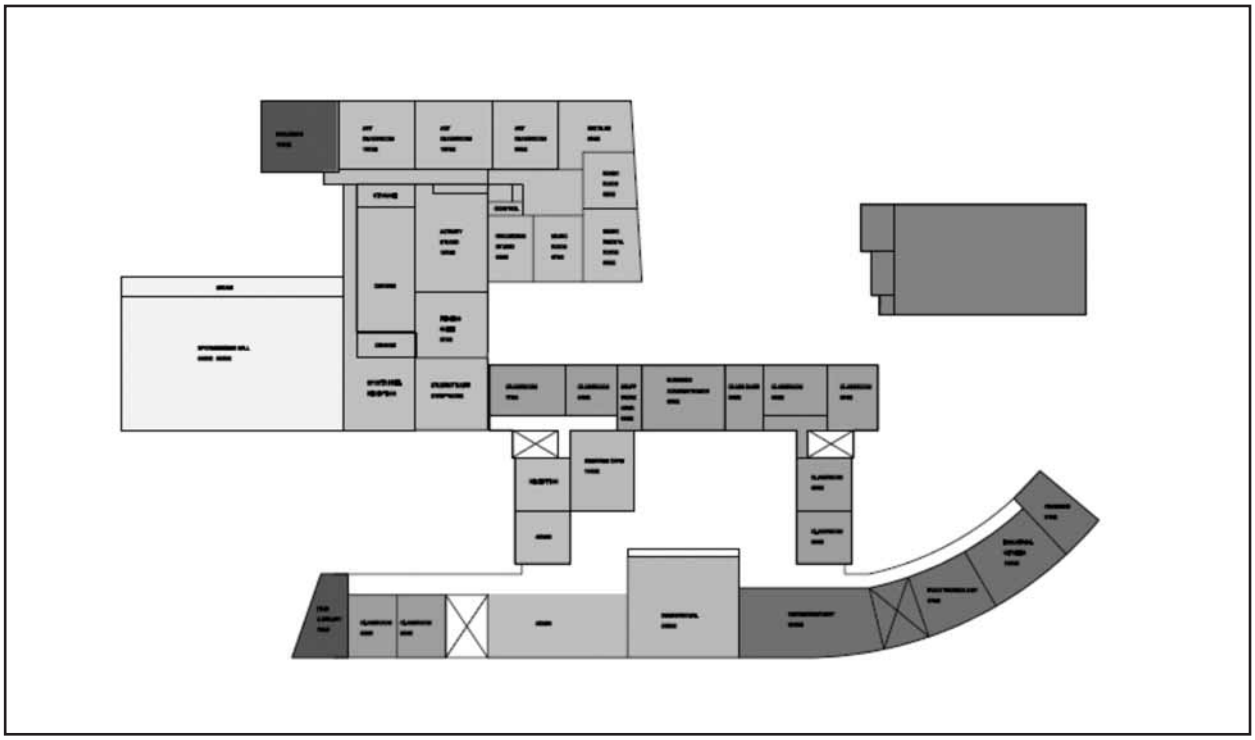

Figure 6. Early concept sketch

Architectural plans and fly through images

Having developed a sound idea of the requirements from the brief, it was possible to develop the accommodation schedule in order to address the issues that had been raised. As the schedule developed, the plans were created first as concepts presented using visual modelling techniques and then as scale plans which bring together both visual and mathematical modelling in order to show increasing levels of detail. Below in Figures 6-8 is a selection of the plans tabled during the process showing the design moving from concept to detailed plan.

This approach is a useful way to develop the detail of the design as the week's progress, showing the big picture moving to fine detail and gaining and acting upon feedback from the client engagement meetings throughout the process. In this way visual modelling (the plan) can be used to support verbal modelling (explanations of the plan) whilst mathematical modelling is employed to ensure that the plan is a scaled representation of reality which can over time be communicated through material modelling in order to show the design development in three dimensional format.

It should be noted that the input of the multi-disciplinary team is vital to success at this point. The educationalist reviewed the plans on a regular basis noting as shown below where key elements of the vision had been prevented by a design decision that had been made.

It should also be noted that during the 12-14 week design development process, there are six client engagement meetings which are used to present developments to the client and to gain feedback. During each of these detailed notes were taken which were then used to inform further design development. Examples of abstracts from the meeting notes are shown below:
'Move music to top floor – recital room at far end of building to cut down noise. Practice rooms one from end next to recital. They feel there are too many music rooms and again will review this on the schedule'.

'Art studios to move to 1st floor – _____ would like us to consider the activities taking place in each Art space when considering which might be open plan if any'.

Here the notes are clearly about where the Executive Principal would like subjects placed within the scheme meaning that the comments are directives. However, other points expressed pleasure with the developments and so were affirming statements. For example:

'Really like business and enterprise, science and technology links to heart of academy'.

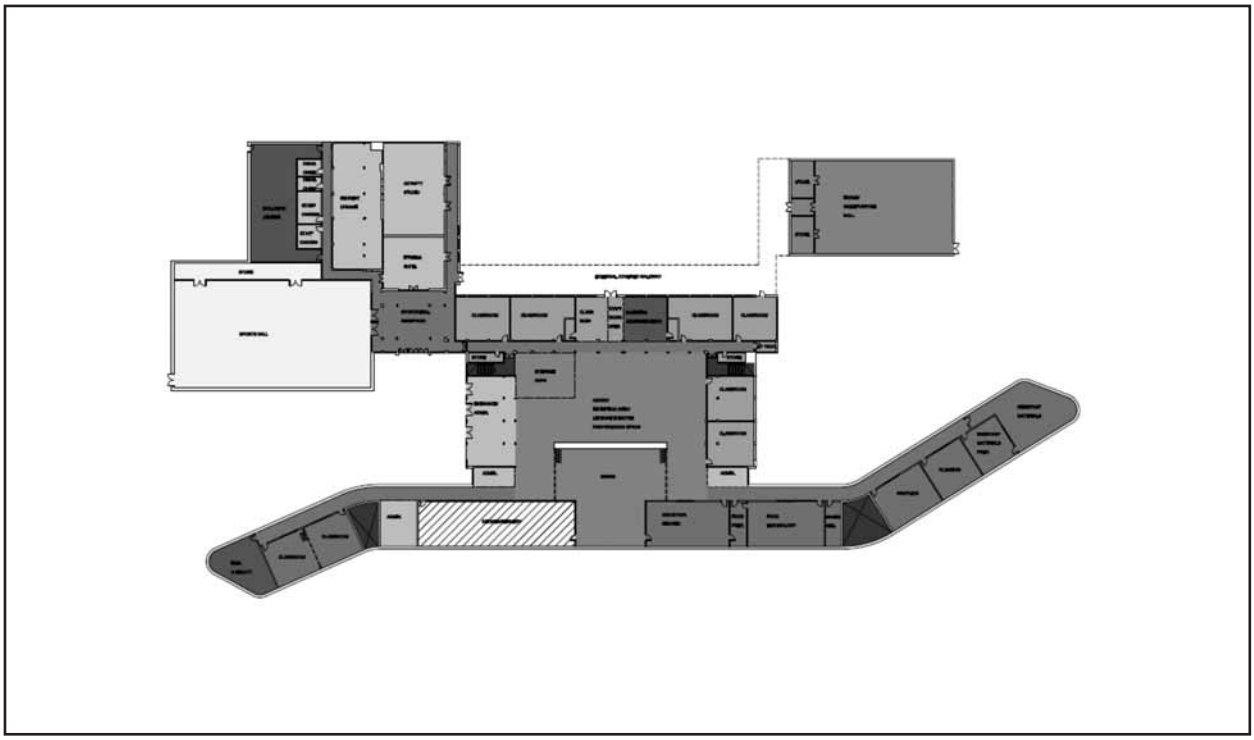

Figure 7. Walls and doors are added

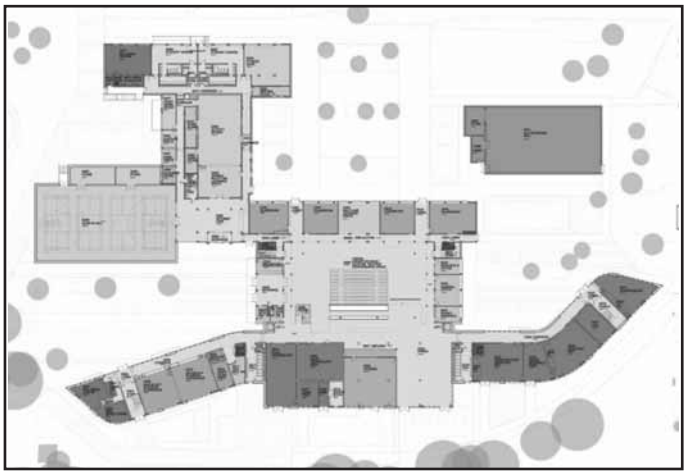

Figure 8. The scale is now correct and much more detail has been added

And others expressed a firm wish e.g.
'Bleacher seating must retract to enable the space to be as flexible as possible'.

Throughout the design development there were numerous examples of this kind of interaction which enabled the design team to co-construct developments with the client team.

The legibility of plans

As part of the design development it was important to present ideas in as many formats as possible in order to ensure that all of the client side team could understand the nature of the spaces that were being created. To this end a fly through was created and the stills used to explain key elements. This turned out to be a very effective form of visual modelling which brought the design to life.

Landscape plans

Another key feature in the design development is the way in which the landscape was developed. In many schemes this is still treated as outside play and recreational space but not as learning space. However, on this scheme a synergistic relationship has been developed between internal and external learning spaces so that the Academy grounds become a learning resource which supports the curriculum.

Discussion

In answering the research question: What are the features of the multi-disciplinary interactions and associated modelling methods, which lead to the development of an Academy proposal which meets its Education Brief?
It has been important to focus on each of the activities outlined in the key activities pentagon. Namely: (a)

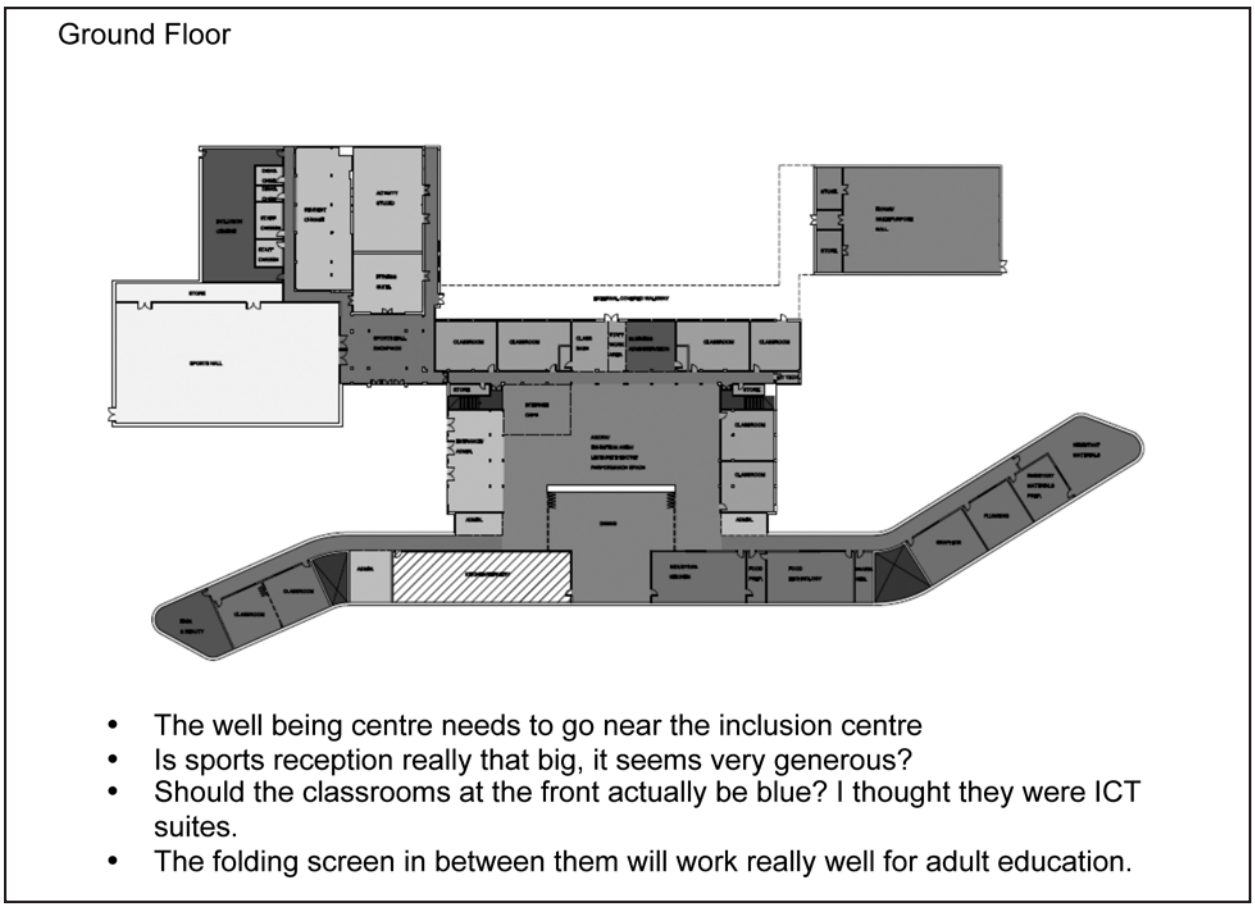

Figure 9. An Example of education feedback during the design development process

Deconstructing the Educational Brief, (b) Educational Concept Sketches, (c) Architectural Concept Sketches, (d) Architectural Plans and (e) Landscape Plans. In analysing the data it has been possible to ascertain the features of the multi-disciplinary interactions and associated modelling techniques, which lead to the development of an Academy which meets its Educational Brief in this context.

Deconstructing the Educational Brief as a feature of the multi-disciplinary interactions that support the Academy Design Development Process

When interrogating the data in terms of the deconstruction of the educational brief through written and verbal modelling techniques, it is clear that this is an essential feature of the Academy design development process as it is vital that complex briefs are interrogated, tested and understood and key features conveyed to architects for inclusion in the design proposals. This approach prompted the architects to make a series of 'What if I did this' moves (Schön, 1987) as he or she considered possible decisions about a feature and its effects on decisions made or yet to be made about other features. This inter-connectedness reflects a constructivist reflection-in-action paradigm for the architect, considering the process of designing as a reflective conversation with the situation (Dorst & Dijkhuis, 1995).

Educational concept sketches as a feature of the multi-disciplinary interactions that support the Academy design development process

In considering the importance of the educational concept sketches conveyed through visual modelling, it is important to remember that the multi-disciplinary team come from a wide range of backgrounds. Each profession has its' own complex language and communication base consisting of rich verbal, visual and mathematical modelling techniques, yet it is essential that communication can take place rapidly and effectively. Hence, in this context educational concept sketches are designed to conquer potential communication barriers in order to convey complex ideas to both the client and design teams. In effect these form part of the 'language of design' (Lawson, 2004) in this context acting as the centre piece for constructive dialogue which illuminates a number of talk functions that empower team members in their thinking and acting: speculating, explaining,

Figure 10. Birds eye view

Figure 11. The Entry Plaza

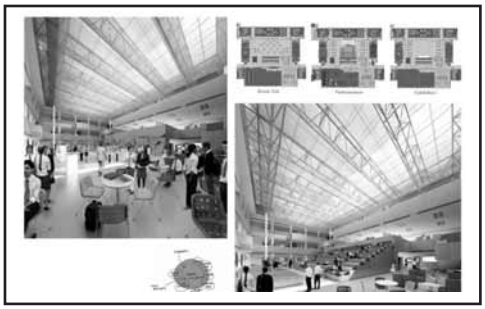

Figure 12. The Agora

Figure 13. Visual Permeability

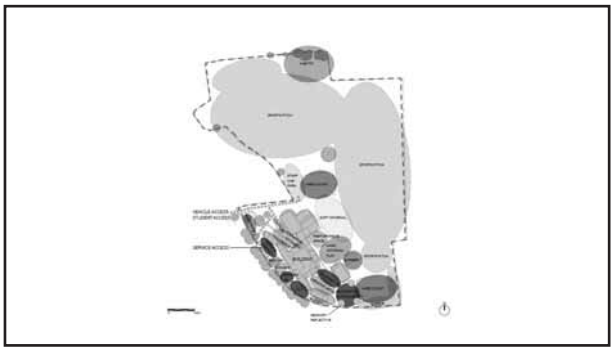

Figure 15. Initial zoning of external spaces

elaborating, questioning, challenging, hypothesising, affirming, feedback, evaluating and reflecting (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007).

Architectural concept sketches, plans, fly through images and landscape plans as a feature of the multi-disciplinary interactions that support the Academy design development process

When considering the importance of architectural concept sketches and plans, represented initially as visual modelling and latterly as a combination of visual and mathematical modelling to the design development process, it is important to consider the nature of the interactions that these tools facilitate and how this interaction supports design development. In studying the data in order to ascertain the features of the multi-disciplinary interactions which take place in the designerly context being studied, it is important to note that the first thing that is striking is the variety of interactions which take place in each client engagement meeting. At key points during the meeting the architect explains what is required of the client team. When doing so she challenges them through questioning, taking their ideas and building on them in order to scaffold their thinking. In doing so, the architect "creates a comfortable and safe environment for thinking…where all ideas matter and where there is no right answer" (Hamilton, 2007).

Research shows that dialogue and conversational engagement is crucial to the creation of a participatory process, critical thinking and empowerment (Mercer, 2000; Shor, 1992). Throughout the study the client and design team utilised a broad range of verbal modelling techniques and interactions in order to facilitate the development of designerly thinking and acting. These included:

- 'speculating' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) as they considered the comments and started to think about additional possibilities;
- 'explaining'(Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) in order to make points clear;

- 'elaborating' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) in order to allow the team to take their thinking further and deeper;
- 'questioning' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) in order to engage in designerly thinking;
- 'challenging' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) usually through the nature of the questioning in order to make the team think more deeply about key elements;
- 'hypothesising' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) when outlining the function and nature of key elements;
- 'affirming' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) as a means of accepting ideas and showing they are valued;
- 'feedback' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) to ensure that the client knew all about their design idea, how effective it was and how it might be improved;
- 'evaluating' in order to make visible what was thought of each design idea and what criteria was being used to judge it against;
- 'reflecting' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) by modelling an ability to reflect on the development of a design idea.

Another feature of the interactions is the ability to reflect on the answers given before extending the thinking. In the view of Schön (1983) "a reflective practitioner strives to provide a learning context that engages learners cognitively, emotionally and socially" as is the case in the design development process. One very important feature which I believe is the cornerstone of designerly conversations is the use of the design or sketch as the centrepiece of the conversation. This was certainly the case as the team modelled the production of design ideas talking through their development. It also served as a useful tool during one to one interactions where the design ideas became the centrepiece of a "conversation with the materials of the situation" (Schön, 1983).

Another key point to note is that not all clients will be able to interpret plans and if this is the only medium used then it is likely to be misunderstood. The introduction of three dimensional images in the form of fly through stills and sketches is highly beneficial in addressing this major issue as is the production of models.

Conclusion

In conclusion the features of the multi-disciplinary interactions and associated modelling techniques, which lead to the development of an Academy proposal which meets its Education Brief are many and varied. They include the use of written modelling used by educationalists to de-construct and re-construct the educational brief in order to share key drivers with the rest of the team, visual modelling used by architects to present a detailed understanding of the educational brief and how it will be manifest in the design and verbal and mathematical modelling where ideas are progressed through discussion both with the client and design teams in both formal engagements and design team meetings.

In summary collaborative interactions are key features of effective design development in this context with cross disciplinary creative collaboration being important to the development of successful outcomes.

Further research

Despite major capital investment in the Building Schools for the Future Programme, it is of concern that design development is rarely based on Educational Research linking Pedagogy and Space (Fisher, 2006). I view this paper as the start of a journey tracking school design from Education Brief to the realisation of space and over time through longitudinal studies the effectiveness of the spaces in action and their impact on learning outcomes. Through this approach it is hoped that a coherent and well evidenced approach to Learning Led Design will emerge.

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