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FACILITATING COLLABORATION: A NEW ROLE FOR THE PROTOTYPE IN DESIGN.

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ABSTRACT:

This paper will briefly review the problems associated with these working practices. Comparisons will then be made between problems associated with (and addressed by) design process, design prototyping and rapid prototyping.

It will then go on to propose how 3D modelling of the design process itself seems to enhance communication and decision-making in complex-working environments.

It will conclude with a proposal for the development of an adaptive 3D modelling system for designers to use in conjunction with a portfolio of techniques for dealing with these relationships.

1. INTRODUCTION.

In design, as in many other fields, there is usually great uncertainty as to whether a new product or service will actually perform as desired. New designs, more often than not, have unexpected problems or consequences.

Traditionally, a prototype is built to test the function of a design before starting production. Building a full prototype, analysing the problems and then re-iterating the process can be an expensive and time-consuming process (but not as expensive as producing an un-tested product could be).

The arguments for prototyping are well accepted and similar arguments can be made for the prototyping of the design process itself.

Adopting new methods of working, taking on new projects and being involved in collaborative or interdisciplinary working scenarios present similar challenges to efficiency, in terms of time-management, economics and productivity.

1.1 DEFINING THE PROTOTYPE.

Several types of prototype exist. The Oxford English Dictionary defines a prototype as: a first or preliminary model of something, especially a machine, from which other forms are developed or copied. This is probably the most common understanding of the word and is therefore a good generic description to use.

According to Ulrich and Eppinger, prototypes can be usefully classified along two axes. The first is the degree to which a prototype is physical as opposed to analytical. “Physical prototypes are tangible artefacts created to approximate the product. Aspects of the product of interest to the development team are actually built into an artefact for testing and experimentation. Examples of physical prototypes include models which look and feel like the product, proof-of-concept prototypes used to test an idea quickly, and experimental hardware used to validate the functionality of a product”.

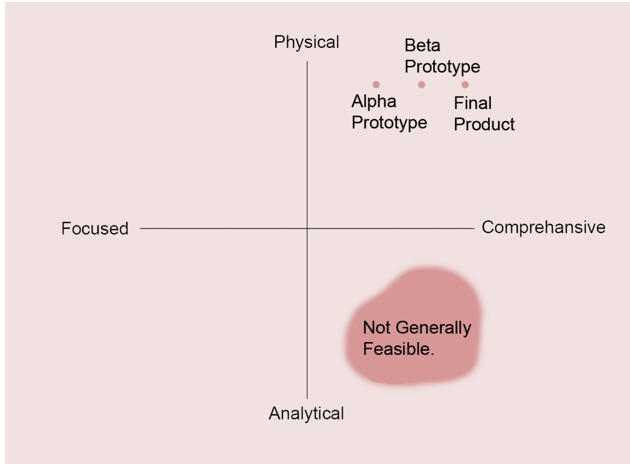

Figure 1. Ulrich & Eppinger. Types of Prototypes.

“Analytical prototypes represent the product in a non-tangible, usually mathematical, manner. Interesting aspects of the product are analyzed, rather than built. Examples of analytical prototypes include computer simulations, systems of equations encoded within a spreadsheet and computer models of three-dimensional geometry”.

The second axis is the degree to which a prototype is comprehensive as opposed to focused. “Comprehensive prototypes implement most, if not all, of the attributes of a product. A comprehensive prototype corresponds closely to the everyday use of the word ‘prototype’, in that it is a full-scale, fully operational version of the product”.

“In contrast to comprehensive prototypes, focused prototypes implement one, or a few, of the attributes of a product. Examples of focused prototypes include foam models to explore the form of a product and wire-wrapped circuit boards to investigate the electronic performance of a product design. A common practice is to use two or more focused prototypes together to investigate the overall performance of a product. One of these prototypes is often a "looks-like" prototype, and the other is a "works-like" prototype. By building two separate focused prototypes the team may be able to answer its questions much earlier than if it had to create one comprehensive prototype” (Ulrich and Eppinger, 2003).

So here we can see what form the prototype may take but when we consider the role of the prototype and specifically in the context of team working scenarios, we see it performs many more functions than may initially be apparent.

- ☐ The prototype informs us. We learn if the product is viable, if it can be mass-produced and how it will perform and so forth.

☐ Prototypes allow us to communicate the design's qualities with the clients, colleagues, or end users, facilitating the gathering of indispensable feedback about the design in a manner that a two dimensional illustration may not provide.

☐ They allow us to ensure that all the components and systems of the product work well together.

☐ Prototyping provides us with tangible goals on the timeline of product development and demonstrates the functions before going on to production.

With these factors in mind it is easy to see why the principles of prototyping may be of use when transposed for other purposes. This is where prototypes perform other less obvious, but just as important, functions. Learning, communication, integration and goal setting are all desirable aspects in the development of cohesive collaborative working environments. So it is logical to assume that if prototyping products can inform project teams in this manner, then prototyping collaborative working processes could have similar benefits.

1.2 THE BENEFITS OF COLLABORATIVE PROTOTYPING.

In recent MPhil work, conducted at the University of Dundee by Sean Kingsley, two small problem-solving teams were given two prototyping environments (drawing in 2D and modelling in 3D). It was found that the latter had "more fun, enjoyed each other's company more, felt happier about their end design, were more committed to the goals of the group, appeared to have consistently higher energy levels and had greater interest in the project" (Kingsley 2005). This seems to confirm the views of Michael Schrage on the benefits of prototyping. "I looked for the best predictor for effective collaboration, I found not psychological profiles, but something else: shared space, the object s and artefacts people played with to transform their ideas from notions to innovations. The real key to getting into collaboration was to look at the artefacts – the models and prototypes individuals used to collaborate – and to look at the way they interact around those models and prototypes" (Schrage 2000).

Although this pilot study was too small to be conclusive, evidence suggests that there is a difference in cohesion, and, therefore, in the performance of teams, according to the prototyping methods involved. This is a phenomenon noted by others, particularly in the field of team facilitation, collaborative working and user centred design. "An evolution of prototyping has been taking place since then [twenty years ago] and we know now that the earlier and rougher the prototype, the more the design team can learn through its creation" (Saunders, 2005). Bruce Tuckman noted in a paper in the American Journal of Psychology in 1964 that project driven teams and teams that interacted around an object from an early stage in the project performed better than teams led in a more traditional or managerial style.

So we know that the main reasons to use prototypes are to inform, communicate, integrate and set goals. And the use of prototyping may allow us to do this in the context of the design process in its entirety or more accurately, permit us to inform, communicate, integrate and set goals in the context of the collaborative design process viewed in a more holistic light. Ideally, this would inform all involved about the processes at work, communicate the working practices to all individuals involved and to external bodies, and to set generic goals for the team, taking a more participatory approach to the management of the design and team process itself.

If this is done using three-dimensional elements that are worked out, or rather worked upon by the group, then the process may serve as a medium of shared space for the team. Working together in this manner, on a model or a shared vision, would hopefully accelerate team development, rather than building up power relationships within the team. Accelerating team development in this manner should allow more time for the team to perform its intended task to their highest ability.

1.2 COLLABORATIVE VISUALISATION PILOT STUDY.

Two experimental "collaborative visualisation" sessions were held using prototype kits. Participants were asked to model their roles, responsibilities, personal goals and group goals. These experiments were recorded using video and stills cameras (Figures 1 and 2). The model outputs and the video recordings were studied in order to extract information from the project. Observations, concerning the level of involvement, focus and interaction among team members, were made. Participants were also asked to provide general feedback through a questionnaire. While not an ideal team scenario for the research, invaluable knowledge was gained from these experiments.

Figure 1. First "Collaborative Visualisation" experament.

Figure 2. Second "Collaborative Visualisation" experament.

Using this collaborative visualization technique at the outset of a project may help cast off negative hierarchical power relationships often associated with traditional managerial structures in large organisations.

In the course of this study it became evident, from participant feedback, that greater understanding between individuals concerning themselves and their project was experienced. Team-members stated that because the model visualised their roles, responsibilities and ideas they became more easily understood. They also stated that because everyone had a different visual style and level of input in the construction of the model, a clearer picture of the individuals and their willingness to be involved as team players became apparent.

These experiments were designed to test if '3-D' visual planning could act as a platform for interaction, common understanding and acceleration of team development. Although they do not unequivocally prove the hypothesis they certainly point to the successful building of the aforementioned elements within he group (For further reading on this pilot study please see; Townson, Colvin and Baxter. (2006) Proceedings D2B Shanghai. Manchester. Adelphi.).

2.2 PROTOTYPING PROCESS.

Tools already exist to support design's traditional role, although tending to be linear and prescriptive in nature, they offer step-by-step methods for communicating and applying design techniques and structured thinking. They are of most value to companies engaged in business where the ‘product’ is understood and industry boundaries are clear (Townson, Colvin, Baxter. 2006).

Difficulties exist when attempting to fit a unique scenario into any preconceived model or plan. Of course, in reality practitioners do not do this but instead adopt the most applicable aspects from a wide range of methods and models. This ‘bricolage’ construction of working practices is, however, often difficult to explain or manage, leading to the need to use external (to the project team) facilitation or managerial intervention. Indeed, this is a common role performed by design management consultancies.

Although this is the case, design management models tend to be interpretations on behalf of, rather than made by, design teams. That is to say, they are retrospective models rather than real-time models and thus, obviously, not in any way true prototypes but visual guides for the design process adopted by the group.

But how does prototyping work when considering abstract ideas or mental processes? In his book No More Teams, Michael Schrage asserts that in Crick and Watson's bid to find the double helix the scientists found that the key to their success was a collaborative tool of their own invention. Rather than rely exclusively on X-ray crystallography patterns, organic chemistry data, and pencil sketches, the two scientists continually built and rebuilt metal models of their proposed DNA structures. Both Watson and Crick recall in their memoirs that these jury-rigged metal structures were an indispensable part of the way they tested their theories, fitted in new data, and created shared understandings about their individual perspectives (Schrage, 1995). In this example we see how Crick and Watson used physical prototyping to gain understanding of the structure of DNA, a structure that at that time was effectively an abstract concept (in three-dimensions at least). In this way we can see how physical prototyping may hold similar possibilities when considering collaborative processes. There is obviously a strong case for the benefits of prototyping in the context of product development and strong indications that it may hold similar benefits for team development and collaborative working. But if prototyping and its benefits have been in place for such a long time, why do we need to make this paradigm shift from product to process?

2. INTERDISCIPLINARITY.

The designer's role is changing, from designer of things to designer of processes, recognising users' emotional experiences and ultimately becoming the facilitator of innovation itself.

Problems do not come in disciplines (Spence, Macmillan and Kirby. 2001): as they become more complex and multi-disciplinary we increasingly work collaboratively to solve them. Rather than supplying solutions to pre-defined problems, we may define problems themselves using creative processes. Designers are evolving from being individual authors of objects, to being facilitators of change among large groups of people (Thackara. 2006).

2.1 ADOPTING NEW METHODS.

With these changes we see the implementation of new practices in design research as well as the execution of design practice in new areas. The designer is now having to process information from sources as varied as sociologists, ethnographers, story tellers, cultural probes and end users. Obviously this is an incredibly difficult process to manage alone and with modern time constrictions to consider, nigh on impossible. Most designers, therefore, work in collaboration with other professionals from these disciplines, a difficult process to manage in itself.

So are we finding ourselves moving from designer, to team facilitator? In some ways, yes but it is not as simple as that; we still need to interpret all these ideas, influences and evidence into a design solution. But now it is not our own solo act: it is a collaborative vision, produced by all the individuals involved in the process and embodied in a product or a service by the designer with all the individuals involved playing vital roles in its generation. But it is all too easy when working in these situations to become obstructed by the processes involved in the team's development, losing sight of their true goals and not performing to their full potential. It is for this reason that new, more adaptive methods of management must be applied when dealing with these emergent working scenarios.

2.2 TEAM DEVELOPMENT.

As mentioned previously, it is imperative to manage the team's development in a project. With the correct structures and methods in place this is possibly not as great a problem as it could be. But firstly we must look into the processes at work in team relationships.

Bruce Tuckman is widely recognised as one of the fathers of the modern team developmental sequence. Tuckman identified four sequences in team development; the first of his stages being “Forming”; this is the polite stage, when the team starts to form. Everyone is trying to figure each other out, members are positive and no one has offended anyone yet.

The second stage is “Storming”. The silent leaders may be clashing for control, disagreements tend to be blamed on the team concept and there is an air of argument and defensiveness. People may resist tasks and question the wisdom of others.

“Norming” is where the team starts to work well together. A positive feeling is adopted and members begin to work out their differences. Teams often move between the Norming and Storming stages but as time progresses the frequency of these regressions decreases but do not necessarily stop altogether.

“Performing” is the last of Tuckman’s initial stages. This is where a team becomes a high-performance team. They can take on new work without regressing to the Storming phase very often (Tuckman. 1964). New members can join without problems and little, if any, external management direction of the team is needed (this may take six months or more to accomplish).

It is important to note that there are significant correlations between Tuckman’s observations made in the1960s and the relatively new ideas and practices of natural or emergent management in organisations.

2.3 ORGANISATION.

Self-organizing systems have the capacity to create for themselves the aspects of organization that we thought leaders had to provide. Self-organizing systems create structures and pathways, networks of communication, values and meaning, behaviours and norms. In essence, they do for themselves most of what we believe had to be done for them. Rather than thinking of organization as an imposed structure, plan, design or role, it is clear that in life organization arises from the interactions and needs of individuals who have decided to come together (Wheatley, 2005).

It is true that, given enough time, order develops naturally in a chaotic system and emergent patterns will form. These patterns then become coherent structures or systems, systems that we find ourselves living in and being a part of. So what has this got to do with teamwork or the design process?

Tuckman's four stages of team development can be viewed through the lens of complexity. The first two stages could be referred to as the chaotic stages where people are thrown together and have to sort out the structures in the team. Then a third stage begins to develop (what Tuckman refers to as Norming) and lastly the team begins to perform (the Performing stage) which could be seen as an emergent pattern. Tuckman noted several points that have particular significance when viewing the team process through the lens of complexity.

Consider the team-working scenario using Reason & Goodwin's six principles of the science of complexity:

- ☐ Rich interconnections: "complex systems are defined in terms of rich patterns of interconnections between diverse components". The view has already been expressed that inter-disciplinarity in design is a necessity. In order to work in these scenarios with other, possibly diverse, disciplines, bridges and connections must be formed between them.

- ☐ Iteration: "complexity theory describes novel, emergent form and behaviour as arising through cycles of iteration in which a pattern of activity, defined by rules or regularities (constraints), is repeated over and over again, giving rise to coherent order". We have seen that prototyping is, in its nature iterative behaviour; where iteration of prototypes ultimately results in a coherent form of the product, iteration of team dynamics, may result in a more coherent team.

- ☐ Emergence: "the order that emerges in a complex system is not predictable from the characteristics of the interconnected components and can be discovered only by operating the iterative cycle". The outcome of team development cannot be predicted, it must be experienced, it would not be enough to recognise that bridges ought to be built; they actually *need* to be built. In design management terms, this is perhaps analogous to executive management stating the organisation needs certain features in its design process and that it should carry them out in a prescriptive manner for certain results. We know from other research (Hollins, Blackman, and Shinkins 2003), that this is often not done. The rather reductionist view of design management may exist because it promises an outcome, when the appropriate response is to facilitate the outcome (Townson, Colvin and Baxter, 2005).

- ☐ Holism: "emergent order is holistic in the sense that it is a consequence of the interactions between the component elements of the system and is not coded in or determined by the properties of a privileged set of components…this is a condition of dynamic organisation; it is not a set of preordained instructions." This relates to team management: dictatorial leadership is not effective when conditions are complex. People will naturally resist imposed roles and responsibilities: it may be far more effective to allow them be adopted by individuals within the team allowing power based relationships to evolve rather than be imposed.

- ☐ Fluctuations: "complex systems in their chaotic state have a distinctive pattern to the fluctuations in the variables. However, this pattern changes as order begins to emerge from chaos…of course the transition can equally well go the other way, from order to chaos…then the pattern is from initial organisation…to chaotic patterns of individuals, with pockets of local order in small groups." This could relate to what Tuckman refers to as the Storming and Norming stages.

- ☐ Edge of chaos: "occurs in a region of dynamic space…at which there is a mixture of nascent order and chaos…if the system moves far into the ordered regime, particular dynamic patterns may become firmly established and there is a loss of capacity to respond flexibly to an unpredictably changing environment…manifesting…as 'too much order'…too much chaos or disorder is equally malfunctional in complex systems." The edge of chaos is where complexity exists. It is the interface between order and chaos and without it a system will become too ordered and then stagnate. We need a degree of chaos to provide new or emergent properties in a system; evolution for example would not occur if there were no random elements in the system.

3. THE EVOLUTION OF THE PROTOTYPE IN TEAMS.

We have already looked at Ulrich and Eppinger's prototype 'type' matrix and parallels have been drawn between the prototyping of products and the prototyping of processes. But what if we consider the prototype from a broader, more holistic standpoint in the context of the team?

The prototype could have a much longer lifespan or (more accurately) stages of evolution, beginning far earlier than previous models suggest. The appearance of the physical artefact is in itself a result of an emergent pattern born from a chaotic system: the team.

Groups are open and complex systems that interact with the smaller systems (i.e. the members) embedded within them and the larger systems (e.g. organizations) within which they are embedded. Groups have fuzzy boundaries that both distinguish them from and connect them to their members and their embedding contexts (Arrow, McGrath and Berdahl. 2000). In this example the group or team is a complex system open to the influences and forces of the external world. In this context the prototype could act as a convergent point (the approach toward a definite value, a definite point or a common view or opinion) facilitating the disambiguation of complex elements of the project and leading to the formation of the appropriate mechanisms and techniques to facilitate the collaborative team process.

3.1 DEGREES OF AMBIGUITY.

If we consider the team process in this holistic manner we can imagine it as exhibiting levels of ambiguity. This is reflected in the development of the prototype; the lower the definition of the prototype or the more ambiguous it is, the more complex the environment that it exists in. That is to say that there are more possible iterations, decisions or outcomes etc in the prototype's development and it is therefore a more complex situation. With a high definition (less ambiguous) prototype, on the other hand, there are fewer options and therefore the situation is far less complex. This idea can be superimposed onto the Ulrich and Eppinger model with the prototype being less ambiguous at the centre of the matrix.

But of course we are thinking holistically and for that reason a two-dimensional model is not enough. We must consider the process in three-dimensions. We can imagine the beginning of the project, which is high in complexity and ambiguity, as the base of a pyramid and the product, which is low in ambiguity and complexity, as the point (Figure 3).

In this model we can consider the Ulrich and Eppinger model as a transitional phase between process and product, or more accurately (if we are going to physically model the processes as well) an event horizon on the timeline of the life of the prototype. Of course, due to possible un-intended uses or developments etc when the prototype gets into the hands of the user the pyramid is turned on its head and the situation becomes more and more complex once again.

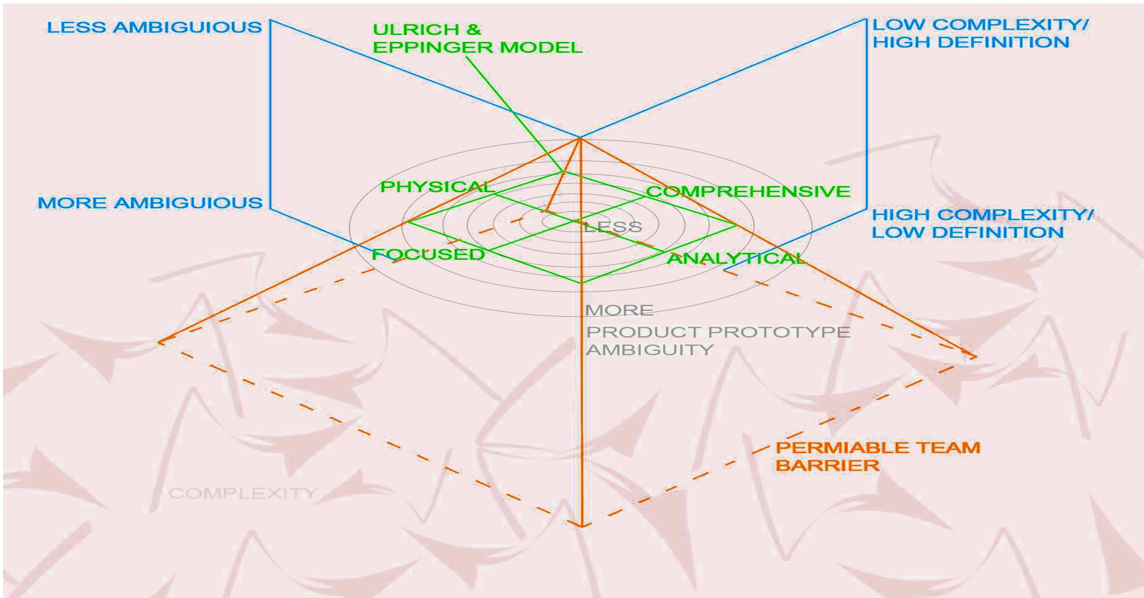

Figure 3. The Colvin and Baxter “Proto-pyramid”.

3.2 IMPLICATIONS FOR DESIGN TEAMS.

The implications of this theory are, of course, at this point somewhat subjective. But it is certain that the possible benefits to design teams outlined in this paper would also be applicable to teams from other disciplines. It is the case however, that in design we are finding ourselves having to “juggle more balls” than ever before. If this process is to be successfully managed in an increasingly complex world, then the correct mechanisms must be in place.

As previously indicated, when working in a recognisably complex environment, linear tools and models may not be appropriate for the facilitation of collaborative working scenarios, be they design related or not. But by using prototyping as a facilitation tool in the manner discussed in this paper it is hoped that significant benefits, in terms of team performance, may be achieved.

It may be that the production of a physical modelling tool for the construction of these models is needed; or perhaps a set of methods or guidelines allowing more abstract models to be built by teams using their own materials is more applicable. There are questions regarding visual metaphor, for example, that throw up potential problems over how possible it would be to produce a generic tool.

There is no indication at this point as to what form any such kit will take, but research into both the forms to be represented and the method for its application are underway.

It is certain, however, that in this age of ever increasing globalisation, the huge growth in the use of interdisciplinary working practices and the expansion of the service design sector that the role designers have to play in large organisations, and the methods they use, will have more and more bearing on the world in times to come.

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