



HOW DESIGNERS COMMUNICATE IDEAS TO EACH OTHER IN DESIGN MEETINGS

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Keywords: Multi Disciplinary Design, Teams, Communication, Shared Understanding

1. Introduction

Technological innovation has had a major impact on the world of design, it is not only an outcome of the design process, but also provides opportunities and options for the designer. Technology has not only provided opportunities but it has also contributed to the complexity of many design processes. In the Industrial world there often exists the need for large teams of designers to work collaboratively in the production of large or complex projects. In such situations Multi Disciplinary Design Teams (MDDTs) are formed. The complexity of the problem demands that the team comprise individuals who have training and experience in a variety of design disciplines. These discipline areas, depending on the design project, could include designers from a range of design fields, e.g. electrical engineering, industrial design, architecture etc. Reasons for working collaboratively in the design process are:

1. The complexity of designing a major item, e.g. large building, requires specialists from a diverse range of disciplines, including architects, quantity surveyors, structural and service engineers.
2. The group's effectiveness in reaching a successful outcome is greater than the effectiveness of an individual designer undertaking the same problem [Peng, 1991].

Lawson, using the example of architects, demonstrated the importance of collaboration to their role as designers;

An examination of professional diaries is likely to show that most architects spend more time interacting with other specialist consultants and with fellow architects than working in isolation.....[1990, p.184].

2. The nature of the problem

An important consideration in the organisation of an MDDT is the process of re-organisation of knowledge, attributable to participation in these teams. The re-organisation of design knowledge most frequently occurs at design team meetings where designing involves interaction between the team members. It is in the activities of these meetings that ideas of individuals become shared understanding of the team. Consequently as a result of a team's design meetings it would be expected that an individual's knowledge, established prior to the meeting, would change and be augmented as a result of the interactions and experiences of participation in the meeting. Dunbar [1995] in research relating to scientific research groups, established that individuals were more likely to change their thinking about a problem as a result of comments from a team discussion than would be evident in a person working individually.

The issue which impacts most significantly on the process of reaching shared understanding, through the design discussion in the team, is the ability of team members to communicate their design ideas

with other members of the team. The ability to effectively participate in the forum of a design team unquestionably requires an ability to communicate design ideas and discipline specific information. The study, reported in this paper, identifies the diversity of communication strategies, which contribute to effective communication within the design team context.

3. The study of communication

To date research has been limited¹ in the acquisition of an understanding of the reasoning heuristics used by designers working in the context of functioning (real world) MDDTs. Also there is limited understanding [Radcliffe, 1996] of how MDDTs actually function and what strategies individuals need to acquire in order to facilitate the level of cooperation and interaction necessary for effective participation and contribution to these design teams. Literature documenting research conducted, to date, is primarily focused on homogenous disciplinary teams in a laboratory environment. The teams documented in the research were also working on problems within a limited time frame and the participants in the team being students or recent graduates, [Cross, 1996].

This project, reported in this paper moved from the laboratory situation to the real world design activity and monitored a design team in the workplace involved in the activity of designing a major project. The process of communicating design ideas requires multifarious strategies. To effectively monitor and analyse this activity the methodology requires the consideration of both verbal and visual interactions. The research methodology using Interaction Analysis, which has been widely employed as a strategy for analysing verbal interactions of discussions. For the purpose of this study the Interaction Analysis strategy was broadened to effectively accommodate the range of communication strategies employed within the design team [Holt, 1991].

The research project involved the collection of data by recording the design team's activity on video. The video documentation of the design activity was then analysed through a video analysis system, Noldus Observer, across eight domains. A second phase of analysis was then performed using statistical analysis.

3.1 The train design project team analysed in the study

The design project team of the Tuen Mun Light Rail carriage, (a tram or streetcar) for use in Hong Kong, was the subject of the research project documented in this report. The project involved the development of an updated version of an existing model (the previous model had not been designed by the team documented in the study). The design project had restricted dimensional parameters to work within but was required to emend the technology and address the need to improve maintenance requirements.

The design meetings, both formal and informal, were documented over a twelve month period. The meetings covered a wide range of design activities including issues relating to managing the project but were predominantly interactions associated with the development of the design.

4. The range of communication strategies

The study found the teams designers used a wide range of communication strategies to achieve shared understanding between members. It was also apparent that there was a progression among the strategies used by team members. Table 1 outlines the stages of this sequence:

Table 1. Communication Strategies Employed by the Team

Verbal Strategies	Visual Strategies
1. Technical Language	3. Gesture
2. Analogy <ul style="list-style-type: none"> • Project Specific • Domain Specific • External to Domain 	4. Graphics – Sketching
	5. Existing Graphics
	6. Actual Objects

If the team members failed to achieve shared understanding with the initial communication interaction then a subsequent attempt would be made by using a communication technique from down the list of strategies, e.g. if technical language failed to achieve understanding then a strategy 2-6 (from table 1) would be employed. Following are descriptions of the individual communication strategies:

Technical Language

This was recognised as the use of technically-specific language that is using the “correct” name of an item or procedure to be used in the project, e.g. “servo motor” or “plug welding”.

Analogy

The *project specific* analogy related to using examples drawn from the specific project the team was working on, e.g. “its what we did at the drivers cab end”. The *domain specific* analogy related to the use of examples drawn from the experiences of the team members from within the industry domain itself such as a previous project they had collaborated on, e.g. “its like we did on the ThaiRail project”. The third level of analogy, *external to domain*, related to the use of metaphors drawn from outside the specific design domain of the team. The third level of analogy related to the use of examples drawn from outside the railway industry domain. Team members used examples drawn from the automobile, aircraft or marine domains but would also use “unsophisticated” metaphors, e.g. “its the black stuff used to hold car windscreens in”.

Gesture

This involved the use of hand and arm movements and was considered a visual level, e.g. drawing with the finger on the surface of the table or moving the hand to show the curvature of a surface. These gestures are used predominantly to depict a number of aspects about the design, including:

- size,
- function/mechanism,
- relationship to other components,
- shape.

Drawing

The use of graphics or freehand drawing by the team members was usually a result of having been unsuccessful in gaining acknowledgement of understanding by group members as a result of the using the above strategies. It is interesting to note that some members seemed to be more comfortable with the use of graphics and would initiate its use much sooner in the discussion of issues. 2D drawings and sectional drawings were the most commonly used with 3D used only on rare occasions. Graphics on both paper and white board were used most commonly in demonstrating shape, articulation and situational change.

Existing Graphics

The use of an existing medium was common throughout the design process, This use expanded as the design project progressed and previously designed outcomes were documented. The graphics forms, of communication, used primarily consisted of technical or production drawings but also included photographs.

An Object

The final strategy for transfer of technical information or design discussion was when the actual object being discussed was used to demonstrate the issues under examination. An object was used lastly as a communication strategy in the meetings observed. It generally caused disruption to the meeting as someone had to leave to get the item or the meeting had to be reconvene at another location. An example of such a situation was the explanation of a partial window hopper being discussed by the team. One member had trouble with the functional aspects of the window so a team member left the

room to find one to demonstrate the functionality.

5. Findings

The findings of this study have provided a insight into the activities of the MDDT associated with the achievement of shared understanding with the aim of progressing a design process. Communication in the team fell across a broad range of activities to do with managing a design project but the interaction specifically associated with progressing design was in the process of design discussion and responses to design questions. It is in these activities that the communication for shared understanding was most intense. Over the period of the study in excess of 14,000 interactions were documented and analysed providing a comprehensive set of data which was used to define the communication activity.

The analysis indicated that it was uncommon for team members to limit their communication to a single strategy in any one interaction, in 98% of interactions team members used two strategies simultaneously. Analysis also revealed that there was a primary and a secondary level, the primary conveying the most significant detail of the interaction and the secondary supporting and/or amplifying the information provided in the primary level. The overall breakdown of the frequency of use of the communication strategies is shown in table 2, below:

Table 2. Frequency of Communication Strategies Used

Technical language	54.80%
Project analogy	2.65%
Domain analogy	2.92%
External analogy	2.45%
Gesture	8.25%
Sketch	3.45%
Chart	24.73%
Object	0.70%

To provide clearer detail of the communication interactions the categories of verbal and visual were considered. The primary and secondary methods of communication where categorised as verbal or visual methods of communication (see Table 1). Table 3 shows the relationship of the verbal and visual categories of communication.

Table 3. Verbal and Visual Grouping

Verbal only	41.7%
Verbal and Visual	57.4%
Visual only	0.9%

These results show the relationship between the two categories of communication and the reliance of team members on employing both visual and verbal forms of communication simultaneously to transfer design information to group members.

An evaluation of the outcome or the success of each of the interactions in achieving shared understanding provides further detail. It can be seen from the results, table 4, that verbal interactions have a greater level of *not* being understood by other team members when used in isolation from a visual form of communication

Table 4. Verbal and visual method of communication outcomes

	Not understood	Understood
Verbal only	25.5%	74.5%
Visual component	13.3%	86.7%

In the “follow up” communication strategy, the clarification of an initially *not understood* communication, was examined the results indicate that the use of a visual component only increased marginally to 63%, from 57.4%. It is of interest to note that the success rate of the subsequent communication did not change significantly, remaining at 76% for a verbal only response but rising to

95% for subsequent responses that included a visual component.

Of consideration to the function of the individual member within the team is that each individual demonstrated a unique communication profile. This profile was developed by documenting the specific strategies members employed to communicate ideas and concepts to each other. Over the length of the project it was observed that members had preferred methods of communication and would in the majority of interactions, use consistent communication strategies, especially so in the initial interaction. This situation was most notable for the application of verbal strategies only, resulting in a small number of team members being responsible for verbal-only interaction. Therefore individuals success at achieving shared understanding, and being an effective communicator, was consistent with the success rate of the communication strategy the individual employed.

6. Conclusion

This study indicates that designers have to be competent in communication strategies at each level of the hierarchy outlined above. This situation is most evident in the MDDT design environment where using domain specific technical language was indicated as a poor communication strategy. The roles of graphic or visual forms of communication were fundamental to successful achievement of shared understanding by members of the design team. This consideration will have an impact on the way in which these teams are worked and managed.

A further consideration is the housing of the design team in an environment which provides the tools to support the design activity. It was identified in the study that sketching was a fundamental communication strategy employed by the designers in the team. The team used various media to support this activity including the use of existing drawings or at the least the paper of the existing drawings. Some of the meeting rooms contained a white board with markers. When meetings were held in these locations the white board was invariably used for sketching design concepts. When meetings were held in rooms without the white boards the designers had to resort to other media to sketch, this no doubt having an influence on the effectiveness of the team discussion.

Another consideration is the easy access to design/product drawings. A cataloguing system containing the drawings at easy access to the designers would make the process more efficient as designers would not have to leave the meetings to access such drawings. Aligned with this would be the use of computers to support the design meetings of the team. The team studied did not have access to computer data, graphic or text within the meeting workspace. It was noted that at times meetings reached a hiatus as data was not readily accessible. The ability to easily access digital data of all forms would facilitate a more effective communication environment as the items, drawings, needed to progress discussions would be readily at hand.

The use of artifacts to convey meaning to design interactions was shown to be critical in the context of the design meetings. The artifacts were not limited to real objects but included “mockups” of designs, or at times photographs of objects. Access to these items resolved these issues more quickly and allowed the designers to clarify discussion more effectively. It was noted the ability to handle and manipulate objects assisted the attainment of shared understanding by the team.

A consideration for the management of design teams is the induction process for new members. The ability to communicate concepts through the use of domain specific analogy was seen as an effective communication strategy. The limitation to the use of this strategy was the shared experiences of the team. New team members were not able to share in the use of domain analogy. It was observed that new team members were able to relate to this analogy when they had ready access to the details of the project being employed in the analogy. This was achieved through access to drawings, photographs and components of the previous projects. A possible induction process for a new team member could be to allow them to access information concerning past projects to assist them in the sharing of domain analogy more readily.

This study identified that the communication issue impacts most significantly on the process of reaching shared understanding in the team context. The ability of team members to communicate their design ideas with other members of the team both efficiently and effectively is fundamental to success in an MDDT. A designer to be an effective design communicator, in the MDDT context, must have the communication skills, outlined in this study, and be prepared to employ them.

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